

INDONESIAN STUDENTS' MATHEMATICS PROBLEM SOLVING SKILL IN PISA AND TIMSS

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Abstract

This study aims to describe the critical opinion of Indonesian students' problem solving skill based on PISA and TIMSS's result. This study based on literature which the PISA and TIMSS study showed Indonesian students' achievement was poor. In the last PISA 2012, Indonesia ranked 64 of 65 participant's countries, whereas in the last TIMSS 2011, Indonesia ranked 36 of 40. On the contrary, Indonesian students' got a lot of medals in international mathematics contest with a lot of rival countries. Nevertheless, we can't compare them because of difference test type, but we should have critical thinking about those results. The other reason why we should criticize Indonesian PISA's result is the sampling used. Why a wider country than Indonesia didn't use representative sampling in PISA's test? Why a wider country could participate with just some big cities in there? Was it permitted or by design? Furthermore, the PISA's sampling which was used in some regions in Indonesia wasn't representative, for example the samples were the schools belongs to low grade in national exam and accreditation. Moreover, there was lacking in carrying out PISA test, for example language differences and cultural differences can both influence the difficulty level. There was expert's opinion that questions in different PISA's test booklet have no function in exactly the same way in different countries, so the questions weren't reliable at all. Then, was the Indonesian PISA's result described the true students' achievement? So, it is necessary to criticize the Indonesian PISA's result.

Keywords: Indonesian students, mathematics' problem solving skill, PISA, TIMSS

Introduction

International surveys of students' achievement are becoming increasingly popular with governments around the world, as they try to measure the performance of their country's education system. PISA (*Programme for International Student Assessment*) and TIMSS (*The Trends in International Mathematics and Science Study*) are international study surveying students' mathematics achievement. PISA and TIMSS was held every three years and four years respectively. PISA surveyed 15 years old students' literacy skill. TIMSS was held for eight grade students. Both PISA and TIMSS concern in students mathematics achievement. Shiel, et al. (2007, p. 1) stated that PISA was international assessment for 15 years old students which assess their knowing, understanding, and skill. Since 2000, OECD addressed this by producing a three year cycle of curriculum independent tests of reading, mathematics and science. Each cycle has major and minor emphases, with one of the three skill areas consuming the majority of the assessment every nine years (Baird, 2011, p.1).

In line with today's mathematics education challenge that students not only can arithmetic skill but also apply mathematics in their daily life. Moreover, as standard of process in mathematics learning by NCTM (2000, p. 7), there was some skills in mathematics education that are problem solving, reasoning and proof, communication, connection, and representation.

Those were in PISA and TIMSS tests. TIMSS concern in school mathematics curriculum but PISA which is organized by the Organisation for Economic Co-operation and Development (OECD) concern in mathematics application in everyday life. PISA concerns in literacy skill that focused on procedural, comprehension, and concept mastery in daily life (OECD, 2012, p. 15). It means that PISA concerns beyond school mathematics curriculum that called mathematical literacy. Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments' and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen (OECD, 2012, p. 17). Mathematical literacy is focused and applied for all age range and skill level (Stacey, 2012, p. 3). Mathematical literacy not only concern on arithmetic's skill, but also invoked broad knowledge (De Lange, 2003, p. 76). De Lange (2006, p. 15) said "the OECD/PISA mathematical literacy domain is concerned with the capacities of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve and interpret mathematics in a variety of situations".

Based on PISA's technical report, the PISA 2012 study (OECD, 2014, p. 66 – 69) showed that less than one percent of Indonesian students could answer the questions in complex problem situations which require mathematical modeling, reflection, conceptualization, generalization, and reasoning skills. Furthermore, TIMSS 2011 study showed that only two percents Indonesian students could work with high benchmark question or reasoning level. Only 43% of them could answer low benchmark question which only knowing skills whereas the International median in knowing skills was 75% (Mullis, et al., 2012, p. 114). These poor result as one of reflective matter for changing Indonesian curriculum from KTSP to Kurikulum 2013.

In the last PISA test 2012, Indonesia ranked 64 of 65 participant's countries, whereas in the last TIMSS test 2011, Indonesia ranked 36 of 40. On the contrary, Indonesian students' got a lot of medals in international mathematics contest with a lot of rival countries. In IMO (*International Mathematics Olympiad*) 2013, in Colombia, Indonesia got one gold medal, one silver medal, and four bronze medals. In there, Indonesia ranked 19 of 97 participant countries. In IMO 2014 Indonesia ranked 29 of 101 with 2 golds, 3 silver medals, and 1 honorable mention (Dolinar, 2014). However this does not mean we can compare PISA and TIMSS result and mathematics olympiad results because of difference test type, but we should have critical thinking about those results. So, in this paper the general goal of this study was describe the critical opinion of Indonesian students' problem solving ability based on PISA and TIMSS's result. The benefit of this study was the readers have broad point of view in perceiving PISA and TIMSS result.

Explanation

Indonesian Students' Mathematics Problem Solving Skill in PISA and TIMSS

A. PISA and TIMSS

PISA study focused on fifteen years old students because in that age where compulsory schooling is still largely universal. So testing focused on 15 years olds enrolled in both school-based and works-based educational program (OECD, 2014, p. 14). In PISA study, the content described in broad terms and TIMSS are based school curriculum (Stacey, 2012, p. 4). That study is to survey students' readiness face knowledge society challenges. PISA assessment used a broad approach to assessing knowledge and skills that reflecting the current changes in curricula, moving beyond the school base approach towards the use of knowledge in everyday tasks and challenges (Kamaliyah, Zulkardi & Darmawijoyo, 2013, p. 11). According to Fleischman, et al. (2010, p. 4) PISA mathematics assessed how well students in analyzing, reasoning, and interpret mathematical problems in a variety of situations.

TIMSS test the effectiveness of curriculum and instruction in schools associated with students achievement (Mullis, et al., 2009, p. 13). In other words, TIMSS aims at measuring educational systems according to the stated aims for those systems. TIMSS provide useful information that helps a country in monitoring and evaluating the teaching of mathematics and science over time. The objective is to measure the TIMSS mathematics and science achievement

of eighth grade students in the participating countries. For Indonesia, the benefits that can be obtained, among others, is to determine the position of Indonesian student achievement when compared with the achievements of students in other countries and the factors that influence it. Therefore, the results of this study are expected to be used as inputs in the formulation of policies for improving the quality of education.

In each survey, student achievement is assessed in three key life skills domains: ‘reading literacy’, ‘mathematical literacy’ and ‘scientific literacy’. Each domain is given major emphasis every nine years (Table 1), being allocated two-thirds or more of the available testing space (OECD, 2009). Table below showed the timeline for major/minor literacy emphasis.

Table 1. Timeline for major/minor literacy emphasis

	2000	2003	2006	2009	2012	2015
Reading literacy	Major	Minor	Minor	Major	Minor	Minor
Mathematical literacy	Minor	Major	Minor	Minor	Major	Minor
Scientific literacy	Minor	Minor	Major	Minor	Minor	Major

Source: Baird, et al. (2011: 3)

From that table, we know that mathematics as a major component in PISA study in 2003 and 2012. It means that in 2003 and 2012, PISA focused on mathematics literacy.

The different ways that mathematics is held in TIMSS and PISA reflect different opinions of what school mathematics is or should be. PISA is testing students in the type of applied mathematics they may need in their daily life as citizens in a modern society, it is an aim for PISA to embed all items in a context as close to a real life problem as possible. Most of the items in TIMSS however, are either pure mathematical items with no context, or items with the simple and artificial contexts that are almost a signature of traditional mathematical problems in school. TIMSS will therefore to a great extent give information about students’ knowledge in pure mathematics, while PISA will display students’ knowledge in applied mathematics (Gronmo & Olsen, 2006, p. 3). Both TIMSS and PISA eventually released not only the average national scores on their tests but also a rich international database from which analysts can disaggregate test scores by students’ social and economic characteristics, their school composition, and other informative criteria.

B. Problem Solving Skill

Problem solving is one of skill concerned in mathematics standard of process. According to Adams & Hamm (2010, p. 67) stated that the ability to solve the problems and the ability of the theory are needed in mathematics. Furthermore, Polya (1973, p. 1) stated that one of the important tasks in learning math teacher is helping learners to develop their ability in solving mathematics problems. Students should be educated for recognize mathematics as branch of science which is has an important contribution in their everyday life (Mullis, et al., 2009, p. 19). According to cognitive development stage by Piaget (Slavin, 2006, p. 39 – 40) that 15 year old students belonging to formal operational stage. In this stage, students should have abstract and symbolic thinking. They are able to solve problems with systematic procedure. They can generalize relation abstract concepts from information given and compare relation among them. In line with that theoretical cognitive development, PISA study has included those skills. In overall PISA study for mathematics 2003, 2006, and 2009 (OECD, 2014, p. 41) there are six proficiency level, (1) students can answer question involving familiar context where all relevant information is present and the questions are clearly defined, (2) students can interpret and recognize situation in contexts that require no more than direct inference, they can extract relevant information from a single source and make use of a single representational mode, (3)

students can execute clearly described procedures, including those that require sequential decisions, they can select and apply simple problem solving strategies, (4) students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions, they can select and integrate different representations, including symbolic, linking them directly to aspects of real world situations, (5) students can develop and work with models for complex situations, identifying constraints and specifying assumptions, they can select, compare, and evaluate appropriate problem solving strategies for dealing with complex problems related to these models, (6) students can conceptualize, generalize, utilize information based on their investigations and modeling of complex problem situations.

Indonesian government has concerned with mathematics problems like PISA, as we know in National Exam 2013/2014 there are some questions from PISA. It means that higher order thinking is important. Moreover, according to Hayat & Yusuf (2010, p. 5), nowadays, people should have skill to discover new concepts, make relation, and fulfill highest occupational standard (concept, competence, connection). In the past, the teacher could teach if what students learn will be used in their future life, but nowadays they need real and concrete evidence about the benefit of mathematics learning. According to Russell (Salsabilla, 2013) four aspects of reasoning that need to be developed since early childhood is (1) developing justification and using generalization, (2) interconnecting mathematical knowledge in mathematics application in daily life, (3) developing mathematical understanding will be the basis of mathematical sensitivity widened base to look to the point when children encounter with math problems, and (4) using reasoning of mathematical knowledge in solving problems. PISA and TIMSS math problem models can be used to make students' habit to use their mathematical reasoning.

C. Indonesian Students' Mathematics Achievement in PISA and TIMSS

In the last PISA test 2012, Indonesia ranked 64 of 65 participant's countries, whereas in the last TIMSS test 2011, Indonesia ranked 36 of 40. From those result, it can be seen that both study showed poor result for Indonesian students. Based on PISA's technical report, the PISA 2012 study (OECD, 2014, p. 66 – 69) showed that less than one percent of Indonesian students could answer the questions in complex problem situations which require mathematical modeling, reflection, conceptualization, generalization, and reasoning skills. It means that, they almost couldn't work problem needed reasoning skill. Furthermore, TIMSS 2011 study showed that only two percents Indonesian students could work with high benchmark question or reasoning level and no one could work reasoning problem with some informations missing. Only 43% of them could answer low benchmark question which only knowing skills whereas the International median in knowing skills was 75% (Mullis, et al., 2012: 114). These poor result as one of reflective matter for changing Indonesian curriculum from KTSP to Kurikulum 2013. As mentioned above that mathematics as a major assessment in PISA study was in 2003 and 2012. Look at the table below for the explicit result.

Table 2. Indonesian Students' Mathematics Performance in PISA 2012

Country	Mathematics Performance					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Indonesia	78%	25%	<10%	<5%	<1%	<1%
International mean	92%	77%	54,5%	30,8%	12,6%	3,3%

Source: (OECD, 2014, p. 66 – 69)

Table 3. Indonesian Students' Mathematics Performance in TIMSS 2011

Country	Cognitive Domain			
	Advanced Benchmark	High Benchmark	Intermediate Benchmark	Low Benchmark
Indonesia	0%	2%	15%	43%
International median	3%	17%	46%	75%

Source: (Mullis, et al., 2014, p. 114)

D. Indonesian Students' Mathematics Achievement beyond PISA and TIMSS

On the contrary, Indonesian students' got a lot of medals in international mathematics contest with a lot of rival countries. In IMO (*International Mathematics Olympiad*) 2013, in Colombia, Indonesia got one gold medal, one silver medal, and four bronze medals. In there, Indonesia ranked 19 out of 97 participant countries. In IMO 2014 Indonesia ranked 29 out of 101 with 2 golds, 3 silver medals, and 1 honorable mention (Dolinar, 2014). How proud we are! However this does not mean we can compare PISA and TIMSS result and the others mathematics contest results because of difference test type, but we should have critical thinking about those results.

Based on data from UNESCO, the quality of mathematics education in Indonesia is ranked 34 out of 38 countries surveyed. Other data showed low mathematics achievement Indonesian students can be seen from the results of the survey the International Center for Education Statistics (National Center for Education in Statistics, 2003) of the 41 countries in mathematics, where Indonesia get ranked 39th under Thailand and Uruguay. Although, we may proud of Indonesian students' achievements in the international world mathematics contests last 5 to 10 years. From Tempo Magazine (2014), Indonesian students from elementary, middle, and high school incised with a proud achievement which won 14 gold medals, 26 silver, and 53 bronze and 34 awards expectations in the International Mathematics Olympiad Contest (IMC) which held on 1 to 4 August 2014 in Singapore. Moreover, the students of Mathematics Education Clinic representing Indonesia won eight gold medals, five silvers, and three bronze for individual categories. It is much better than that achieved in WIZMIC 2011, namely two gold medals, five silver and nine bronze. Those means that Indonesian students' achievement in mathematics contest was good differ with PISA and TIMSS result. Whereas in PISA and TIMSS only test participating countries slightly, whereas prestigious events such as mathematics contest like IMO there are many participating countries. Notwithstanding, the school sample in PISA study in Yogyakarta province was schools lower category. Therefore, the question arises how the actual ability of Indonesian students in PISA and TIMSS study, especially the ability of students in Yogyakarta province.

E. Comparison of Indonesian Students' Mathematics Achievement in and beyond PISA and TIMSS

From those contrast result, let we discuss about Indonesian students' mathematics achievement in and beyond PISA and TIMSS. How those can be different result? However, we can't compare those results because of the difference test type. But, we still receive both results wisely. Further reason why we should criticize Indonesian PISA's result is the sampling used. As a part of Indonesia, in Yogyakarta the sampling was used in PISA 2012 study was only low grade schools. Is it representative sampling for this study? Why a country wider than Indonesia didn't used representative sampling in PISA's test? Why a wider country could participate with just some big cities in there? Was it permitted or by design?

Beside of that, the PISA's sampling which was used in some regions in Indonesia wasn't representative, for example the samples were the schools belongs to low grade in national exam and accreditation. Moreover, there was lacking in carrying out PISA test, for example language differences and cultural differences can both influence the difficulty level. There was expert's

opinion that questions in different PISA's test booklet have no function in exactly the same way in different countries, so the questions weren't reliable at all. Then, was the Indonesian PISA's result described the true students' achievement? So, it is necessary to criticize the Indonesian PISA's result

OECD (2014, p. 14) claims that PISA uses: (i) strong quality assurance mechanism for translation, sampling, and test administration, (ii) measures to achieve cultural and linguistic breadth in the assessment materials, particularly through countries' participation in the development and revision process for the production of the items, and (iii) state of the art technology and methodology for data handling. Between 4500 and 10000 students from at least 150 schools are typically tested in each country, providing a good sampling base from which to break down the results according to a range of students characteristic. Notwithstanding, a number of issues have been identified that render international comparison of survey results problematical. These include: materials translation, the measurement model used for analysis, student sampling, domain representation, student motivation, and consequential validity (Baird, et al., 2011, p. 8). How can the theory differ with the sampling determination?

There are many critics to PISA study, one of them from Alexander (2013) in BBC News Magazine who stated that language differences and cultural differences can both influence the difficulty level. In line with him, Stephen (2013), High Master of ST Pauls School founder, stated that translation quality and cultural differences can deviate in PISA assessment. As we know that, in PISA mathematics 2012 there are 13 booklet with different content used to test the students and each of them did the different booklet. Does each booklet have same difficulty level? Those curiosity underlined by Kreiner in BBC News Magazine who said "I'm not actually able to find two questions in PISA's test that function in exactly the same way in different countries, I don't think it's reliable at all" (Alexander, 2013). Furthermore, Wuttke (2007, p. 243) stated that there are some difficulties in PISA assessment because not at all students work with the same task. She also said that there are 13 booklets which need tested difficulty level in order to certain each booklet have same difficulty level. Beside of that, in many countries there are many items test which is not valid because of translation error. In line with those, cultural, social, and economical differences in each country affect difficulty level of PISA item test.

Sampling differences in many countries was also criticized. For example in China, PISA 2012 result were not reported as a whole country and just some province in there or actually the sample of PISA 2012 study just some province there such as Shanghai, Hongkong, and Macao. Shanghai and Hongkong got upper rank in PISA 2012 study. This sampling difference also makes discrepancy in PISA assessment for other countries. Shanghai is not representative of China as a whole, because it is probably better resourced than other regions (Baird, 2011, p. 26). Although assessment was undertaken in a number of Chinese provinces, only the results for Shanghai-China and Hong Kong-China were published in 2009 and there is little information about the policy response in substantive terms as yet. It is striking that PISA results seem to have been used for sabre-rattling political rhetoric to drive through educational reforms in some of the countries (Baird, et al., 2011: 1). China has an unusual arrangement with the Organization for Economic Co-operation and Development (OECD), the organization responsible for PISA. Other provinces took the 2009 PISA test, but the Chinese government only allowed the release of Shanghai's scores. The *Financial Times* quotes Andreas Schleicher, one of the OECD officials responsible for PISA, as saying, "We have actually done PISA in 12 of the provinces in China. Even in some of the very poor areas you get performance close to the OECD average." Was it permitted or by design?

Then, how about in Indonesia? According to Puspendik (2011) determining sample based on three strata, school type (junior and senior high school), status of school (state owned or private school), and school performance (good, moderate, poor in quality). But, actually in Yogyakarta, the samples were the schools belongs to low grade in national exam and accreditation. Is that theory really used in sampling determination? Beside of that, the PISA's sampling which was used in some regions in Indonesia wasn't representative, for example the

samples were the schools belongs to low grade in national exam and accreditation. Moreover, there was lacking in carrying out PISA test, for example language differences and cultural differences can both influence the difficulty level. There was expert's opinion that questions in different PISA's test booklet have no function in exactly the same way in different countries, so the questions weren't reliable at all. Then, was the Indonesian PISA's result described the true students' achievement? So, it is necessary to criticize the Indonesian PISA's result. We used PISA and TIMSS result to improve our low grade students wisely and those not only the one and only survey that must be considered faithfully.

Conclusion and Suggestion

So far all international test scores measure the extent to which an education system effectively transmits prescribed content. Indonesian students' mathematics problem solving skill in PISA and TIMSS were not show good achievement. Notwithstanding the PISA and TIMSS study showed Indonesian students' achievement was poor, those make us very desperate. In the last PISA study 2012, Indonesia ranked 64 out of 65 participant's countries, whereas in the last TIMSS study 2011, Indonesia ranked 36 out of 40. PISA and TIMSS study contained many reasoning task, so based on the result, it means that Indonesian students' mathematics reasoning and problem solving skill is poor. On the contrary, Indonesian students' got a lot of medals in international mathematics contest with a lot of rival countries. So, we are very proud with Indonesian students' achievement in mathematics contest beyond PISA and TIMSS. Although, there are some flaws and critics about PISA and TIMSS study, we can reflect those results wisely for improving students' reasoning skill and achievement.

In this regard, to improve education quality in Indonesia, all stakeholders should be concern with higher order thinking. Mathematics learning not only assess routine mathematics problem which stress in arithmetic skill only, but also improve students' reasoning skill. How to make mathematics learning can improve higher order thinking?

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