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EVALUATION OF TIMSS AND PISA TYPE MATHEMATICS LEARNING

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ABSTRACT

Assessment is the process of giving or determining value to a particular object based on certain criteria (Sudjana, 2006). According to Merrens and Lehmans in Purwanto (2006) assessment is a process of planning, obtaining and completing information that is very necessary to make alternative decisions. Winkel (2009:535) argues that assessment is the determination of the level of quality of student achievement based on certain norms, benchmarks, or criteria. The objectives of the study are 1) to describe the steps in implementing student ability tests in solving TIMSS and PISA type mathematics problems in junior high schools, 2) to describe the results of the analysis of students' ability to solve TIMSS and PISA type mathematics problems, 3) to describe the supporting and inhibiting factors for students in solving TIMSS and PISA type mathematics problems. This study took place at SMP Negeri 1 Sidomulyo. The data sources were students of class IXC. The research techniques used were observation, interviews, and tests. The results of the study 1) the steps for implementing the student's ability test to solve TIMSS and PISA type Mathematics problems in students of SMP Negeri 1 Sidomulyo can be known by the stages of preparation, data collection, analysis and students' ability to work on TIMSS and PISA type Mathematics problems and analyzing abilities into categories based on literacy and levels that have been made, 2) the results of the analysis of students' ability to solve PISA type Mathematics problems include groups of mathematical content mastery abilities, mathematical process mastery abilities and mathematical context mastery abilities to solve TIMSS and PISA type Mathematics problems, 3) supporting factors for readiness, student abilities, PMRI approach and the material taught. Inhibiting factors, question variations, test implementation and selected materials.

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1. INTRODUCTION

As the push to improve student learning continues, evaluations of all aspects related to educational quality are ongoing. This is to gather information on some of the best teaching methods currently in use. One evaluation method used is the assessment of student learning outcomes at both the national and international levels. Nationally, the government routinely assesses educational success through national reporting. Globally, Indonesia participates in comparative studies such as TIMSS and PISA. One such study is called the Program for International Student Assessment (PISA). PISA is a study conducted by several major international organizations affiliated with the Organization for Economic Cooperation and Development (OECD) and is based in Paris, France. PISA is conducted every three years by the Organization for Economic Cooperation and Development (OECD) (Wilkens, 2011). PISA is a student learning outcome monitoring system that covers three types of literacy: reading literacy, mathematics literacy, and science literacy. It is implemented in all 50 states.

Indonesia has participated in the PISA study from 2000 to 2009 and the last one was in 2012. The 2000 PISA study was attended by 41 countries and Indonesia was ranked 39th with a score of 367 for the study of mathematical literacy. In 2003, the PISA study was attended by 40 countries and Indonesia was ranked 38th with a score of 360 for mathematical literacy, which is only one rank higher than Tunisia. In 2006 the PISA study was attended by 57 participating countries and placed Indonesia in 50th position with a score of 391 for mathematical literacy, and Taiwan obtained the highest average score of 549, while Kyrgyzstan obtained the lowest average score of 311. In 2009 the PISA study was attended by 65 countries and Indonesia was ranked 60th. Meanwhile in 2003 the Trends International Mathematics and Science Study (TIMSS) Survey placed Indonesia in 34th position out of 45 countries. Although the average score rose to 411 compared to 403 in 1999, the increase was not statistically significant, and the score was still below the average for the ASEAN region. This performance was even relatively worse on PISA. Western countries generally performed better on PISA than on TIMSS, and Eastern European and Asian countries generally performed better on TIMSS than on PISA (Wu, 2011).

PISA data provides a wealth of valuable information, so it would be a shame if it wasn't analyzed in Indonesia. Through this research, students at SMP Negeri 1 Gemolong will be tested on PISA-type questions using the PMRI approach, and their ability to solve these questions will then be analyzed.

Assessment is the process of giving or determining value to a particular object based on certain criteria (Sudjana, 2006). According to Merrens and Lehmans in Purwanto (2006), assessment is a process of planning, obtaining, and completing information that is essential for making alternative decisions. Winkel (2009:535) argues that assessment is the determination of the level of quality of student achievement based on certain norms, benchmarks, or criteria. Muslich (2010:78) states that assessment is a systematic process of collecting information (numbers, verbal descriptions), analyzing, and interpreting information to provide feedback on work results. In relation to the opinion about the new educational paradigm, it can be concluded that in the teaching and learning process, students must always be activated in exploring their knowledge, education today must follow the developments of the times, in education there is a need for adjustments to the abilities that children have, and education should not only occur in the classroom.

The PISA study is a study conducted on 15-year-old children to measure how far children have been prepared to face the challenges of a modern, knowledge-based society at an international level. The focus of the assessment in this study is the field of reading literacy, mathematical literacy and scientific literacy. Thus, PISA will provide information on the profile of knowledge and abilities in mathematical, reading and scientific literacy for each student in each participating country. This information can be used as input in determining policies in an effort to improve the quality of education in each participating country. The International PISA Study has been conducted for five periods (OECD, 2000; OECD, 2003; OECD, 2006; OECD, 2009; OECD, 2012), namely: (1) PISA 2000, with the main focus on assessing reading literacy, where scientific and mathematical literacy are complementary. PISA 2000 was attended by 43 countries consisting of 28 OECD countries and 15 OECD countries, (2) PISA 2003, with the main focus on assessing mathematical literacy, where science and reading literacy as companions. PISA 2003 was attended by 41 countries consisting of 30 OECD countries and 11 non-OECD countries, (3) PISA 2006, with the main focus on assessing scientific literacy, where reading and mathematics literacy as companions. PISA 2006 was attended by 57 countries consisting of 30 OECD countries and 27 non-OECD countries, (4) PISA 2009, with the main focus on assessing reading literacy, where science and mathematics literacy as companions. PISA 2009 was attended by 65 countries consisting of 34 OECD countries and 31 non-OECD countries, (5) PISA 2012, with the main focus on assessing mathematical literacy, where reading and science literacy as companions. PISA 2012 was attended by 67 countries consisting of 33 OECD countries and 34 non-OECD countries.

Table 1. PISA Report Survey Results

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	385
2018	73	79	379

Indonesia's performance in international assessments remains concerning. This is evident from the results of the TIMSS *(Trends in International Mathematics and Science Study)* , which aimed to determine the unsatisfactory development of fourth and eighth grade students in mathematics and science. Table 1 shows the mathematics achievement of eighth grade Indonesian students based on their participation in the TIMSS study.

Table 2. Achievement of Indonesian Grade VIII Students in TIMSS 1999-2011

Year	Indonesia's ranking	Number of Participating Countries	Participant Score	Average International Score
1999	34	38	403	487
2023	35	46	411	467
2007	36	49	397	500
2011	38	42	386	500

The results of the international scale test provide an overview of the problems in mathematics learning, which causes Indonesian students to be unable to compete with students from other countries. Indonesian students' mathematical abilities are at the cognitive knowing level, which is the lowest level according to the criteria of Mullis et al. Indonesian students have not been able to apply their basic knowledge to solve problems *(applying),* and have not been able to understand and apply knowledge in complex problems, draw conclusions and compile generalizations *(reasoning).* This paper will discuss the objectives of TIMSS, TIMSS domains, levels of mathematical ability in TIMSS and examples of TIMSS questions so that educational observers, especially mathematics teachers, can understand the targets of this international assessment.

1.1 Objectives of TIMSS and PISA

The purpose of TIMSS is to measure the mathematics and science achievement of fourth and eighth grade students in participating countries. For Indonesia, the potential benefits include understanding the position of Indonesian students' achievement compared to that of students in other countries and the factors influencing it. Therefore, the results of this study are expected to inform policy formulation to improve education quality.

The general objective of PISA is to assess the extent to which 15-year-old students in OECD countries (and other countries) have acquired the appropriate skills in reading, mathematics, and science to make a significant contribution to their society (Wilkens, 2011). Through the analysis of students' abilities in solving PISA-type mathematics problems, it is hoped that students will be trained and accustomed to working on PISA-type mathematics problems using the PMRI approach.

1.2 TIMSS and PISA Domains for Mathematics

The basis for assessing mathematics and science achievement in TIMSS is categorized into two domains: content and cognitive, taking into account the applicable curriculum in each country. The distribution of these specifications and assessments is as follows:

1. Content *domain*

The TIMSS 2015 *Assessment Framework* states that the content dimension consists of four domains: number, algebra, geometry, data, and probability. Each content domain is further detailed into several topics, for example, the number content domain includes topics on whole numbers, fractions and decimals, whole numbers, ratios, proportions, and percentages. Table 2 shows the proportion of abilities tested in each domain assessed in the content dimension.

Table 3. Proportion of Abilities Tested on the Content Dimension in the 2015 TIMSS Study

Domain	Proportion	Topic
Number	30%	Whole numbers
		Fractions, decimals and whole numbers
		Ratio, Proportion and Percentage
Algebra	30%	Algebraic expressions and their operations
		Equations and inequalities
		Relations and functions
Geometry	20%	Geometric shapes
		Measurement
		Location and Movement
Data and Opportunities	20%	Data characteristics
		Interpreting data
		Opportunity

In the 2012 PISA assessment draft, the observed mathematical content was divided into four parts.

Table 4. Abilities Tested on the Content Dimension in the 2012 PISA Study

Domain	Topic
Space and Shape *(space and shape)*	Geometry
Change and Relationship *(change and relationship)*	Algebra
Number *(quantity)*	Number relationships
	Number patterns
Probability and *Uncertainty*	Statistics
	Probability

2. Cognitive *domain* in TIMSS

The cognitive dimension consists of three domains: knowing, applying, and *reasoning.* The cognitive dimension is defined as the behavior expected of students when they encounter the mathematical domains covered by the content dimension. Table 2 shows the proportion of abilities tested in the cognitive dimension in the TIMSS 2015 study.

Table 5. Proportion of Abilities Tested on the Cognitive Dimension in the TIMSS 2015 Study

Domain	Proportion	Topic
Knowing	35%	*Recall* means understanding the definitions, properties, terminology, and notations in mathematics (example:$a \times b = ab, a + a + a = 3a$)
		Recognize numbers, expressions, quantities, and shapes and recognize mathematical entities.
		Classify /order classifies objects, shapes, numbers, based on certain properties.
		Compute performs algorithmic procedures, +, -, x, :, on integers, fractions, and decimals and performs simple algebraic procedures.
		Retrieve takes information from graphs, tables, or other simple sources.
		Measure, namely using measuring instruments and selecting appropriate units of measurement.
Applying	40%	*Determine* the selection of appropriate operations, methods and strategies in solving problems where the procedures, methods or algorithms for solving the problem are already known.
		Represent /model presents mathematical information or data in the form of tables or graphs, creates equations, inequalities, uses mathematical models to solve routine problems, produces equivalent representations for given or related mathematical entities.
		Implementation is applying strategies and operations to solve problems involving mathematical concepts and procedures.
Reasoning	25%	*Analyze* describe or use relationships between numbers, algebraic expressions, quantities and shapes.
		Integrate/synthesize makes connections between knowledge elements, related representations and procedures for solving problems.
		Evaluate evaluate alternative problem-solving strategies and solutions.
		Draw conclusions making valid conclusions based on information and evidence.
		Generalize makes statements that represent more general relationships and broader terms that apply.
		Justify provides mathematical arguments to support a strategy or solution.

The questions are designed in such a way that both assessment dimensions, namely content and cognitive, can be observed. The form of questions in TIMSS is multiple choice with 4 answer options, short answer and essay. Short answer and essay are often called *"constructed response".* For multiple choice and short answer questions, if correct is given a score of 1 and if incorrect is given a score of 0. For essay questions, a score of 2 will be given for a complete and correct answer, a score of 1 for a correct but incomplete answer and a score of 0 for an incorrect answer or no answer.

3. The Context of Mathematics in PISA

In PISA, the mathematical context is divided into four situations.

Table 6. Mathematical Contexts Tested in PISA

Domain	Topic
Personal context	It directly relates to students' daily personal activities. In their daily lives, students inevitably encounter various personal problems that require immediate resolution. Mathematics is expected to play a role in interpreting and then solving these problems.
Educational and work context	Relating to students' lives at school and/or in the workplace, students' knowledge of mathematical concepts is expected to help them formulate, classify, and solve general educational and work-related problems.
General context	Relating to the use of mathematical knowledge in social life and the wider environment in everyday life, students can contribute their understanding of mathematical knowledge and concepts to evaluate various relevant situations in social life.
Scientific context	Specifically related to scientific activities which are more abstract and require understanding and mastery. theory in solving mathematical problems.

1.3. Student Ability Levels in TIMSS and PISA

Students' mathematical abilities in TIMSS, according to international benchmarks, are divided into four categories: very high *(advanced),* high *(high),* intermediate *(medium)* , and low *(low).* The reference explains the mathematical competencies achieved by students according to international benchmarks.

Table 7. Mathematics Ability Levels in TIMSS

International benchmark	Mathematical competence
Advance (≥ 625)	Students can reason, draw conclusions, make generalizations, and solve linear equations. Students can solve various fraction, proportion, and percentage problems and justify their conclusions. Students can express algebraic generalizations and model situations. They can solve a variety of problems involving equations, formulas, and functions. Students can reason using geometric figures to solve problems. Students can reason using data from multiple sources or unusual representations to solve problems with multiple steps.
High $(550 \leq x < 625)$	Students can apply their understanding and knowledge in relatively complex situations. They can use information from multiple sources to solve problems involving various types of numbers and operations. They can convert fractions to decimals and percentages, and vice versa. Students at this level demonstrate basic procedural knowledge related to algebraic expressions. They can use relationships between lines, angles, plane and solid shapes to solve problems. They can analyze data from given graphs.
Intermediate $(400 \leq x < 475)$	Students can apply basic mathematical knowledge in a variety of situations. They can solve problems involving decimals, fractions, proportions, and percentages. They understand simple algebraic relationships. They can relate two-dimensional images to three-dimensional objects. They can read, interpret, and create graphs and tables.
Low $(x \leq 400)$	Students have knowledge of whole numbers and decimals, basic arithmetic and graphing operations.

The following are the PISA test assessment criteria according to (Khoirudin et al., 2017) as shown in the table.

Table 8. PISA Test Assessment Criteria

Value Interval	Criteria
≥ 71	Tall
$41 - 70$	Currently
≤ 40	Low

PISA provides an overview of the extent to which students can apply mathematical concepts and understanding in real-life situations. The level of PISA mathematical ability is an important indicator in evaluating the effectiveness of a country's education system. Countries that successfully achieve high levels of PISA mathematical ability demonstrate that their education systems are capable of providing quality mathematics education to students, defining mathematical literacy as the formulation, use, and interpretation of mathematics in various contexts (Dinni, 2018). The following PISA mathematical ability levels are shown in the table.

Table 9. PISA Mathematics Ability Levels

Level	Description
6	Students use their reasoning to explain mathematical problems, can make generalizations, formulate and communicate their findings.
5	Students can work with models for complex situations and can solve complex problems.
4	Students can work effectively with models and can select and integrate different representations, then relate them to the real world.
3	Students can carry out procedures well in solving problems and can choose problem-solving strategies.
2	Students can interpret problems and solve them using formulas.
1	Students can use their knowledge to solve routine problems, and can solve problems that have a general context.

Based on previous research conducted by (Syaifurohman et al., 2022), the results of the research discussed the levels in PISA.

Table 10. Ability Levels in PISA

Level	Presentation
1	73%
2	35,3%
3	67,6%
4, 5 and 6	- (students have difficulty getting answers)

2. RESEARCH METHODS

According to Sugiyono (2007:224) data collection techniques are the most strategic step in research, because the main objective of research is to obtain data in this research, the data collection techniques that researchers will use are observation, testing and interview methods.

1. Observation Method

According to Marshall (in Sugiyono, 2007:226), observation is the process of studying and uncovering insights from the behavior of the person being studied. In this study, the researcher used active participant observation. This type of observation is more appropriate for research. The researcher visits the research site and participates in what the informant or data source does.

2. Test Method

This method is used to determine the profile of students' abilities in solving TIMSS and PISA type mathematics problems. The expected data is in the form of student work results on answer sheets accompanied by the steps. The data obtained from this test is used as analysis material regarding students' abilities in solving TIMSS and PISA type problems. The steps taken by the researcher in collecting this data are: (1) preparing test questions, (2) distributing test questions to students, (3) supervising students in working on questions, (4) collecting test results, (5) checking and evaluating test results, (6) analyzing test results.

3. Interview Method

Iskandar (2009: 70) stated that "Interviews are questions and answers between researchers and relevant people to serve as data sources." One technique that can be used to check the validity of data is triangulation. According to Sugiyono (2010: 241), triangulation is defined as a data collection technique that combines various existing data collection techniques. When researchers conduct triangulation collection, they are actually collecting data while simultaneously testing the credibility of the data, namely checking the credibility of the data using various data collection techniques and various data sources.

In this study, qualitative descriptive data analysis techniques were used with the following stages:

1. Data Reduction

Data reduction is a form of analysis that sharpens, classifies, directs, removes unnecessary data and organizes data in such a way that final conclusions can be drawn and verified.

2. Data Presentation

After data reduction, the next step is data presentation. Data presentation is a collection of organized information that allows for drawing conclusions and taking action.

3. Conclusion

Drawing conclusions is a further analysis of data reduction and data display. Conclusions are the process of extracting the essence and presenting the organized data in the form of short, concise sentences and/or formulas that convey broad meaning.

3. RESULTS AND DISCUSSION

This research is supported by topical instruments and interviews to assess students' proficiency in Solving PISA-Type Mathematics, which includes data collection, analysis, and interpretation.

The following lesson is about the implementation of student performance analysis in mathematics using PISA and PMRI at SMP Negeri 1 Sidomulyo. In this case, student performance is measured based on individual performance in accordance with the latest mathematics literature in TIMSS and PISA learning. The TIMSS and PISA student ability groups work on Mathematics problems described as in the TIMSS and PISA assessment domains including learning materials, learning knowledge and skills, and problem-solving abilities from knowledge that can be used to solve problems that exist in everyday life or reality.

The model of students' ability to solve PISA-type Mathematics problems in SMP Negeri 1 Gemolong students can be identified using the following stages:

1. Preparations were made in relation to students' activities working on TIMSS and PISA type Mathematics questions by the Mathematics teacher of class IXC SMPN 1 Sidomulyo, including reviewing PISA type questions and selecting and creating PISA type questions.
2. Data collection in this study was carried out by conducting tests to determine students' ability to work on TIMSS and PISA-type Mathematics tests at SMP Negeri 1 Sidomulyo. Data collection was carried out using PISA-type test instruments four times.
3. Data analysis of students' ability to work on TIMSS and PISA-type mathematics problems, and the analysis of these abilities into categories based on literacy and established levels, was conducted starting with scoring and analyzing student answers.

The results of the analysis of students' abilities in the subjects of Content, Process, and Context in presenting mathematical topics using TIMSS and PISA consist of the following groups:

1. Students must be able to use mathematical concepts in solving problems based on TIMSS and PISA. Furthermore, PISA-style mathematics instruction facilitates students' understanding of mathematical concepts, even though subject matter such as shape and size, change and relationships, and calculations in PISA-style mathematics instruction is difficult for them to grasp. Nevertheless, with the help of this lesson plan, students are able to understand the material. Students' ability to correctly classify mathematical concepts is good because the questions are written in clear and simple terms, making them easier for them to understand.
2. After students complete the TIMSS and PISA subjects, their mathematical reasoning skills in explaining the subject matter improve. It can be said that these TIMSS and PISA topics can improve students' mathematical reasoning skills in solving problems and utilizing appropriate formulas, particularly in the areas of problem solving, reasoning and argumentation, and the use of mathematical tools.
3. Students' mastery of mathematical contexts is categorized as good, meaning that diverse mathematical mastery skills facilitate students in finding the right methods and answers when working on TIMSS

and PISA-type math problems. It can be stated that students are able to understand mathematical contexts, especially in the general and specific categories.

3.1. Supporting Factors

Supporting factors for the analysis of students' ability to solve TIMSS and PISA type Mathematics problems are:

1. Students' readiness to carry out tests to determine their ability to solve TIMSS and PISA type Mathematics problems.
2. TIMSS and PISA type Mathematics questions with PMRI approach, this will facilitate the selection and creation of questions according to the material.
3. The selected material has been taught previously.

3.2. Inhibiting Factors

The following factors inhibit students' ability to solve TIMSS and PISA type Mathematics problems for students at SMP Negeri 1 Sidomulyo:

1. The large variety of questions makes students think too hard, making it difficult for students to understand completely.
2. Carrying out the test 4 times in a row and close together makes students tired and bored.
3. The material chosen is difficult material.

The implications of this study are regarding students' ability to solve PISA-type mathematics problems, which include components of mathematical content mastery, mathematical process mastery, and mathematical context mastery, which can be achieved if PISA-type mathematics problems are frequently taught and administered in mathematics lessons. After drawing conclusions, suggestions will be provided that can be used to develop further research and also serve as input for teachers in developing PISA-type problems in schools. The suggestions are:

1. PISA-type questions can be applied in schools to improve students' mathematical abilities, not only limited to the time of this research.
2. Students can study PISA-type mathematics questions in more depth so that they can become material for participating in PISA literacy.
3. Students are accustomed to working on PISA-type mathematics problems using the PMRI approach in learning created by subject teachers or searching for problems on the internet.
4. Research on PISA should address all categories in PISA content, process and context.
5. Research assessment can be included in some report card assessments so that students are serious about doing research tests.
6. In research, it is necessary to consider the right time to conduct the research, because activity factors at school can influence the research results.

4. CONCLUSION

To assess junior high school students, the content in the TIMSS domain is aligned with the junior high school mathematics curriculum standards, which include geometry, data, probability, and algebra. The cognitive dimension is seen as the behavior expected of students when interacting with the highly varied mathematical domain. The three cognitive dimensions in TIMSS are knowing , applying , and reasoning . The mathematical problems in TIMSS learning reduce students' ability to understand facts, theories, or procedures to the point where they can be used to solve complex problems that require higher penalty levels. The mathematical topics in TIMSS are similar to those taught in schools or according to the curriculum, but they also cover the conceptual and cognitive domains in a consistent manner across all levels. The PISA mathematics proficiency level plays a crucial role in evaluating the effectiveness of a country's education system. The government takes PISA results seriously and makes efforts to improve the quality of education through curriculum revisions. The PISA test also provides an overview of students' ability to apply mathematical concepts in real-life situations. The PISA mathematics ability level is divided into six levels, where the highest level is level 6 and the lowest level is level 1. In this study, students were mainly at levels 1 and 2, with a percentage of students who were able to apply mathematical procedures in solving problems. The PISA test not only tests the correct answer, but also involves students' thinking processes and their ability to explain and justify the solutions.

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