



ANALYSIS OF STUDENTS' DECISION MAKING TO SOLVE SCIENCE REASONING TEST OF TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS)

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ABSTRACT

This study aims to determine students' decision making strategy to answer TIMSS science reasoning test in cognitive reasoning domain. This research is quantitative descriptive research. The result shows that students tend to use compensatory strategy for decision making in solving multiple-choice questions and use rational category to answer essay questions. The result shows that more than half of students have been able to answer the questions TIMSS science tests correctly.

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INTRODUCTION

Trends in International Mathematics and Science Study (TIMSS) is an international study of mathematics and science achievement of primary school and junior high students. The study was coordinated by the IEA (The International Association for the Evaluation of Education Achievement) (Mullis and Martin, 2013). Study held every four years is intended to measure students' achievement in mathematics and science grade IV and VIII in the participating countries. Basic math and science achievement assessment in TIMSS was categorized into two domains of content and cognitive.

TIMSS cognitive domain is divided into three domains that describe the thinking process that is expected to be used by students when they meet science test developed by TIMSS (Mullis and Martin, 2013). TIMSS cognitive domain consists of knowledge (knowing), application (applying), and reasoning (reasoning). First, the

domain knowledge (knowing), demonstrates the ability of students in remembering, finding out, and explaining the facts, concepts, and procedures that are basic needs in science. Second, the application domain (applying), focuses on the use of knowledge to explain and resolve practical problems. Third, domain reasoning (reasoning), includes using evidence and understanding science to analyze, synthesize, and generalize, that often happens in uncommon situation and complex context (Mullis and Martin, 2013). Thus, the problems given to students are high-level tasks. Stein, Grover, Henningsen (1996) mention that high level tasks often less structured, more complex, and longer than tasks to which students are typically exposed.

TIMSS content domain for eighth grade is divided into four contents of biology, chemistry, physics, and earth science. Each content domain consists of one or more major topic, and each topic is divided into several topics. Each topic is described with specific subjects that represent the material, and students should be able to master every topic (Mullis and Martin, 2013).

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Indonesia is one of TIMSS participants. During the years of participation, Indonesia is always rated under international standard. Based on IEA publications related to TIMSS result in 2011, it is known that Indonesia was ranked 40 of 45 participant countries with an average of 406. According Rustaman (2009), the low achievement of TIMSS is due to the average ability of Indonesian student remaining in the ability of knowing and Indonesian students do not get used to solve the applicative and reasoning problems. Indonesian students' difficulties in dealing with such problems are caused of their reading strategies are still very limited, it results the level of reasoning is low, linear, and incomprehensive. Rustaman (2009) expressed the needs to emphasize on implementation curriculum oriented to expected competencies. Learning is directed to encourage students to find out various sources of observation, to formulate the problem (ask) and not only solve the problem. Besides, learning is aimed to train students to think analytically (decision-making), cooperate and collaboration in solving problems.

Decision-making is a part of human life that affects life, both individually and socially, depending on the position of decision maker (Polic, 2009). According Bavolar (2013), decision making can be associated to reasoning tasks performed by a person in learning process. Lamond and Thompson (2000) explain that the inappropriate decision making can cause poor accuracy of problem solving result.

According to Wang and Ruhe (2007), there are four categories of decisions making, they are based on intuition, empirical, heuristic, and rational. First, decision making based on intuition is emphasizing on the use of feelings in determining right and wrong (Scott and Bruce, 1985). In the process, even though the time used to take a decision relatively short, but the decision result taken is often relatively inappropriate because they often ignore the basic of other considerations (Tawil and Liliyasi, 2013). Oppeinheimer, Eplay & Eyre (2007) mention that intuition can activate analytical thinking in decision making activity. Second, decision making in empirical category is decision making based on empirical data and facts that can result healthy, solid, and good decisions (Tawil and Liliyasi, 2013). Third, decision making in heuristics category, in the process, the decision maker uses scientific theory, based on limited information, existing rules, assumption and individual consideration. Decision making in heuristics category is often used by human as decision maker (Wang & Ruhe, 2007).

According to Khader (2011), decision making based on heuristic highly depends on the person's ability to recall information that has been learned from the ongoing learning process and it is influenced by the memory activation in the brain. Fourth, decision making in rational category, that decision is objective, logical, more transparent and consistent to maximize result or value in certain constraints, so it can be said that it is closer to the truth and fulfilling expectation. This category occurs entirely in ideal circumstances (Tawil and Liliyasi, 2013). In decision making process, students should be able to process the data and information that converge on several options and ultimately they obtained an option to be selected.

There are two decision making strategies that students can use in processing information to obtaining a decision, they are called compensatory and non-compensatory strategy. Compensatory strategy is strategy when students consider all options and then choose the most appropriate choice according to them based on the positive and negative aspects of each option. In this strategy, all information is used to evaluate the overall quality of each option. This strategy assumes that all choices are equally logical and decision makers need all the information to consider (Gresch, Hasselhorn & Bögeholz, 2013).

In some cases, the logical level is presented in unequal choice. In that cases, students can use another strategy called non compensatory strategies. In this strategy the student may receive or eliminate choice. This strategy will only select the option if the option reaches a certain value, the lack of choice cannot be compensated by advantages in other criteria. (Gresch, Hasselhorn, Bögeholz, 2013). This strategy focuses on a single criterion and ignores most of information (Papadouris & Constantinou, 2010).

Students can also use mixed strategy, where they can use compensatory and non-compensatory strategies to get a decision. Students eliminate some options that will not be considered further and then left a few other options to consider deeper until finally they obtain decision. That strategy may be one of aspects to improve decision making competence in certain decision making situations (Eggert & Bögeholz, 2010). It takes a students' ability to focus on the chosen reasons for choosing the selected option and rejecting other reasons (Eggert & Bögeholz in Böttcher & Meisert, 2013; Eggert & Bögeholz 2010; Eggert, Bögeholz & Frauke, 2012; Gresch, Hasselhorn & Bögeholz, 2013).

Researches dealing with decision making have been made by several researchers. Rese-

arch conducted by Cojuharenco (2007), showed that respondents are more likely to use intuition to make decisions. The results also showed that people who make decisions based on intuition has done some comprehensive evaluation even though having limited information from several alternative choices. While research on decision making strategy has previously been done by Gresch, Hasselhorn and Böggeholz (2013) that showed students tend to use compensatory strategies when performed pretest time while they tend to use non compensatory strategies in posttest time. Besides, decision making ability could be useful in making important choices. Large survey conducted by Moogan and Baron (2003) showed that young peoples' decision making when considering extending their education, obtaining training or deciding on their careers is a complex interactive process. For example, by examining the selection of a university as a decision making process, much can be learnt which will provide recruitment personnel with a means of choosing more functional tools in achieving their enrolment goals.

This research aims to see type and category of decision making strategies used by students, find out students' achievements in answering TIMSS science reasoning questions. Types of question material used in the research consisted of chemical, physics, and biology content. This study focused on one domain of cognitive reasoning domain.

The data obtained is expected to be used as a basis to create a policy related to learning and evaluation processes in school. Policy taken based on those data is expected to improve the quality of learning and evaluation. Therefore, further and deeper study was conducted on "Analysis of Students' Decision Making to Solve Science Reasoning Test of Trends In International Mathematics And Science Study (TIMSS)".

METHOD

This research is quantitative descriptive research that describes size, amount or frequency. The research did not provide treatment, manipulation or alteration of its independent variables, but tend to describe the real condition (Sukmadinata, 2012).

The subject was 28 students of grade IX in one of clusters 1 junior high school (SMP) in Bandung. The instruments used were TIMSS science reasoning test consisting of 25 questions. It consisted of 11 multiple choice questions and 14 essay questions. It was divided into 3 biology,

3 chemistry and 2 physics content, biology content consisted of Organism, Cell and Its Function, and Ecosystem topic, chemistry content consisted of Material Composition, Material Characteristic and Chemical Change, while physics content consisted of Physical State, Change of State and Force and Displacement. Their time allocation to do the test was 80 minutes.

In multiple choice test type, students should answer the questions by choosing provided answer dealing with answer and strategy to answer the questions. The option was aimed to find out their decision making strategy to answer the questions. The decision making options consisted of: a) Considering all options then choosing the most appropriate option; b) Choosing one option and ignoring others; c) Ignoring some options and leaving some considered options then choosing the most appropriate option. Option (a) is referring to compensatory strategy, (b) is referring to non compensatory strategy, (c) is referring to mixed strategy.

Meanwhile in essay test type, students should answer the questions by writing their answer. After writing it they were asked to choose provided decision making option category consisting of: a) My feeling; b) Learning process experience in the class; c) Related theory, concept and information; d) Logical thought and consideration. Option (a) is referring to intuition strategy, (b) is referring to empirical strategy, (c) is referring to heuristic strategy, (d) is referring to rational strategy.

RESULT AND DISCUSSION

The result of students' decision making strategy in answering multiple choices test is presented in Table 1.

Table 1. Percentage of Students' Decision Making Strategy

Test Number	C	NC	CNC
1	89	0	11
2	54	39	7
3	54	25	18
4	82	4	7
5	82	7	7
6	61	14	11
7	64	25	4
8	61	18	18
9	39	46	7
10	71	7	11

	11	39	50	0
Average		63	21	9

Note:

C = Compensatory; NC = Non compensatory;
CNC = Mixed Strategy

Table 1 shows students' tendency of choosing decision making strategy in answering multiple choices test. When answering test number 1, 2, 3, 4, 5, 6, 7, 8, and 10, they tend to use compensatory strategy. Students tend to consider all options then choose the most appropriate option compared to directly choose one option (non compensatory) or eliminate some options and then choose the most appropriate option (mixed strategy). For question number 1, there were no students who were choosing one option and ignoring the others (non compensatory). For question number 9 and 11, they tend to choose one option and ignore others (non compensatory). So, it can be seen that students tend to use compensatory strategy with the percentage of 63% compared non compensatory of 21 % and mixed strategy of 9%.

Table 2 shows the percentage of students' decision making strategy in answering essay test type. Based on Table 2, to answer test number 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, and 14 they tend to use rational category compared to other categories. For question number 2 the percentage spread

in four categories, 14% of students use intuition category, 36% use empirical category, 32% use heuristic category, and 25% use rational category. While in question number 6 the intuition category is used more than other categories with percentage of 39%.

When taking the data, students were able to choose more than one category, but in fact only few of them did that. For question number 1, 4% of students answered by using intuition and rational (IR) category, and 4% of students used heuristic and rational (HR) strategy. For question number 7, 4% of students used heuristic and rational (HR) category. While, for question number 8, 10, and 12, 4% of students used intuition and rational (IR) category. It can be summed up that to answer essay test type, students tend to use rational strategy compared to other strategy.

Students' score of TIMSS science reasoning test can be observed from the total correct number of each test item. It turns out that there are 8 multiple choices test that is answered correctly of more than 50% of students, they are question number 1, 2, 3, 4, 8, 9, 10, and 11, while for question number 5, 6, and 7, less than 50% of students are answered it correctly.

For essay type question, 8 from 14 questions are answered correctly by 50% of students, the questions are number 1, 2, 5, 6, 7, 8, 9, and 12. For question number 3, 4, 10, 11, and 14, less than 50% of students are answered it correctly.

Table 2. Percentage of Category of Students' Decision Making

Test Number	I	E	H	R	IE	IH	IR	EH	ER	HR	IEH	IER	IHR	HER	IEHR
1	18	7	4	54	0	0	4	0	0	4	0	0	0	0	0
2	14	36	32	25	0	0	0	0	0	0	0	0	0	0	0
3	7	11	18	57	0	0	0	0	0	0	0	0	0	0	0
4	4	0	18	68	0	0	0	0	0	0	0	0	0	0	0
5	4	0	11	79	0	0	0	0	0	0	0	0	0	0	0
6	39	7	14	14	0	0	0	0	0	0	0	0	0	0	0
7	4	21	21	25	0	0	0	0	0	4	0	0	0	0	0
8	25	18	14	36	0	0	4	0	0	0	0	0	0	0	0
9	18	7	11	36	0	0	0	0	0	0	0	0	0	0	0
10	18	7	7	57	0	0	4	0	0	0	0	0	0	0	0
11	7	0	7	46	0	0	0	0	0	0	0	0	0	0	0
12	18	4	25	39	0	0	4	0	0	0	0	0	0	0	0
13	18	0	11	57	0	0	0	0	0	0	0	0	0	0	0
14	29	0	18	43	0	0	0	0	0	0	0	0	0	0	0
Average	16	8	15	45	0	0	1	0	0	1	0	0	0	0	0

Note:

I = Intuition; E = Empirical; H = Heuristic; R = Rational

Table 3. Percentage of Students' Correct Answers of Test

Multiple Choice			Essay		
Test No.	Maximum Score	Percentage (%)	Test No.	Maximum Score	Percentage (%)
1	1	93	1	1	68
2	1	86	2	2	71
3	1	64	3	1	25
4	1	54	4	1	43
5	1	7	5	1	64
6	1	46	6	1	75
7	1	25	7	2	70
8	1	86	8	2	70
9	1	71	9	2	55
10	1	75	10	2	39
11	1	82	11	1	21
Average		63	12	1	71
			13	1	50
			14	1	14
			Average		55

Then for question number 13 is answered correctly by 50% of students. Students test score can be seen in Table 3.

Based on analysis it can be determined that 63% of students can answer multiple choices test correctly and 55% of students can answer essay test correctly. That percentage is obtain by comparing students' achievement score to ideal score that should be achieved by students when they answer all questions correctly.

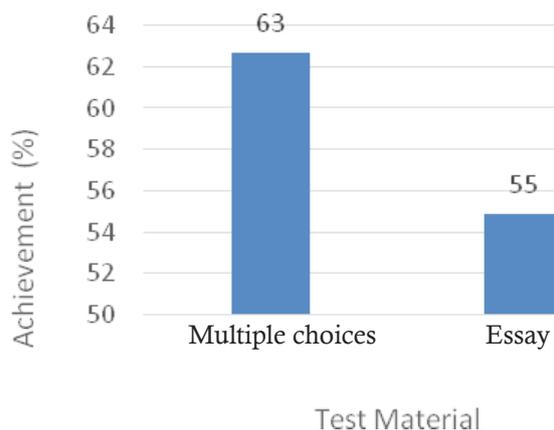


Figure 1. Students' Achievement Score of TIMSS Science Reasoning Test Based on Test Type

From the data presented in Figure 1, it shows that more than 50% of students can answer reasoning test question correctly. So it can be said that more than half of students can answer test question correctly.

CONCLUSION

The research shows the tendency of students' decision making based on the strategy and category and their achievement of answering TIMSS science reasoning test. The result shows that more than half of students used compensatory strategy to solve multiple choices test, there were few of them used non compensatory strategy, and mixed strategy was rarely used in this case.

Meanwhile, to answer essay type question students tend to use rational category compared to other categories. In some test items, students used empirical and intuition category. Although rational category was not chosen by more than half of students but it was the category that is used by most of students.

The data shows that more than 50% of students can answer reasoning test question correctly both of multiple choices and essay test type.

REFERENCES

Bavolar, J. 2013. Validation of Adult Decision Making Competence in Slovak Student. *Judgement and Decision Making*. 8 (3): 386 – 392.

Böttcher, F. dan Meisert, A. 2013. Effect of Direct and Indirect Instruction on Fostering Decision-Making Competence in Socioscientific Issues. *Res Sci Educ*. 43 (2): 479 – 506.

Cojuharenco, I. 2007. Lay intuitions about overall eval-

- uations of experiences. *Judgement and Decision Making*. 2 (1): 40 – 47.
- Eggert, S. and Bögeholz, S. 2010. Students' Use of Decision-Making Strategies with Regard to Socioscientific Issues: An Application of The Rasch Partial Credit Model. *Science Education*. 94 (2): 230 – 258.
- Eggert, S., Bögeholz, S., Frauke, O. 2012. Socioscientific Decision Making in the Science Classroom: The Effect of Embedded Metacognitive Instructions on Students' Learning Outcomes. *Education Research International*. vol. 2013 (ID. 309894).
- Gresch, H., Hasselhorn, M., and Bögeholz, S. 2013. Training in Decision-making Strategies: An Approach to Enhance Students' Competence to Deal with Socio-scientific Issues. *International Journal of Science Education*. 3 (15): 2587 – 2607.
- Khader, P.H. 2011. Memory-Based Decision with Heuristic: Evidence for a Controlled Activation of Memory Representations. *Journal Cognitive Neuroscience*. 23 (11): 2540 – 3554.
- Lamond, D. & Thompson, C. 2000. Intuition and Analysis in Decision Making and Choice. *Journal of Nursing Scholarship*. 32 (2): 411 – 414.
- Moogan, Y.J. and Baron, S. 2003. An Analysis of Student Characteristics within the Student Decision Making Process. *Journal of Further and Higher Education*. 27(3): 271– 287.
- Mullis, IVS. & Martin, M.O. 2013. *TIMSS 2015 Assessment Frameworks*. United States: TIMSS & PIRLS International Study Center.
- Oppeheimer, D., Eplay, N., & Eyre, R.N. 2007. Overcoming Intuition: Metacognitive Difficulty Activates Analytic Reasoning. *Journal of Experimental Psychology General*. 136 (4): 569 – 576.
- Papadouris, N. and Constantinos P.C. 2010. Approaches Employed by Sixth-Graders to Compare Rival Solutions in Socio-Scientific Decision-Making Tasks. *Learning and Instruction*. 20: 225 – 238.
- Polic, M. 2009. Decision Making: Between Rationally and Reality. *Interdisciplinary Description of Complex System*. 7 (2): 78 – 98.
- Rustaman, N.Y. 2009. *Analisis Konten dan Capaian Sains Siswa Indonesia dalam TIMSS (Trends in International Mathematics and Science Study) tahun 1999, 2003, dan 2007*. Jakarta: Badan Penelitian Pengembangan Departemen Pendidikan Nasional.
- Scott, S.G. & Bruce, R.A. 1985. Decision Making Style: The Development and Assessment of a New Measure. *Educational and Psychological Measurement*. 55: 818 – 831.
- Stein, M.K., Grover, B.W., and Henningsen, M. 1996. Building Student Capacity for Mathematical Thinking and Reasoning: An Analysis of Mathematical Tasks Used in Reform Classrooms. *American Education Research Journal*. 33(2): 455.
- Sukmadinata. 2012. *Metode Penelitian Pendidikan*. Bandung: PT. Remaja Rosdakarya.
- Tawil, M. dan Liliyasi. 2013. *Berpikir Kompleks dan Implementasinya dalam Pembelajaran IPA*. Makasar: Badan Penerbit UNM.
- Wang, Y. & Ruhe, G. 2007. The Cognitive Process of Decision Making. *International Journal of Cognitive and natural Science Intelligence*. 1 (2): 73 – 85.