ANALYSIS OF MATHEMATICAL PROBLEM SOLVING SKILLS BASED ON *TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY* (TIMSS)

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Abstract: The purpose of this research is to determine the level of problem-solving ability and a mistake in doing mathematical problem solving test based on Trends in International Mathematics and Science Study (TIMSS) on Integrated Islamic Junior High School (SMPIT) in Bandung. The method used in this study was a survey with a qualitative-quantitative descriptive approach. The population was the 2nd grade students from three schools of SMPIT which represents the category of top, middle and bottom. The data collection technique using is test, interview and documentation. The results showed that (1) Based on the TIMSS assessment categories as much as 64% of students are still in the low category, moderate 9%, 9% higher and 26% is very high. (2) Mistaken done by the student because (a) a lack of understanding of the mathematical problem in understanding the problem and troubleshooting steps, (b) students are not accurate in the calculation, (c) problem solving strategy is less precise, and (d) student does not check re-count results.We conclude that the level of problem solving ability of students SMPIT in Bandung is still low.

Keywords: mathematical problem solving, Trends in International Mathematics and Science Study,TIMSS, Integrated Islamic Junior High School, mistake in doing mathematical problem solving,

1. Introduction

Problem solving is one of the mathematical abilities that must be possessed by students in learning mathematics. This as stated in Ministry of National Education (Permendiknas) Regulation No. 22 of 2006, which said that one of the objectives of learning mathematics in education is to solve problems which include the ability to understand problems, design and solve mathematical approaches, and interpret obtainedsolutions. Aside from being a goal forlearning mathematics, Hartono (2014, p. 3) said that through problem solving, students will gain experience in using their knowledge and skills to solve problems.

The importance of mathematicalproblem solving ability for students is also confirmed by Branca (Mansyur, 2014, p. 25) as: (1) a general goal of teaching mathematics, (2) Problem solving which includes methods, procedures and strategies is the core process and main in mathematics curriculum, (3) a basic ability in learning mathematics. However, the facts shown that students' mathematical problem solving abilities in Indonesia are still low. Fatmawati (2011) revealed the study results of seventh grader students' ability of Secang Middle School in solving quadrilateral material mathematics problems usingPolya's steps. The results of the study showed that in the initial test, students percentage who could achieve the steps to understand the problem, design mathematical approaches, and solve the approaches,respectively is 47.7%, 29%, and 16.7% of the total students. This shows that the ability of students to solve mathematical problems is still low, especially in terms of designing a mathematical approach and solving it.

Hasanah (2015) explained that the results of *Trends in Student Achievement in Mathematics and Science* (TIMSS) in 200 showed that the mathematical understanding ability in eighth grade students in Indonesia was ranked 38th out of 42 countries with an average score of 386 while the average score obtained in TIMSS 2007 were 405, decreased compared to 2003, which was 411. Indonesia's ranking in TIMSS in 2007 was ranked 36th out of 49 countries. In 2011, Indonesia was ranked 38th out of 42 countries with an average score of 386.

One of the possible causes of this problem is the strategy used for teaching mathematicsatschools mostly by continously giving questions which can be solved by using a template formula and algorithms given in the example preblem. Consequently students will find it difficult to solve other type of problems, especially those which requires problem solving. Students are not accustomed on making solution plans because they are unable toconnect the problems encountered with the mathematical concepts that have been learned, because during learning students are accustomed to applying the formulas directly taught as given in the sample problems (Sari, 2014, p. 54),even though 7th and 8th grader are expected to improve their ability to work on unfamiliar type of questions including TIMSS and preparing for the National Examination, which is required for their graduation. In addition, Indonesian students needs to be accustomed on solving TIMSS questions as a benchmark of their problem solving ability with other students onan international scale.

Nowadays, more and more schools are implementing a more comprehensive education system through a school system with additional curriculum and religion-based schools which called Integrated Islamic Schools (SIT). The Integrated Islamic School is essentially a school that adapt religious values in every educational process in it. However, based on the National Exam results in Bandungat 2014, the average mathematics National Exam result from 42 Integrated Islamic Schools (SMPIT) registered in Bandung City Education Office is 4.90. This result is still far from the standard for junior high school students as proposed on Bandung Education Office's work agreement, which is 8.70 (LKIP, 2014, p. 33). In addition, the score is also lower compared to National Exam average score in Bandung, which is 5.15.

This study aims to determine the level of mathematical problem solving ability based on TIMSS subjected on8th graderjunior highschool students in Bandung City, and to analyze errors made by them in working on TIMSS questions.

2. Literature Review

Herlambang (2006, p. 17) explains that "problem solving is an attempt to find a solution of a situation as to achieve the desired goal". According to Polya (Suherman, 2003: 91),solving a problemrequires four steps of completion: (1) Understanding the problem, this step is very important to be carried out as the initial stage of problem solving so that students can easily find solutions to the proposed problem. Students are expected to be able to understand the condition of the problem which includes: recognizing the problem, analyzing the problem, and extracting all information provided on the problem. (2) Planning the solving steps. It is important for students to make a connections between what is known and unknown from the problem and planning the steps to get unknown data from all information they gathered. (3) Resolving the problem according to plan, this calculation step is important because in this step students' understanding of the problem can be seen. At this stage students are ready to do calculations with all the necessary concepts and appropriate formulas. (4) Double check and validating every solving steps, at this stage students are expected to check carefully every stage he has done. Thus, any errors in solving problems can be found. The problem solving indicator used in this study is an indicator revealed by Polya.

TIMSS is an international study that aims to evaluate development of mathematical and science knowledge on 9 years old students in elementary school (SD) and 14 years old students in junior high school (SMP). This study was conducted in 50 countries by the International Association for the Evaluation of Educational Achievement (IEA) which is centered on the Lynch School of Education, Boston College, USA.

TIMSSheld every 4 years. It was first held in 1995, then it continued succesfully in 1999, 2003, 2007 and 2011. In each year the form or composition of the TIMSS question almost has the same model. In 2011 Indonesia got the lowest average TIMMS score on algebraic content which was 22% correct answer. In the cognitive dimension, the type of reasoning problem (solving non-routine problems) has the lowest average score of 17%. This shows that it is necessary to test students' mathematical abilities, especially problem solving abilities.

The concept of integrated education according to Syarifudin (2007) consists of the integration of parents and teachers in guiding students, integration in curriculum, and integration in the concept of implementing education. The results of research on Islamic-based curriculum management at the Integrated Islamic Junior High School (SMPIT) Miftahul Jannah Bandar Lampung (Novariza, 2015, p. 7) revealed additional context in the curriculum applied therewhich is the national curriculum and Islamic-based curriculum.

3. Method

This research is using a quantitative-qualitative descriptive research methods with the aim of expressing students' mathematical problem solving abilities in working on TIMSS-based questions. The research method used in this research is a cross-sectional survey. This descriptive research only attempts to clearly and sequentially describe the research objectives that have been determined before the researchers. Research is conducted in the even semester of 2015/2016 school year. The population of this researches was SMPIT in Bandung City which was officially registered with the Bandung City Education Office. Table 1 show that study sample was eighth graders from three SMPIT who represented each of the categories below:

TABLE1.Islamic Junior High School Categories based on National Exam Final Score

Categories	Score range
Upper	7.12 – 8.83
Middle	5.40 – 7.11
Lower	3.68 – 5.39

Before analyzed, a different code is implemented in each school category. The upper category schools were coded "SMP A", the middle category school was given the code "SMP B", and the lower category school was given the code "SMP C". While the sample size used in one school in this study was determined using a sampling technique from Taro Yamane (Riduwan, 2010. pp. 65) as follows:

$$n = \frac{N}{Nd^2 + 1}$$

with n = number of samples
N = number of population
d^2= determined precision number

Based on the formula above, table 2 show the number of samples used in this research is 74 students with the details as follows:

TABLE2.Number of participants in Problem Solving Ability Test

No	Category	Number of Students
1	SMP A	50
2	SMP B	14
3	SMP C	10

Source: Researcher

The instruments that will be used in this study are test instruments and non-test instruments. 15 questionsof test instruments is given as a sample question for TIMSS in the form of multiple choice and essay. Furthermore, the questions are translated into Indonesian using terms known by students. The questions used are made by TIMSS, so it can be said that the test instrument has logical and empirical validity. Researchers also conducted an initial validity test to check the readability of the questions, the suitability of the questions with the curriculum, and the suitability of the questions with the subjects. The initial validity test was carried out by professors of learning methods, mathematicians, mathematics teachers, and supervising professor. As for non-test instruments used in this study are interviews and documentation.

Data analysis are divided into two stages: (1) analysis of test result on the TIMSS-modeled questions. Each students test result will be scored using the formula as follows:

$$Score = \left(\frac{Obtained\ Score}{Maximum\ Score} \times 700\right) + 100$$

(Witri, 2014, p. 35)

These scores were analyzed descriptively, quantitatively, and qualitatively. The grouped with the following categoriesare presented in table 3:

TABLE3.Category of Students Ability based on TIMSS 2011 score

Range of Score	Category
625 – 800	Advance
550 – 624	High
475 – 549	Intermediate
100– 474	Low

Source: TIMSS 2011

(2) The qualitative data used is in the form of test results, interviews, and documentation to analyze errors made by students during the test. Those data will be concluded as an additional information for this research.

4. Results And Discussion

This research begins with the test using TIMSS-modeled questions. A total of 15 questions were chosen afterit was tested for their validity and reliability internationally (TIMSS, 2011). The questions are translated into Indonesian using terms that can be understood bt students. The researcher conduct initial validity test to check the translated question and its suitability with the subjects and curriculum. From the test results, the data obtained from TIMSS-based mathematical problem solving skills are presented in table 4 form, as follows:

TABLE 4. The Percentage of Students Category based on their Mathemathicsproblem Solving Ability

Range of score	Category	SMP A	SMP B	SMP C
625 – 800	*advance*	26%	0%	0%
550 – 624	High	10%	14%	0%
475 – 549	*Intermediate*	14%	0%	0%
100 – 474	*Low*	50%	86%	100%
Total		100%	100%	100%

Source: Researchers data

Based on Table 3, it can be seen that the average mathematical problem solving ability of SMPIT students in Bandung is still low.47 students or 64% from total participants have their scores ranging from 100 to 474.The only SMPIT that able to reach category Advance is only SMP A. Only 2 students from SMP B is able to reach high category while the other 12 students get low category.On the other hand, none of SMP C students is able to reach intermediate category or above. The highest student score is 800 with all the answers correct and the lowest score of the student is 100 with all the answers wrong. The results of the percentage category level of students' mathematical problem solving abilities are presented in Figure 1:

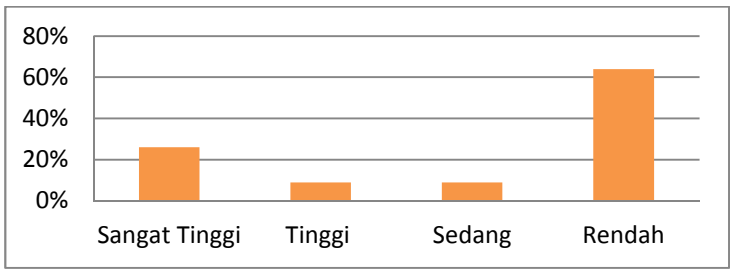

Fig 1. Percentage of Students Ability on solving Mathematical Problems

To identify and describe comprehensively students error on solving problems, any incorrect (either the result or the solution steps) orincomplete answers found are analyzed. Based on the results of the tests, students error is categorized into 4 error category, which is errors in understanding the problem (first stage), error in planning problem solving steps (second stage), errors in implementing the problem solving plan (third stage), and error in double check the answer (fourth stage). The percentage of errors made by students will be presented in table 4, as follows:

TABLE 5.Percentage of Students' Error in each Questions

Question No.	First Stage	Second Stage	Third Stage	Fourth Stage
1	85%	94%	62%	89%
2	71%	82%	66%	80%
3	78%	79%	61%	96%
4	80%	83%	64%	100%
5	96%	97%	78%	95%
6	94%	96%	87%	98%
7	98%	100%	90%	100%
8	86%	98%	66%	100%
9	92%	88%	62%	100%
10	71%	71%	66%	100%
11	86%	89%	72%	92%
12	79%	86%	72%	92%
13	86%	67%	70%	98%
14	91%	90%	64%	92%
15	93%	92%	57%	97%
Average	85,7%	87,5%	69,1%	95,3%

Source: Research Data

The first stage of errors made by students can be seen from the number of students who did not rewrite the things that were known or asked in the problem, or the students who incorrectly interpret data or pictures in the problem, or the students who did not use all of the information given in the questions. An example of error in understanding the problem on question number one is shown in Picture 2.

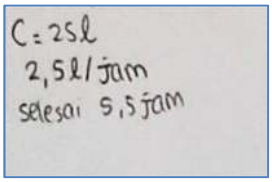

Fig 2. Students' Error on Question Number One

In the Picture 2, the student didn't completely write every information given on the problem. The student is missing the main question as an information on the problem. This happened because students understand the problem but theyare unable togather every information providednor they are able to determine the steps in solving the given problem.

The second stage of errors can be seen from the number of students who understand the problem but do not know the next steps to solve it, or the students who use incorrect analogy for the problem, or the students who use incorrect formula to solve the problem. An example of error in planning the solution steps on question number ten is shown in Picture 3.

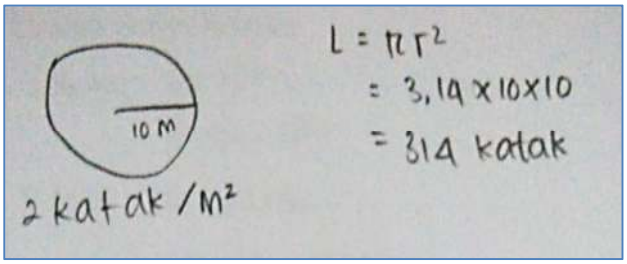

Fig 3. Students' Error on Question Number Ten

Picture 3 shows the unfinished solution plan.The student is supposed to find a number of frogs in the pond, but in the picture the solution steps is stopped at calculate the circle area.

The third stage of error can be seen from the number of students who are not careful in doing calculation, or the students who use the algebraic operation incorrectly, or students who answer correctly but do not write down the completion steps. An example of error in carry out the solution steps on question number one is shown in Picture 4.

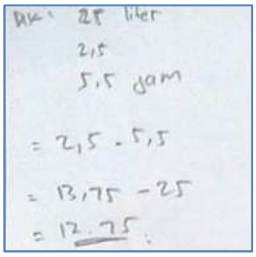

Fig 4. Student's Error on Question number One

This stage of erroris due to students' inaccuracy in calculating. In general, students have been able to make a correct completion plan, but are less thorough in carrying out problemsolving stages. In the Picture 4 the student calculate incorrectly which should be 25 - 13.75 = 11.25 to be 13.75-25 = 12.75. Students are careless in writing a mathematical operation and inaccurate in doing calculations.

The biggest mistake is at the re-checking stage, this can be seen that there are very few students who re-check their answer sheet. This happened because some students are not able to use the information on the problem to solve the questions and the experience of the students in the previous learning is very little so that students are not used to solving international-based questions such as

TIMSS-based. The interview results show that students are not used to checking the results of their answers. An example of error in re-checking the solution steps on question number two is shown in Picture 5.

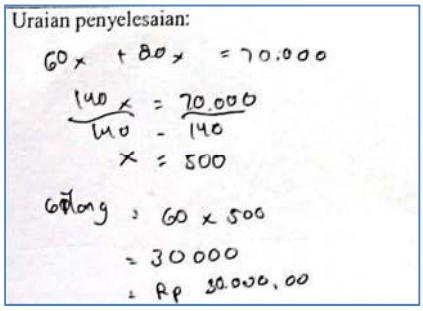

Fig 5. Student's Error on Question Number Two

Based on the results of the analysis and interviews, students 'mistakes in this section were due to students' inaccuracy in calculating. The students did not re-examine the completion steps. In the picture 5 the student is supposed to find the profit of magazine sold by Gilang (person A in ratio problem) but then the student make a mistake by calculating the profit of other person instead.

5. Conclusions

Based on the results of the research and discussion that has been obtained, the following conclusions can be drawn:

1. The level of mathematical problem-solving ability based on TIMSS questions of SMPIT students in the city of Bandung is still low. Based on the TIMSS assessment category, most of the students are still in the low category by 64% respondents, 9% students in the medium category, 9% students in the high category, and 26% other in the very high category.
2. Types of errors made by students in working on mathematical problem solving abilities test caused by (1) lack of understanding of mathematical problems, both in terms of understanding the problem and determining the steps of problem solving, (2) the lack of thoroughness in doing calculation, (3) students use strategies that are incorrect for solving problems, and (4) students do not re-examine the results of calculations.

Based on the results of the research and discussion that has been obtained from this study, suggestions that can be submitted include:

1. Students are expected to be able to work more on non-routine math problems, which is more complex and relate to everyday life, to minimize student errors when working on problem solving.
2. Mathematics teachers give more varied math questions or tests with various kinds of solutions, so that students become more creative and honed in their mathematical problem-solving abilities. The questions should be a matter of application related to daily life
3. For further research, it is expected that the questions will be more representative and adapted to all components in the TIMSS assessment, so that the data obtained is more accurate and can be processed properly.

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