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The Relationship Between Indicators of Mathematical Problem-Solving Ability and Performance on The PISA Test: Systematic Literature Review

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Abstract

The mathematical problem-solving ability of Indonesian students has declined significantly, as reflected in PISA 2022 results with an average score of 366, far below the OECD average. This decline is attributed to the disruption of the education system during the COVID-19 pandemic and challenges in distance learning. Studies highlight students' difficulties in connecting math problems to real-life situations and performing basic math operations. Innovative learning methods like flipped classroom and problem-based learning have been shown to improve problem-solving ability. Common errors at comprehension and transformation stages indicate the need for teaching approaches that develop conceptual understanding. This study employs the Systematic Literature Review (SLR) method to analyze 30 articles on mathematical problem-solving within the PISA context (2018–2023). Findings reveal the effectiveness of systematic approaches like Polya's four-step method (see, plan, do, check) and the IDEAL model (identify, define, explore, act, look) in enhancing problem-solving ability. Learning styles and innovative models also play key roles. Adaptive and context-based learning strategies are recommended to improve students' critical thinking and problem-solving abilities. At the policy level, continuous teacher training in innovative methods and improved access to technology are essential. At the classroom level, integrating real-life problems and project-based learning is advised to enhance students' engagement and skills. These strategies aim to address the challenges and improve PISA performance while fostering critical thinking.

Keywords: Problem-Solving Ability, PISA, Junior High School

Introduction

Problem solving ability is one of the competencies measured through contextual and non-routine questions in the Program for International Student Assessment (PISA), to assess the extent to which 15-year-old students can apply their knowledge in real situations (OECD, 2023). The PISA 2022 results showed a decline in Indonesian students' math skills, with an average score of 366 and a ranking of 69th out of 81 countries, marking a significant decline compared to the 2015-2018 period. This score is far below the average of OECD member countries which ranges from 465-467 (OECD, 2023). This decline was not only experienced by Indonesia, but also by 81 other participating countries compared to the previous period. According to the OECD (2023), this score decline was influenced by the COVID-19 pandemic which forced distance learning. Disruptions to the education system have led to instability and reduced teaching quality due to schools being closed for long periods of time, creating limited learning time and educational disparities. Distance learning also presents its own challenges, especially for students who do not have adequate access to technology and the internet.

Various studies show that junior high school students in Indonesia have difficulty in solving PISA questions. Research by Oktaviana et al. (2018), found that students face obstacles due to

a lack of understanding of the material being tested, especially on story problems where the context or core of the question is often not fully understood. According to Haji et al. (2018), dentified the main problems, namely (a) difficulty understanding the problem, (b) difficulty connecting the context of daily life with mathematical models, (c) difficulty performing mathematical operations, and (d) difficulty applying the results of mathematical calculations to real situations. Research by Febrianti & Nurjanah (2022), added that these difficulties are often caused by students' low mathematical literacy and understanding of the material being tested.

This shows that students have difficulty in applying mathematical knowledge in real contexts and understanding non-routine questions, which are the main components of PISA questions. To overcome this problem, a habit of giving story problems that adapt to everyday life is needed. Thus, students will be familiar with mathematical contexts that are equivalent to PISA questions and will develop more complex mathematical problem-solving ability. Mathematical problem-solving ability is an effort to find solutions to obstacles to achieve goals that are not immediately easy to achieve.

According to Polya (1957), mathematical problem solving involves four main steps: understanding, planning, executing, and checking. The first step, understanding the problem, involves identifying the problem, understanding the terms, determining known and unknown information, and describing the problem through diagrams or guiding questions. The second step, planning, involves determining strategies, sequencing steps, considering alternatives, and estimating outcomes. The third step, execution, includes implementing the plan, recording actions, and periodic monitoring. The final step, evaluation, includes verification of results and validation of steps, and revision if needed.

The low problem-solving ability of students indicates the need to improve the quality of education. Improving this ability not only improves students' performance in international tests such as PISA, but also prepares them for a global economy based on innovation and technology (Muala & Nugraheni, 2024). This is in line with the Sustainable Development Goals (SDGs) which emphasize the importance of inclusive and quality education.

Indonesia can learn from what is known as a strong and competitive education system, especially in skill development and problem solving. South Korea has implemented various policies to improve the quality of education and ensure equitable access for all students. According to Lee (2019),), South Korea's national curriculum emphasizes mastery of mathematics, science and reading with long study times and additional tutoring at 'Hagwon' reflecting a high commitment to education. South Korea is also evolving their education system to develop critical thinking, problem solving, creativity, and digital competencies through programs such as free semesters and SMART education that increase student engagement through interactive approaches and technology (Jeong, 2020). The mathematics curriculum in Korea emphasizes critical thinking, logical reasoning, and practical application of mathematical concepts to solve real-world problems, in line with international education standards (Park, 2022). By adopting a similar approach, Indonesia can improve students' mathematical problem-solving skills and compete better in international assessments such as PISA.

As part of its efforts to support the SDGs for quality education, South Korea has implemented a flexible and innovative curriculum that has integrated with technology to help students develop 21st century ability. In addition, South Korea not only supports the achievement of the SDGs but also prepares the younger generation to face increasingly complex global challenges. This commitment reflects a comprehensive strategy in improving the quality of education and ensuring that all students have access to the resources and opportunities needed to succeed. The following figure illustrates the VOSviewer visualization to understand

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the relationships and factors that influence mathematical problem-solving ability, as well as identify areas that need more attention in mathematics education.

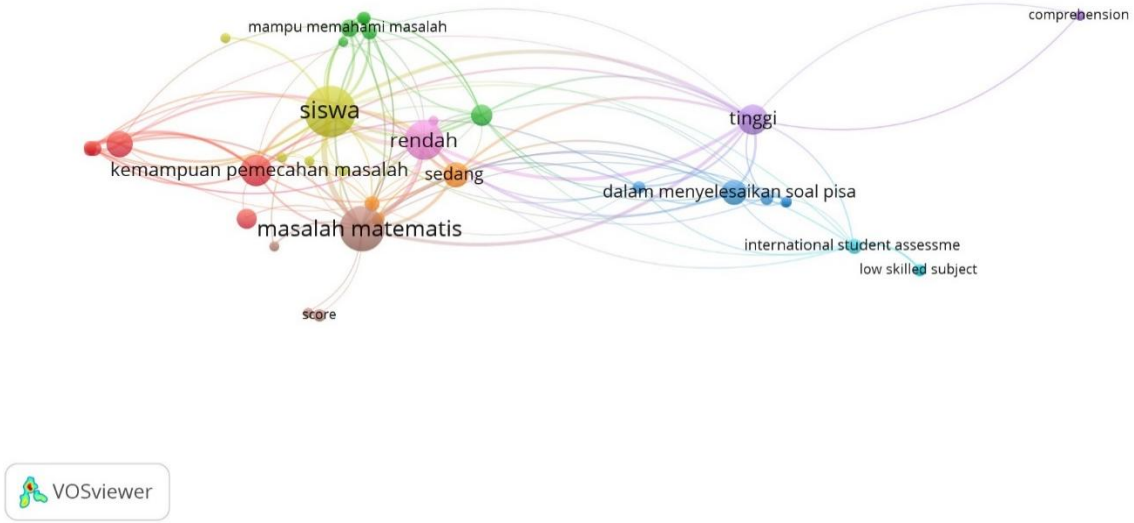


Figure 1. VosViewer visualization

The VOSviewer visualization illustrates the relationship between concepts that influence students' mathematical problem-solving ability. The center point shows the relationship between “students” with “problem solving ability” and “mathematical problems,” indicating that much research focuses on how students solve mathematical problems. The variation in students' abilities can be seen in the two main poles of high and low abilities. In addition, the term “in solving PISA problems” indicates the focus of research on students' performance in the international PISA test that measures mathematical problem-solving ability of different countries.

Causal factors are also identified, such as “able to understand the problem,” which shows the importance of the ability to understand the problem as a key indicator in mathematical problem solving. The term “score” refers to the results of students' assessment in the PISA test. The results of this visualization emphasize the importance of students' mathematical problem-solving ability, where performance in the PISA test is a key indicator of this ability. The studies analyzed highlight differences in student ability and the factors that influence mathematical understanding and problem solving, with a particular emphasis on performance on the PISA test and how this relates to indicators of problem-solving ability.

Method

This research uses the Systematic Literature Review (SLR) method which consists of seven stages based on the guidelines of Triandini et al. (2019) including:

The first stage was the formulation of research questions that included the performance of Indonesian students in the PISA test, indicators of problem-solving ability, and their relationship with PISA.

The second stage involved searching for relevant articles using Google Scholar and the Publish or Perish app, with keywords spanning the years 2018-2023, yielding up to 200 articles per year. The first type of keywords used are problem-solving, junior high school, mathematics education and the second type of keyword is problem-solving, PISA, math education.

The third step is inclusion and exclusion criteria by deciding whether a scientific article is eligible or not. The selected eligible articles have criteria that can be seen in table 1.

Table 1. Inclusion Criteria

Criteria	Type
Data in the form of articles or proceedings	Inclusion
Articles published between 2018-2023	Inclusion
Data related to the keywords first type of problem-solving, junior high school, mathematics education	Inclusion
Data related to the keywords second type of problem-solving, PISA, mathematics education	Inclusion
Data in Indonesian or English	Inclusion
Google Scholar and Sinta indexed data	Inclusion

In the fourth stage, quality assessment was conducted through specific questions such as keyword relevance, article language, and indexation in Google Scholar or Sinta. The fifth stage involved data collection, where articles that met, the criteria were stored using Zotero and Excel to record key data such as title, author, theory, findings, and DOI. The sixth stage was data analysis of 15 articles for each keyword to answer the research questions. Finally, in the seventh stage, adjustments were made to some keywords and search methods. This method is designed to systematically identify, evaluate, and synthesize relevant research.

Results

The first type of keywords is problem-solving, PISA, mathematics education in the publish or perish search there are 15 articles which will be presented in table 2 below.

Table 2. First Type of Problem-Solving, PISA, Mathematics Education

No	Title	Author Name and Year	Main Theory	Findings and Results
1	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Cerita Matematika Berdasarkan Langkah Penyelesaian Polya	Rofi'ah et al. (2019)	George Polya's Theory	Junior high school students often make mistakes at the planning and checking stages due to a lack of understanding of concepts and a habit of not double-checking.
2	Analisis Kemampuan Pemecahan Masalah Matematis Ditinjau Dari Gaya Belajar Siswa di Masa Pandemi COVID-19	Al-Hamzah & Awalludin (2021)	George Polya's Theory	The ability to solve math problems varies, students with visual learning styles are superior according to Polya's indicators.
3	Profil Pemecahan Masalah Matematika Berdasarkan Teori Polya Ditinjau dari Kemampuan Matematika Siswa	Putri & Putri (2022)	George Polya's Theory	High ability students were good at all Polya stages, but less thorough at the final stage, while medium and low students struggled at the comprehension and planning stages.
4	Kemampuan Pemecahan Masalah Matematis Siswa dalam Menyelesaikan Soal PISA	Mashuri & Jahring (2023)	George Polya's Theory	The problem-solving ability of grade VIII students on PISA questions is generally high (average 71.32).
5	Kemampuan Pemecahan Masalah Serupa PISA pada Model Problem Based Learning dengan Pendekatan Flipped Classroom	Nafiah et al. (2023)	George Polya's Theory	Low category students were weak in planning, execution, and checking; medium category was good; high category was very good in all Polya steps. This research used PBL model with flipped classroom.
6	Kesalahan Siswa Menyelesaikan Soal PISA berdasarkan Kemampuan	Rosehana & Haerudin (2023)	George Polya's Theory	High ability students solved the problem correctly, medium ability students only fulfilled 3 indicators,

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	Pemecahan Masalah Matematis Siswa			and low ability students were wrong in planning and executing.
7	Analisis Kesalahan Peserta Didik dalam Menyelesaikan Soal PISA Matematika Berdasarkan Mathematization Terhadap Materi Aljabar di SMPN 97 Jakarta	Andreani et al. (2022)	Jupri Drijvers Theory	High-ability junior high school students solved the problem correctly, medium-ability students only fulfilled 3 indicators, and low-ability students were wrong in planning and executing.
8	Identifikasi Faktor-Faktor yang Mempengaruhi Kemampuan Pemecahan Masalah Matematika	Dwianjani & Candiasa (2018)	Bransford and Stein theory with the IDEAL model	The main factor in math problem solving is strategy implementation, followed by exploration, identification, goal setting, and evaluation.
9	Kemampuan Pemecahan Masalah Siswa Menyelesaikan Soal Materi Garis Singgung Lingkaran	Kristianingsih (2019)	John Dewey's theory	Subject SE failed at the hypothesis testing and evaluation stages, while SA and SN successfully passed all stages. Students' ability to solve math problems remains varied even though it exceeds the minimum criteria.
10	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Matematika PISA pada Konten Change and Relationship	Pranitasari & Ratu (2020)	Newman's Error Analysis (NEA) Theory	Students' main errors were in understanding, transforming, and writing results due to lack of reasoning, confusion, and low interest.
11	Analisis Kemampuan Pemecahan Masalah Peserta Didik Dalam Menyelesaikan Soal PISA	Zahro & Haerudin (2022)	Newman's Error Analysis (NEA) Theory	Math problem solving ability of PISA students: 33.33% high, 50% medium, 16.67% low. The main difficulty is in understanding and transforming the problem into mathematical form.
12	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Model PISA	Artati et al. (2022)	Newman's Error Analysis (NEA) Theory	Students often make mistakes in understanding, transforming, processing, and writing answers to PISA questions.
13	Analisis Kesulitan Siswa dalam Menyesaikan Soal-Soal PISA (Programme for International Student Assessment) di SMP Kota Bengkulu	Haji et al. (2018)	PISA Theory	Students' ability to solve PISA problems is still low, especially in understanding the problem, connecting real aspects, mathematical operations, and interpreting results.
14	Kesulitan Siswa SMP dalam Menyelesaikan Soal PISA 2021	Febrianti & Nurjanah (2022)	PISA Theory	Students have difficulty understanding, solving, and concluding PISA questions due to low mathematical literacy and material understanding.
15	Kesulitan Siswa Sekolah Menengah Pertama dalam Menyelesaikan Soal Matematika PISA-Like	Sujadi et al. (2022)	PISA-Like Theory	Junior high school students have difficulty solving PISA-like questions due to lack of understanding, complex stimulus, and ignorance of the question format.

The second type of keywords, namely problem-solving, junior high school, mathematics education in the publish or perish search, there are 15 articles which will be presented in table 3 below.

Table 3. Keywords Second Type of Problem-Solving, Junior High School, Mathematics Education

No	Title	Author Name and Year	Main Theory	Findings and Results
1	Kemampuan Pemecahan Masalah Matematis Siswa dalam Menyelesaikan Soal PISA pada Topik Geometri	Annizar et al. (2020)	George Polya's Theory	High-ability students completed all stages, while medium and low-ability students struggled with comprehension and planning.
2	Analisis Kesalahan Siswa SMP Pada Materi Perbandingan Ditinjau dari Indikator Kemampuan Pemecahan Masalah Matematis	Yuliani et al. (2019)	George Polya's Theory	Junior high school students often make mistakes due to lack of understanding of concepts, haste, and rarely check answers.
3	Analisis Kemampuan Pemecahan Masalah Matematik Peserta Dididk Kelas VIII SMP	Nuraeni et al. (2020)	George Polya's Theory	Class VIII students' problem-solving ability are low, due to reliance on practical formulas, and difficulty in understanding and planning solutions.
4	Kemampuan Pemecahan Masalah Siswa SMP	Fitriani (2020)	George Polya's Theory	Class VIII students' problem-solving ability are good, but weak in double-checking, influenced by teaching methods and learning habits.
5	Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Masa Pandemik Covid-19	Munengsih et al. (2021)	George Polya's Theory	Grade VII students' math ability: 14% high, 74% medium, 12% low. High students succeeded, medium students checked less, and low students struggled at all stages.
6	Analisis Kemampuan Pemecahan Masalah Matematika Pada Siswa SMP Dalam Menyelesaikan Soal Cerita Ditinjau Dari Tahapan Polya	Mawardi et al. (2022)	George Polya's Theory	The average problem-solving ability of grade VIII students is in the medium category, with difficulties in the evaluation and planning stages.
7	Analisis Kemampuan Pemecahan Masalah Matematis Siswa Sekolah Menengah Pertama (SMP) Kelas VIII	Melsita & Yulia (2023)	George Polya's Theory	VIII grade students are in the low category, with the main difficulties in problem identification, strategy formulation, and application of mathematical concepts.
8	Analisis Kesulitan Siswa SMP Dalam Menyelesaikan Soal Cerita Pada Materi Sistem Persamaan Linear Dua Variabel	Sari & Lestari (2020)	George Polya's Theory	Grade VIII students have difficulty solving SPLDV problems due to lack of understanding of the concept and lack of accuracy. A contextualized learning approach is needed to improve their ability.
9	Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Materi	Purnamasari & Setiawan (2019)	George Polya's Theory	High VIII students excelled in strategy but were weak in checking answers, while medium and low struggled at all stages.

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	SPLDV Ditinjau dari Kemampuan Awal Matematika (KAM)			
10	Analisis Kemampuan Pemecahan Masalah Siswa SMP Pada Materi Sistem Persamaan Linear Dua Variabel	Jaelani & Hidayati (2021)	George Polya's Theory	Students' ability in SPLDV is low, with 66.67% in the low category. Common errors include operations and concepts.
11	Analisis Kemampuan Pemahaman Konsep Matematis dan Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Materi Sistem Persamaan Linear Dua Variabel (SPLDV)	Suraji et al. (2018)	George Polya's Theory	The ability of grade VIII students to understand concepts and solve is very low, with the main difficulty in understanding and applying concepts in real contexts.
12	Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Materi Sistem Persamaan Linear Dua Variabel dengan Pembelajaran Daring	Haryati & Warmi (2021)	George Polya's Theory	The ability of grade VIII students to understand concepts and solve is very low, with the main difficulty in understanding and applying concepts in real contexts.
13	Analisis Kemampuan Analisis Kemampuan Peserta Didik SMP di Bangkinang Melalui Penyelesaian Soal PISA 2015	Zulfah (2019)	Theory based on Permendiknas No. 58 of 2014	Junior high school students have difficulty solving PISA questions because they do not understand the correct steps, but they are superior in inductive reasoning than deductive.
14	Analisis Kemampuan Pemecahan Masalah Matematis dengan Menggunakan Pembelajaran Daring	Kurniawan et al. (2020)	Theory adapted from Pujiastuti 2014	The problem-solving ability of class VIII students is moderate, with low category students having difficulties at the planning and evaluation stages.
15	Kesulitan Pembelajaran Daring Matematika Pada Masa Pandemi COVID-19 di SMP Muslimin Cililin	Fauzy & Nurfauziah (2021)	Online Learning Theory	Students struggle with math online due to poor network, full memory, limited interaction, many formulas, and the abstract nature of the material, with WhatsApp as the main platform.

Discussion

Based on table 2 above, research shows that high-ability students tend to be able to complete all stages in Polya's theory, namely understanding, planning, executing, and checking(Annizar et al., 2020; Putri & Putri, 2022). However, they often lack thoroughness at the evaluation stage. In contrast, students with intermediate and low ability struggled with comprehension and planning, which led to errors when executing the plan. In addition, students' performance varied by PISA content, with the highest results on “quantity” and the lowest on “space and shape” (Mashuri & Jahring, 2023).

Variations in ability based on material and learning style have also received special attention. Research conducted by Al-Hamzah & Awalludin (2021) found students with visual learning styles

to be superior in solving mathematical problems according to Polya's indicators compared to students with auditorial or kinesthetic styles. In addition, Sujadi et al. (2022) added that students often have difficulty understanding the complexity of PISA-based problems, especially those that require the application of mathematical concepts in real situations. Error analysis using Newman's Error Analysis (NEA) by Pranitasari & Ratu (2020) and Artati et al. (2022). Research Zahro & Haerudin (2022) also noted that students have difficulty understanding and transforming problems, so learning needs to focus more on developing concept understanding.

Factors that influence problem solving ability according to Dwianjani & Candiasa (2018), using the IDEAL model (identify, define, explore, act, look) showed that strategy implementation with the IDEAL model (identify, define, explore, act, look) show that strategy implementation (act) is the most dominant factor, followed by strategy exploration and problem identification. This emphasizes the importance of a systematic and structured approach to problem solving. Research by Nafiah et al. (2023), who used Problem-Based Learning (PBL) with a flipped classroom approach found this method significantly improved students' abilities in all stages of problem solving according to Polya, as well as making students more active and involved in learning that improves thinking ability.

From the studies analyzed, a significant relationship between indicators of mathematical problem-solving ability and students' performance in the PISA test. Systematic approaches such as Polya's theory and the IDEAL model help students solve problems effectively. Factors such as learning style and the application of innovative learning models also play an important role in improving students' abilities. Error analysis using Newman's Error Analysis (NEA) provides insight into areas of improvement, especially in problem understanding and transformation. Based on Table 2, Polya's theory was used in five studies, NEA in three studies, while Jupri Drijvers, Bransford & Stein, John Dewey, PISA, and PISA-Like theories were each used in one study.

How do Indonesian students perform on the PISA test?

Indonesian students' performance in completing the PISA test show some major weaknesses. Students have difficulty in understanding the questions and relating them to real-life contexts, which is an important element in PISA questions. Mathematical problem-solving ability as outlined in Polya's theory, are often not optimal, especially in the planning and evaluation stages. Some studies show that many students are in the medium and low categories with common errors in transforming problems into mathematical forms and basic mathematical operations. Learning style factors can also affect results, with visual learning style students tending to be more successful. In addition, the implementation of innovative learning models such as PBL can improve students' problem-solving ability and performance in PISA tests. Overall, although there are some students who demonstrate high ability, most Indonesian students still need to improve their problem-solving ability to achieve better results in the PISA assessment.

What are the indicators of problem-solving ability?

George Polya's theory outlines four main steps in mathematical problem-solving. The first step is See, students must identify what is known and what is asked in the problem. The second stage is Plan, where students determine the right method or approach to solve the problem. Next, students proceed to the Do stage, which is applying the planned strategy carefully. The last stage is Check, students re-examine the results and the solution process, reflect, and correct if there are errors. This indicator helps students solve problems systematically and effectively.

Jupri and Drijvers' theory emphasizes several key indicators in mathematical problem-solving. First, understanding the problem students must be able to recognize and interpret the

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important elements of the problem. Second, formulating mathematical models (formulating equations, models, or diagrams) students convert contextual problems into mathematical models that can be analyzed. Third, mathematical problem-solving which involves using mathematical procedures accurately to find solutions. Fourth, reflection (checking the results of the solution) in which students can evaluate the solution obtained and consider its relevance to the original context of the problem. These stages aim to identify and analyze the types of errors made by students when solving PISA problems.

Bransford and Stein's theory with the IDEAL model categorizes problem-solving ability into five. The first step is identifying the problem, students must understand the situation and important information available. The next step is to define the problem, which is to set clear goals and limits to achieve a solution. Next, students explore various strategies and alternative solutions to consider possibilities and gather relevant information. After that, students carry out the implementation (act) of the strategy that has been chosen, applying it effectively and thoroughly. Finally, the evaluation stage (look) is carried out by reviewing the results and the solution process and reflecting for improvement and further learning. This model guides students in solving problems systematically, analytically, and reflectively.

John Dewey's theory identifies several steps in mathematical problem-solving. First, confronting the problem that needs to be solved. Next, defining the problem by formulating the problem specifically and identifying key elements that need attention. Then, formulating hypotheses, to consider various possible solutions. After that, the stage of testing the hypotheses is done by implementing the chosen solution to see if it is effective. Finally, evaluating the results is done by assessing the results and the solution process, and reflecting for future learning. This indicator emphasizes reflective and analytical thinking in the problem-solving process.

Newman's Error Analysis (NEA) theory identifies five main stages in math problem-solving. The first stage is comprehension, where students must understand the given information and question. The second stage is transformation, which is converting a verbal problem into an appropriate mathematical model. The third stage is process ability, which involves applying mathematical procedures to solve the problem. The fourth stage is encoding, which involves writing down the result appropriately. Finally, review, where students re-examine the solutions that have been made to ensure the correctness and accuracy of the results. This indicator helps in identifying student errors at each stage of problem-solving.

PISA theory identifies several key indicators of mathematical problem-solving ability. First, problem understanding where students can interpret and understand the problem in a real-life context. Second, problem formulation which involves transforming real-world situations into relevant mathematical models. Third, concept application which involves using appropriate mathematical concepts and procedures to solve problems. Finally, the interpretation of results is done by students evaluating and interpreting the results in the original context of the problem. This indicator emphasizes students' ability to think critically and apply mathematics in real situations.

PISA-Like theory emphasizes students' abilities in several aspects of mathematical problem-solving. First, problem understanding which requires students to be able to understand and interpret the problem. Second, linking to real contexts which involves the ability to relate problems to everyday life situations. Third, the application of mathematical concepts, namely using relevant mathematical concepts and procedures to solve problems. Finally, evaluation and reflection are done by students assessing the given solution and reflecting on the solution process to ensure the results are in accordance with the context of the problem.

Based on table 3, several studies show that the mathematical problem-solving ability of junior high school students is generally low to moderate. Research Rofi'ah et al. (2019) and Yuliani et al. (2019), found the biggest errors occurred at the planning and re-examination stages, indicating that many students were less thorough in evaluation. Research Nuraeni et al. (2020), mentioned that only a few students were able to apply problem solving steps systematically, while many still relied on practical formulas. Research Munengsih et al. (2021), reported that during the pandemic, the majority of students were in the medium category, able to understand and plan but lacking in the final evaluation. In addition, Melsita & Yulia (2023) highlighted that motivation, accuracy, and communication skills have a significant influence on students' abilities, especially in solving contextual problems.

Student errors generally occur at the problem formulation and concept application stages. Research Sari & Lestari (2020) and Jaelani & Hidayati (2021), shows students often have difficulty writing mathematical symbols and performing arithmetic operations correctly, reflecting a lack of in-depth concept understanding. Research Suraji et al. (2018), added, students also have difficulty understanding problems and choosing solution strategies, so a more effective learning approach is needed.

Various factors affect students' problem-solving ability, including teaching methods, learning habits, and the use of technology in online learning. Research Purnamasari & Setiawan (2019), revealed that students with better initial abilities were more successful in developing strategies, but still had difficulty in evaluating results. Research Kurniawan et al. (2020), highlighted that online learning presents challenges such as lack of direct interaction with teachers and difficulty accessing materials.

Implementation of innovative learning models is needed as in research Haryati & Warmi (2021), shows that online learning affects students' ability to solve contextual problems, especially in SPLDV material. Research Fauzy & Nurfauziah (2021), stated that the limitations of technology and interaction during online learning are the main obstacles in mastering mathematical material. Overall, junior high school students' mathematical problem-solving ability still need improvement, especially in the planning and evaluation stages of the solution. Factors such as learning methods, motivation, and technology affect students' ability to solve problems. The implementation of a more contextualized and interactive learning approach is expected to help students develop better problem-solving ability, so that they are better prepared to face the challenges in PISA questions.

How do Indonesian students perform on the PISA test?

Indonesian students' performance in the PISA test is generally below the international average. Students often have difficulty in understanding and interpreting problems, especially those that relate mathematical concepts to real-life situations. Low reasoning ability and mathematical literacy are the main challenges, causing errors in problem-solving and application of concepts. In addition, students tend to be less thorough in evaluating and rechecking answers. Factors such as learning methods, motivation and access to learning resources influence these results. Efforts to improve problem-solving ability and mathematical literacy are essential to improve future PISA results.

What are the indicators of problem-solving ability?

George Polya's theory outlines four main steps in mathematical problem-solving applied to students. The first step is see (understanding the problem), by identifying what is known and what is asked in the problem. This is important to ensure that students have a clear understanding of the key elements of the problem at hand. The second stage is plan, which involves students in determining the right method or strategy to solve the problem. Students should be able to design a logical and systematic plan before implementing the solution. Next,

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the do stage (executing the plan) involves the careful application of the planned strategy, where students are expected to perform the necessary calculation steps or procedures carefully. Finally, the check stage includes evaluation and reflection on the results and the solution process, where students need to review the solutions obtained, ensure their accuracy, and correct any errors.

Based on the table, many studies show that common errors occur at the planning and rechecking stages. Research Rofi'ah et al. (2019) and Yuliani et al. (2019), revealed that students often lack thoroughness in evaluating the final result, which leads to errors in problem-solving. Overall, the indicators in Polya's theory help students to solve mathematical problems systematically and effectively, although improvement is still needed in some aspects, such as concept understanding and the habit of re-evaluating answers.

The theory based on Permendiknas No. 58 of 2014, and the adaptation theory from Pujiastuti (2014), includes four main indicators of problem-solving ability: understanding the problem by identifying relevant information, planning the solution by choosing the right strategy, solving the problem through systematic steps, and evaluating the results to ensure accuracy and reflection. Research Zulfah (2019), found that students experienced difficulties especially in the planning and evaluation stages in the 2015 PISA questions. This shows the need for more structured and contextualized learning to improve students' problem-solving ability according to Permendiknas standards, while supporting the development of critical and analytical thinking ability.

How does PISA relate to the problem-solving indicators of the first and second type of keywords?

George Polya's theory outlines four main steps in mathematical problem-solving namely see, plan, do, and check. These steps are in line with the need to understand contextual problems, plan strategies, execute solutions, and evaluate results systematically. The emphasis on problem understanding and strategy planning supports students in overcoming PISA questions that demand critical and analytical thinking ability.

Jupri and Drijvers emphasize understanding important elements of the problem and formulating mathematical models, which helps students identify important information, build models, solve problems accurately, and reflect on results. This is in line with PISA indicators that assess students' ability to connect problems with real situations and apply mathematical concepts in everyday life. Bransford and Stein through the IDEAL model outline systematic steps, from problem identification to evaluation of results, with an emphasis on strategy exploration and reflection on the solution process, in accordance with PISA indicators that measure understanding, formulation, and application of concepts to solve contextual problems.

John Dewey's theory emphasizes reflective stages in problem solving, such as formulating hypotheses and testing solutions, which are relevant to PISA questions that require critical thinking and evaluation of solutions in their original context. Meanwhile, Newman's Error Analysis (NEA) theory focuses on problem understanding, transformation to mathematical models, processing ability, answer writing, and checking. This theory helps identify errors at each stage of problem solving, in line with PISA's goal to evaluate students' ability to solve real problems with accuracy and reflection.

In conclusion, various problem-solving theories provide a systematic and structured framework, which is highly relevant to the indicators in PISA. Ability such as comprehension, planning, execution and evaluation contained in these theories help students develop the critical and analytical thinking skills needed to solve problem-solving problems effectively.

Conclusion

Based on the analysis, students' mathematical problem-solving ability, especially in PISA questions, is strongly influenced by their concept understanding, strategy planning, and the learning approach used. Students with high ability can go through all stages of problem solving according to Polya's theory, although they often lack accuracy at the evaluation stage. In contrast, middle and low ability students had difficulties especially at the comprehension and planning stages, which led to errors in strategy implementation.

The variation in ability based on PISA content suggests the need for more contextualized teaching approaches to address this challenge. Factors such as learning style and innovative learning methods, such as flipped classroom and Problem-Based Learning (PBL), play an important role in improving students' problem-solving ability. Error analysis also shows the need for learning that focuses more on developing conceptual understanding and the ability to transform problems into mathematical forms.

To improve students' mathematical problem-solving ability, teachers can implement contextual and innovative learning in the classroom. For example, teachers can integrate real problems in mathematics learning by using everyday problems that are relevant to students' lives. Problem-based projects can also be implemented, where students work in groups to solve complex problems, such as simple data analysis projects from data they collect themselves.

Innovative learning methods such as the flipped classroom are also effective, where students learn the material through videos at home and class time is used for in-depth discussions and problem solving. For example, students watch a video on the concept of linear equations at home and in class they work in groups to solve real problems that use the concept. The PBL method puts real problems at the center of learning with the teacher as a facilitator. For example, students are given the task of designing a garden with a certain budget that requires calculating the area and cost.

In addition, learning strategies such as group discussion and technology-based learning can be applied. Group discussions help students deepen their understanding and learn from each other, while technology tools such as interactive apps and math simulations help students understand concepts and solve problems. The use of props and mathematical modeling are also important for the development of conceptual understanding. By implementing these strategies, students' problem-solving skills are expected to improve significantly, especially in dealing with PISA questions and real-world challenges.

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