ISSN 2087-8885
E-ISSN 2407-0610

Journal on Mathematics Education
Volume 9, No. 1, January 2018, pp. 129-144

MATHEMATICS SKILL OF FIFTEEN YEARS OLD STUDENTS IN YOGYAKARTA IN SOLVING PROBLEMS LIKE PISA

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Abstract

The aims of this research were to describe mathematics skill of 8th fifteen-year old students in Yogyakarta in solving problem of PISA. The sampling was combination of stratified and cluster random sampling. The sample consisting of 400 students was selected from fifteen schools. The data collection was by tests. The research finding revealed that mathematics skill of fifteen-year old students in Yogyakarta in solving problem of PISA was low in category but it was better than Indonesian students in PISA 2012. Mathematics skill of fifteen-year old students in Yogyakarta in solving problem of PISA was below the OECD average of PISA 2012.

Keywords: mathematics skill, fifteen years old students, problem solving, problem of PISA

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan kemampuan matematika siswa usia 15 tahun di SMP dan SMA di DIY dalam menyelesaikan soal model PISA. Teknik pengambilan sampel menggunakan teknik sampling strata dan kelompok. Sampel berasal dari lima belas SMP dan SMA sebanyak 400 orang. Pengumpulan data menggunakan tes dengan instrumen soal model PISA. Hasil penelitian menunjukkan bahwa kemampuan matematika siswa usia 15 tahun di DIY dalam menyelesaikan soal model PISA lebih tinggi dari siswa Indonesia dalam PISA 2012, akan tetapi masih termasuk kategori rendah. Kemampuan menyelesaikan soal model PISA siswa di DIY masih di bawah rata-rata OECD pada PISA 2012.

Kata kunci: kemampuan matematika, siswa usia 15 tahun, penyelesaian masalah, soal model PISA

How to Cite: Wulandari, N.F. & Jailani. (2018). Mathematics skill of fifteen years old students in Yogyakarta in solving problem like PISA. *Journal on Mathematics Education*, *9*(1), 129-144.

Mathematics was a subject assessed in national exam and PISA study. It was the science that never gets out of our life. Ker (2013) stated that good mathematics skill was one of basic thing in developing latest and sophisticated technology. Therefore it was a basic and dynamic subject given in school to the students for improving their understanding about the world and making their grade in social life (Yore, Anderson, & Hung Chiu, 2010). In mathematical instructional of secondary school, Kilpatrick & Swafford (2002) stated there was five standard must be attained by the students, (1) mathematical understanding, (2) arithmetic fluency, (3) using concept to solve the problems, (4) reasoning logically, and (5) mathematical usefulness. Whereas, PISA using innovative literacy approach, a learning concept linked to students' capability to apply their understanding and skill to analyze, make a reason and judgment, communicate effectively, solve and interpret the problems in many situations (OECD, 2013). Stacey (2012) underlined that mathematics literacy was used to all range of age and all of skill field. He also stated that the content of PISA was described in wide range different from content of TIMSS which taught at school.

However, Indonesian students' mathematics achievement in both UN and PISA was low. Based

on data from BSNP Puspendik Balitbang that the mean of mathematics test in national exam year 2013/2014 was 6.10, while the mean of the test for special Region of Yogyakarta was 6.25 (Puspendik, 2014). UN was used to measure educational success for minimal competence, whereas for international assessment using the PISA results. PISA was conducted every three years and in 2003 Indonesia got second lowest rank of the 40 countries. In PISA 2009 Indonesia got 61th rank of 65 participants. Indonesia's ranking in PISA 2012 was 64 out of 65 with mean value was 375 PISA Indonesia is still below the international average is 494 (OECD, 2014).

Mathematics learning achievement of Indonesian students in PISA 2012 contained in the Table 1.

Table 1. Percentage of the number of students in each level mathematics skill in PISA 2012

Math Skill Level	Indonesia	International Average
Level 1	75.7%	92%
Level 2	16.8%	77%
Level 3	5.7%	54.5%
Level 4	1.5%	30.8%
Level 5	0.3%	12.6%
Level 6	0%	3.3%

Source: (OECD, 2014)

Contradiction with those, in some international mathematics event such as the mathematics Olympiad, Indonesia got good and proud results. A lot of Indonesian students both the primary level and secondary school won the prestigious mathematics event. There are many awards that earned by Indonesian students in international mathematics Olympiad such as the IMO (*International Mathematics Olympiad*). Indonesian student's team won one gold medal, one silver medal and four bronze medals in IMO 2013 in Colombia. Furthermore, Indonesia got 19^{th} rank from 97 countries in that competition. Beside of that, in IMO 2014 Indonesia got 29^{th} rank from 101 countries, two silver medals, 3 bronze medals and one honorable mention awards and in IMO 2015 Indonesia was in 29^{th} rank of 104 countries (Dolinar, 2014). Whereas in PISA study, there were fewer participant countries than another mathematics competition, while in the prestigious event such as the mathematics Olympiad or other event was participated many more countries. In addition, schools in DIY as the sample of PISA 2012 was low category school. Therefore, there was a question about how the true of Indonesian students' achievement in the PISA, especially the for Yogyakarta students.

PISA mathematics achievement in national has already known, but we should know mapping of students' math skills for each region in Indonesia. The government and teachers also need to know which school or region in Indonesia that has high score of PISA, so it can be used as a reference for the improvement of the national curriculum. It was in line to statement from Lessani, Yunus, Tarmiz & Mahmud (2014) that research can reveal comparison of students' achievement in solving TIMSS or

PISA among participant countries or a group of students in a country. After that, Eklöf, Pavešič, & Grønmo (2014) and Ker (2013) stated that the wide test such as TIMSS and PISA gave a lot of information to educational stakeholder to plan better policy in education. It showed that how important knowing students' achievement in solving problem like PISA for each region is. While, Yogyakarta is a city of students that has mathematics average of junior high school national exam 6.25 UN greater than the national average whose score 6.10 (Puspendik, 2014). But, students' mathematics skills were not only minimum competency in national exam, but also oriented to reasoning and mathematical problem solving in our everyday life such as the PISA standards. Moreover, it should be known Yogyakarta students' mathematics achievement in solving problem like PISA that encourages higher order thinking skills.

The weakness of PISA study had been criticized by educational experts. According to Alexander (2013), language and cultural differences could influence the difficulty level in PISA test. Those differences in PISA context were not always same as the condition of participant countries which affect the level of difficulty about PISA. Schleicher (2007) also stated that measuring and comparing a wide range of competencies such as in PISA with language and cultural differences was difficult challenge, but it had been done continually. It was also revealed by Stephen (2013), the founder of High Master of ST Pauls School, that the quality of translation and cultural differences could be biased in PISA assessment. Additionally Kreiner, statisticians from the University of Copenhagen Denmark, also criticized about PISA. Kreiner (Alexander, 2013) in the BBC News Magazine said that he not actually able to find two questions in PISA's test that function in exactly the same way in different countries and he doesn't think it's reliable at all. However, Naumann (Bloem, 2013) stated that there was no sufficient research revealed that performance differences of mathematics skills in PISA cause of language differences or analysis of data on student outcomes assessment.

Another opinion was also expressed by Wuttke (2007) that there are difficulties in assessment of PISA caused of not all of the students solving on the same problem, there are 13 kinds of different questions that need to be tested the difficulties level and in some countries there are invalid items because of mistranslation. Cultures, social, and economy differences in some countries affect the difficulty level of PISA. Ranking system should be based on the ability of students in a country, but in the PISA 2012 China represented only by the city of Shanghai and Hong Kong, which is located on the top ranks. This sampling difference also cause gaps in the PISA assessment for other countries. It is as disclosed Wuttke (2007) that in some countries PISA sampling was not representative. Nevertheless, Arikan (2015) had compared students' skill in more sixty countries. Therefore, there was question how the real mathematics skill of fifteen years old students in region of Yogyakarta in solving problem like PISA?

Apart from those, there are a a lot of research about PISA or it has been trend of analysis to use data from PISA, such as using PISA and TIMSS mathematics assessments to identify the relative

strengths of students in Western and Asian countries (Wu, 2011), comparing the similarities and differences of PISA 2003 and TIMSS (Wu, 2010), moving PISA results into the policy arena: perspectives on knowledge transfer for future considerations and preparations (Yore, Anderson & Hung Chiu, 2010), and comparing adult mathematical literacy with PISA students: result of pilot study (Kiel, Bielefeld & Bielefeld, 2005), etc. Moreover, in Indonesia there is a lot of developmental and analysis research about problem of PISA such as developing the sixth level of PISA-like mathematics problems for secondary school students (Kamaliyah, Zulkardi & Darmawijoyo, 2013), difficulties in solving context-based PISA mathematics task: an analysis of student' error (Wijaya, et al, 2014), unfinished students answer in PISA mathematics contextual problem (Lutfianto, Zulkardi & Hartono, 2013), and exploring primary student's problem-solving ability by doing tasks like PISA's question (Novita, Zulkardi & Hartono, 2012), etc.

Then, based on those reasons and criticism in PISA's test as well as to complete the research and development PISA's research, this study tried to answer the problem of how the true ability of Indonesian students in solving problem like PISA especially for Yogyakarta province and then will be known the mathematics skill of students in Yogyakarta in solving problem like PISA in the context of Indonesian cultures, which can be used as reference for policy making or Indonesian curriculum development related to the standard PISA. The objective of this study was to describe the mathematical skills of fifteen years old students in Yogyakarta in solving problem like PISA.

METHOD

This research was a survey research with quantitative descriptive approach. The research was conducted in 15 junior and senior high schools in Yogyakarta respectively from March 31th, 2015 until May 27th, 2015. The study population was 15 years old students in junior and senior high schools. Determining the size of the sample used Krejcie & Morgan sampling table. Based on it, for significance level of 5%, the sample size for the population size of 51,651 people or be rounded up to 75,000 people was 382 people or at least 382 people or could be more (Krejcie & Morgan, 1970).

The sampling technique used a combination of stratified and cluster random sampling. The researcher took a random one school of each level of junior and senior high schools by stratified random sampling technique, while when took a random one class in ninth and tenth grade in each school level selected by cluster random sampling technique. Selection of 9th and 10th grade students as research subjects based on a consideration of cognitive development of high school students aged 11 and over, according to Piaget (Slavin, 2006) they were in stage of concrete operations to formal operations that correspond to the characteristics of PISA's test which includes understanding until reasoning skill and the use of context in PISA's test.

Beside of that, consideration of taking sample 9th and 10th grade students was based on the age range of approximately 15 years in appropriate to PISA standard. The age of the sample in PISA was in the range of 15 years and 3 months to 16 years and 2 months as from the translation of technical

students aged less than 15 years (OECD, 2014). Similarly, for the OECD countries that most of the students who was 15 years old was in 9th and 10th grade (Bloem, 2013). Table 2 details the composition of the sample used in this problem like PISA study.

Table 2. Composition of sample used in problem like PISA study

Grade	Number of Students		Sum	Age	
	Male	Female		Min	Max
9	77	123	200	15	16.25
10	82	118	200	15	16.25
Sum	**159**	**241**	**400**		

Data collection techniques used in this study was a test. The number of item in problem like PISA was 30 with the limited time 80 minutes. The allocation of time to solve problem like PISA was 80 minutes for 30 questions which means the average time used to solve each problem was 2,67 minutes, while the allocation of time in PISA 2012 test was 30 minutes for each booklet (OECD, 2013). For each math problem booklet consisting of 12-13 items, which means the average time used to solve each problem was in range 2.31 to 2.5 minutes (OECD, 2014).

Descriptive statistics used was standard deviation, maximum and minimum score. Then, data were grouped according to school level (high, average, and low) and further classified based on each domain according to the standard of PISA. In this study, data was tabulated by calculating the percentage of correct answer for each item. Then, the quantitative data such as the mean scores converted into the category of the students' skill with normative standard deviation adapted of Ebel and Frisbie (1991) can be seen in Table 3.

Table 3. Criteria score ability mathematical problem solving model students in PISA

Interval of Score	Criterion
$M_i + 1,5Sd_i < X \leq M_i + 3Sd_i$	Very High
$M_i + 0,5Sd_i < X \leq M_i + 1,5Sd_i$	High
$M_i - 0,5Sd_i < X \leq M_i + 0,5Sd_i$	Average
$M_i - 1,5Sd_i < X \leq M_i - 0,5Sd_i$	Low
$M_i - 3Sd_i < X \leq M_i - 1,5Sd_i$	Very Low

Statistical test used was *t*-test. Skewness test was used to know the normality. Myers & Well (2003) stated that the alternative test for normality with a large sample can use statistical skewness

and kurtosis. Similarly, Kim (2013) stated that the formal normality test using Shapiro-Wilk and Kolmogorov-Smirnov test may be used for a small sample size to moderate (n <300) because it will be more sensitive and unreliable for a large sample size. Therefore, the alternative test was a statistical skewness or kurtosis.

In the skewness test, data has normal distribution if the skewness value divided by standard deviation or z-values in range -2.5 to 2.5. However, for a large sample size will tend to be not normal, so the skewness value is in the range -1 and 1 as the alternative reference (Leech, Barrett & Morgan, 2005). Beside of that, Kim (2013) proposed that for a large sample size over 300 respondents, the normality test depends on the absolute value of skewness and kurtosis without considering the z-values. However, different reference from Kim (2013), data has normal distribution if the statistical value of skewness was in range of 2 or -2 or data was not normal if the absolute value of skew was more than 2 or the absolute value of kurtosis more than 7.

RESULTS AND DISCUSSION

Generally, mathematics skill of fifteen years old students in Yogyakarta in solving problem like PISA can be seen in the following Table 4.

Table 4. Data description of students' skill in solving problem like PISA

Description	Score
Mean	13.41
Deviation Standard	7.30
Ideal Maximum Score	47
Maximum Score	36
Ideal Minimum Score	0
Minimum Score	2
Number of Students	400

Based on Table 4, it could be known that the mean score of fifteen years old students' skill in solving problem like PISA in Yogyakarta was 13.41 out of 47 with a standard deviation 7.30. It means that the overall 15 years old students' ability in Yogyakarta in solving problem like PISA was low. Moreover, the highest score was 36 out of 47 and the lowest score was 2. It can be inferred that there are some students could solve half or more problem correctly, whereas, almost students couldn't solve 50% problems correctly. Furthermore, in Table 5 below represents the percentage of students according categorization score a lot of math skills of students in solving PISA models.

Table 5. Classification of number of students in a solving problem like PISA

Score (X)	Criteria	f	%
$35,245 < X \leq 47$	Very High	1	0%
$27,415 < X \leq 35,245$	High	14	4%
$19,585 < X \leq 27,415$	Average	75	19%
$11,755 < X \leq 19,585$	Low	119	30%
$0 < X \leq 11,755$	Very Low	191	48%

Table 5 showed that only 1 out of 400 students or almost 0% of students was in very high category, 4% of students was in high category, 19% of students was in average category, 30% of students was in low category, and 48% of students was in very low category. Further description of the average of mathematical skills of 15 years old students in Yogyakarta in solving problem like PISA for each domain was in Table 6.

Table 6. Category of students' skill in solving problem like PISA for each domain

Domain	Sub Domain	Average	Max. Score	Category
Content	Quantity	3.42	11	Low
	Change and Relationship	2.24	9	Very Low
	Space and Shape	2.18	10	Very Low
	Uncertainty and data	5.57	17	Low
Process	Formulate	3.31	11	Low
	Employ	7.75	17	Average
	Interpret	2.34	19	Very Low
Context	Personal	3.11	15	Very Low
	Occupational	3.52	9	Low
	Societal	5.52	15	Low
	Scientific	1.25	8	Very Low
Achievement Level	Level 1	4.54	6	High
	Level 2	3.04	6	Average
	Level 3	4.00	12	Low
	Level 4	0.94	8	Very Low
	Level 5	0.60	7	Very Low
	Level 6	0.29	8	Very Low

Data submitted were described by each domain and category of school. Then, the explanation of percentage correct answer based on difficulty level can be seen in Figure 1.

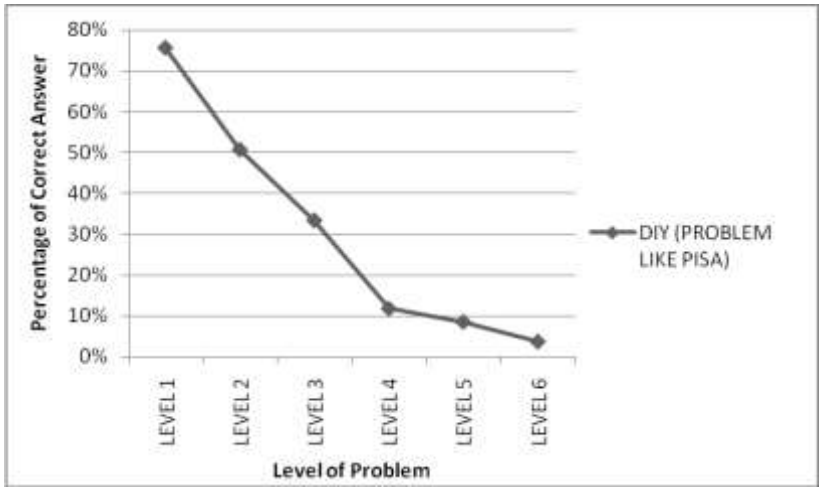

Figure 1. Percentage of correct answers based on level of problem like PISA

Based on Figure 1, the percentage of correct answer for level 1 problem was 76%, while for level 2 was 51% and for level 3 was 33%. In addition, the percentage of correct answer for level 4 was 12%, for level 5 was 8% and for level 6 was 4%. Problem level 1 was the easiest one, while problem level 6 was the most difficult one because problem 4, 5, and 6 require reasoning skill. For the higher difficulty level, just fewer students were able to solve the problems properly. It means that fifteen years old students in Yogyakarta still weak on reasoning skill. Students just familiar with routine problem such as in problem level 1 until 3 without need reasoning competence. Then, in Figure 2 below, the result of this study compared to each category school.

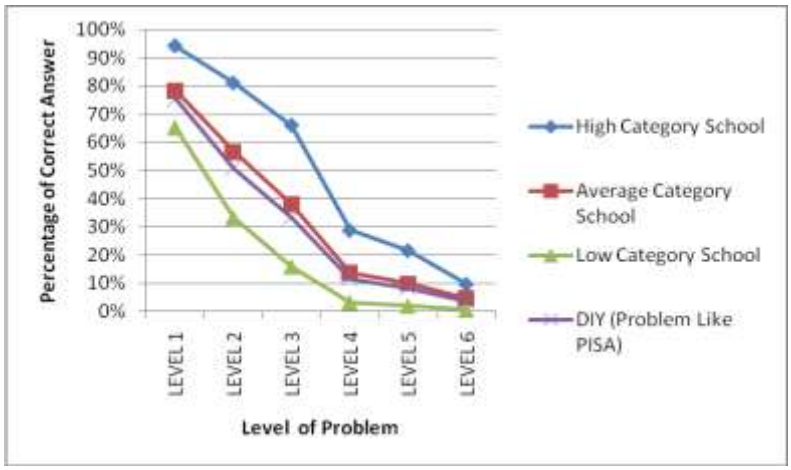

Figure 2. Percentage of correct answers based on level of problem for each school's level

Seen from Figure 2, students in high category school did better than average and low category in solving problem like PISA. It means that mathematics skill of fifteen years old students in line with school category. It can be seen from Figure 2 that overall skill students in Yogyakarta similar to

students in average school. Moreover, the result of this study compared to Indonesian students skill and OECD average in PISA 2012 that can be seen in Figure 3.

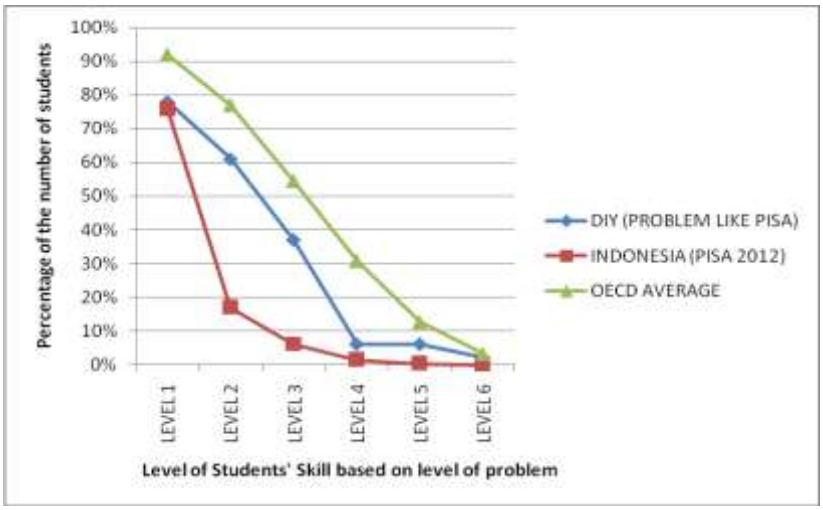

Figure 3. Percentage of the number of students in solving problem like PISA

Viewed from the number of students could solve problem like PISA and compared to Indonesian students and OECD average in PISA 2012, based on Figure 3 above, mathematics skill of students in Yogyakarta in solving problem like PISA was higher than Indonesian students in PISA 2012. While, it was lower than OECD average in PISA 2012. Percentage of the number of students in Yogyakarta who are able to solve problem like PISA from level 1 to level 6 was still below the OECD average. Its results appropriate to previous research from Ariyadi Wijaya, Van den Heuvel-Panhuizen, Doorman, dan Robitzsch (Wijaya, et al., 2014) that reveals students' achievement in Yogyakarta in CoMTI test show better performance than Indonesian students in PISA test 2003. Therefore, students in Yogyakarta which have better performance in national exam also showed their better achievement than Indonesian students at all. Then, the result viewed from domain of content of PISA test such as international report. Therefore, in Figure 4, it will be explained.

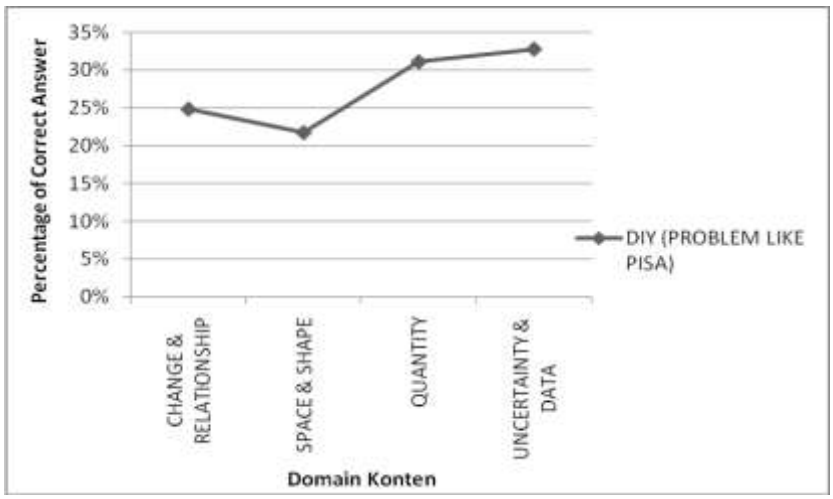

Figure 4. Percentage of correct answer based on content domain

Adopted from PISA test, there are four types of domain content that is (1) change and relationship, (2) space and shape, (3) quantity, and (4) uncertainty and data. From Figure 4, the percentage of correct answer done by 15^{th} years old students in Yogyakarta in solving problem like PISA for change and relationship was 25% and for space and shape content domain content was 22%. The percentage of correct answer for quantity content was 31% and then for uncertainty and data were 33%. From those achievements, it means that space and shape was the most difficult subject for Yogyakarta students. Now, the result viewed from content domain and compared to school category. In Figure 5 can be seen the diagram of the percentage of correct answer done by Yogyakarta students in solving problem like PISA.

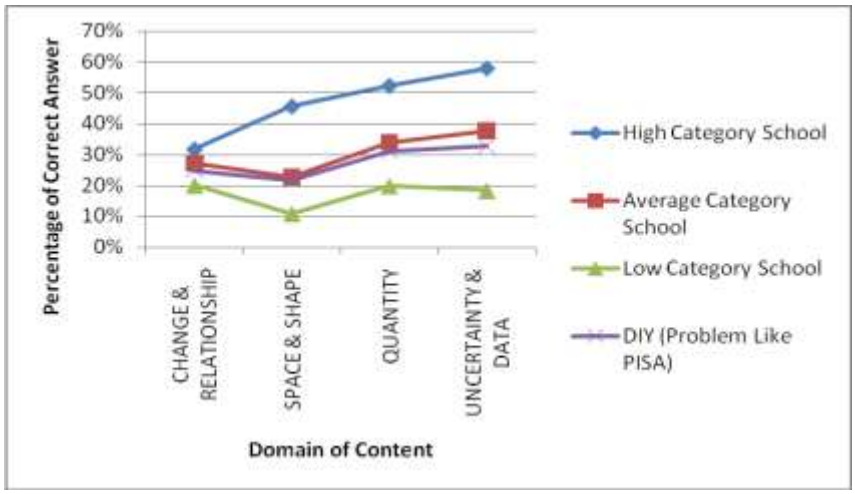

Figure 5. Percentage of correct answer based on content domain for each school's level

Previously, mathematics skill of Yogyakarta students viewed from content domain had been explained. Now, based on Figure 5 it compared to each school level. Students in high category school did better than average and low category in solving problem like PISA. It means that mathematics skill of fifteen years old students in line with school category. It can be seen from Figure 2 and 5 that overall skill students in Yogyakarta similar to students in average school. For more details about the percentage of correct answer based on both level of problem and content domain can be seen in Table 7.

Table 7. Percentage of correct answer based on level of problem and domain of content

	Change & Relationship	**Space and Shape**	**Quantity**	**Uncertainty & Data**
Level 1	85%	51%	80%	84%
Level 2	77%	46%	64%	35%
Level 3	51%	20%	51%	34%
Level 4	5%	15%	17%	10%
Level 5	0%	1%	6%	24%
Level 6	0%	2%	10%	2%

Table 7 explained that 15th years old students in Yogyakarta was still weak in solving reasoning problem in level 4 to 6 for all of domain of content. Almost all students could answer problem in level 1 to 3. From Table 7, change and relationship became the most difficult content in problem like PISA. Then, this study results were described by domain process and context. Figure 6 showed the percentage of correct answer in solving problem like PISA viewed from domain of process.

Figure 6. Percentage of Correct Answer Based on Domain of Process

There are three process assessed in PISA, so, in this study adopted it. First, formulating mathematical situations, then employing which using concepts, facts, procedures, and mathematical reasoning, and the last interpreting, implementing, and evaluating the results of mathematics. According to Figure 6 above, the percentage of correct answer for formulating process was 30% and employing process was 46%, then for interpreting process was 12%. Beside of that, mathematics skill of 15th years old students in Yogyakarta for formulating process was in low category with an average score 3.31 out of a maximum score of 11, while for employing process was in medium category with an average score 7.75 out of 17 and for interpreting process was in very low category with an average 2.34 out of 19.

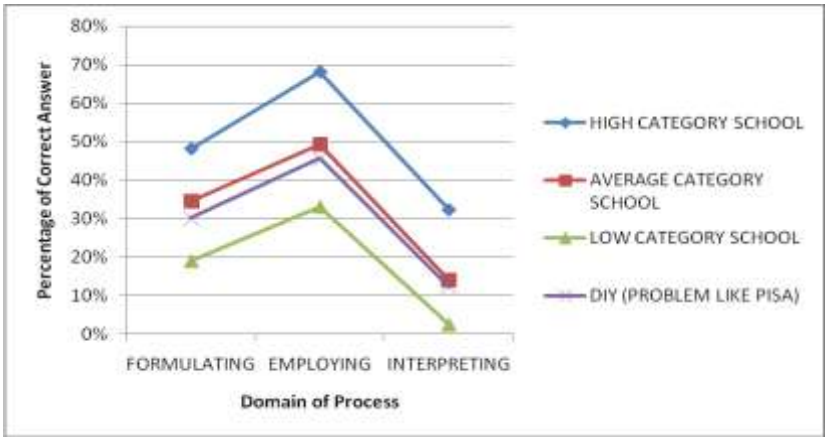

Figure 7. Percentage of correct answer based on domain of process for each schools level

Based on Figure 7 students in high category school did better than average and low category in solving problem like PISA. It means that mathematics skill of fifteen years old students in line with

school category. It can be seen from Figure 2, 5 and 7 that overall skill students in Yogyakarta similar to students in average school. From those sub domains, interpreting process was being the most difficult for students in all school level. Problem requiring employing process was the easiest one. Other than two domains explained previously, further description of students' skill in solving mathematics problem like PISA viewed from domain context was in the Figure 8.

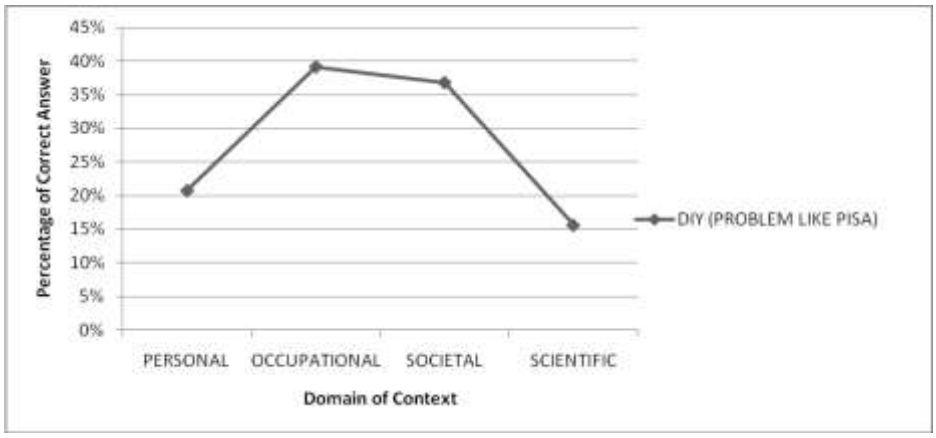

Figure 8. Percentage of correct answer based on domain of context

There are four context used in PISA test, that is personal, occupational, societal, and scientific context. Based on Figure 8, students had many errors when solving problem with scientific context. Precisely, students got good achievement when solving problem with occupational context. It happened because its context was around students' life. Students' skill in solving problem whose personal and scientific context belongs to very low category. It could be because they had mean 3.11 out of 15 and 1.25 out of 8 successively. While for occupational and societal context included low category with mean 3.52 out of 9 and 5.52 out of 15 respectively. After all, this result compared for school level which explicit in this following figure.

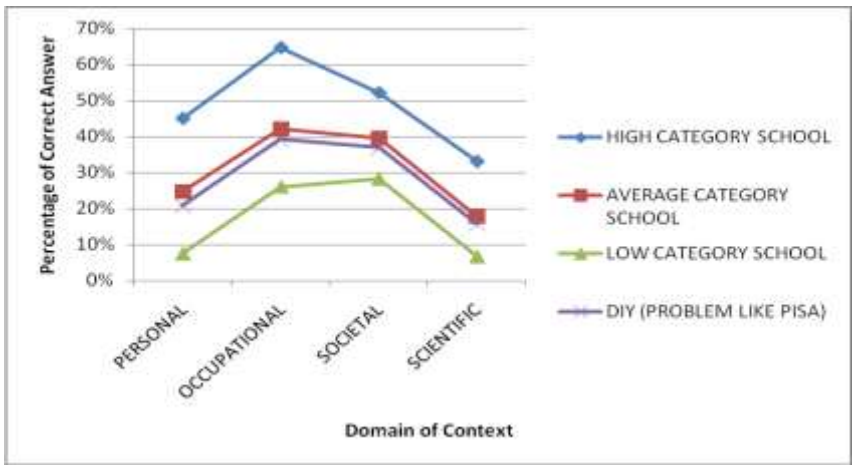

Figure 9. Percentage of correct answer based on domain of context for each school level

Based on Figure 9, problem using occupational context became the easiest one for both high and average school level, but not for low school level. Low school students got the most error when

solving societal problem. Then, seen from domain of context, mathematics skill of 15th years old Yogyakarta students closed to students in average school level. After all, this study result also found out which students' answer belong to full credit, partial credit, no credit or missing answer based on quantitative data analysis. Figure 10 below described the percentage of the number of students who had full credit, partial credit, no credit or missing answer in solving problem like PISA.

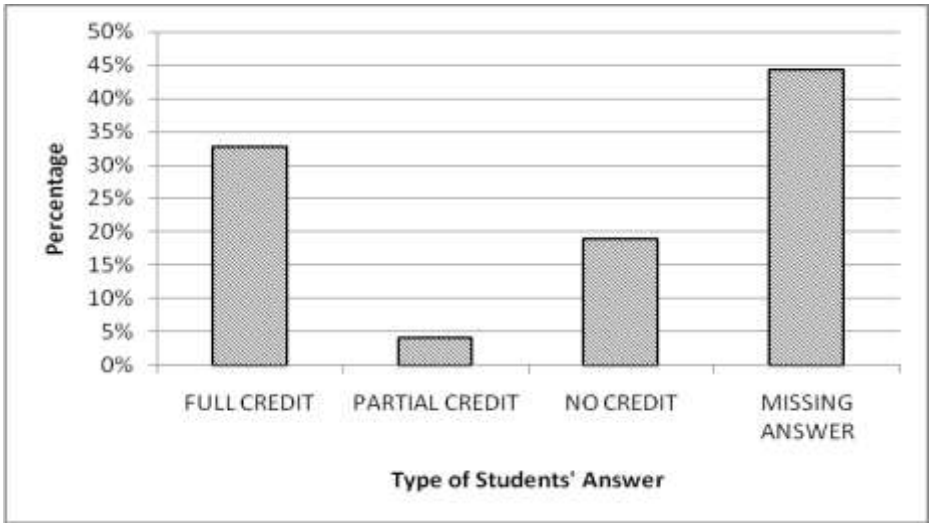

Figure 10. Percentage of students answer type in solving problem like PISA

According to Figure 10, the number of students whose full credit answer was 33%, while whose partial credit answer was 4%. Then, the number of students had wrong answers or no credit was 19% and with missing answer was 44%. The reason why almost half students had missing answer was they couldn't solve their problem and they skipped due to insufficient time. Furthermore, in Figure 11 can be known how students' answer in solving problem level 1 to level 6.

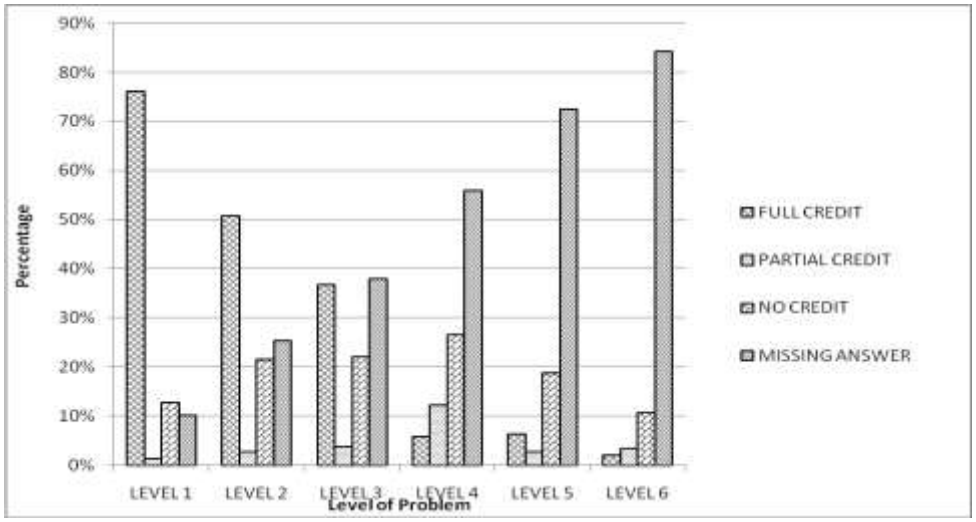

Figure 11. Percentage of students answer type in solving problem like PISA for each level

From Figure 11, almost all students had full credit answer for problem level 1 and just a few of students had no credit and missing answer. In line with the difficulty level, more difficult the problem,

less students could get full credit answer. Contrary to it, almost half and more students had missing answer for problem level 4, 5, and 6. Not only that, but also almost no students whose full credit answer for reasoning problem level 6. It showed that the majority of students didn't finish problem level 4, 5, and 6 because of lack of time or they couldn't answer properly because they are too complicated and difficult.

Students' mathematics skill level was linear with the school level. High school level showed better skill than average and low school level. This result in line with the study results from Rumasoreng & Sugiman (2014, p. 32) that the students' difficulties in solving problem like national exam (UN) was linear to the school level. Low level schools had highest difficulties and average level school had moderate difficulties, then high level school had lowest difficulty. Those encouraged this study result.

CONCLUSION

Mathematics skills of 15th years old students in Yogyakarta in solving problem like PISA was better than Indonesian students in PISA 2012, but it was still included in low category. Mathematics skill for quantity, uncertainty and data sub domain of content were in low category, while for change and relationship, space and shape content included very low category. Mathematics skill for formulating process was in low category, for employing process was in average category, and for interpreting process was in very low category. Based on these results further research was needed to find the reason why students had low skill in solving problem like PISA or similar research for other region. In addition, from this study result students should improve their mathematics skill to formulate mathematical situations, solve reasoning problem, interpret and evaluate arguments.

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