Indonesian Students' Mathematical Literacy And Attitude

Maria Ulfah[1*], Venny Karolina[2],Carla Queiroz[3]

[1,2] Lecturers at Tanjungpura University, Teachers' Training Faculty, Indonesia
[3]Academia BAI, Angola
*Corresponding Author:
Email : maria.ulfah@fkip.untan.ac.id

Abstract.
This study aimed to analyze gender differences in mathematical literacy and attitude among secondary school students in Indonesia. This study also assessed the correlation between mathematical literacy and attitude. Secondary data set of PISA Mathematic 2012 was used in this study. The participants of the survey were 5622 Indonesian secondary school students (2860 females and 2762 males). The findings of this study were as follows. Firstly, the study found evidence that compared to females (m=22.6%), male students (m=23.2%) had significantly higher scores in mathematical literacy ($p < 0.001$, $t = -1.630$, $df = 5542.617$). Secondly. there was no difference between male (m=3.07) and female students (m=3.06) in mathematical attitude ($p = 0.73$, $t = 0.431$, $df = 3716$). Lastly, this study found that there were no linear correlations between mathematical literacy and attitude ($p = 0.982$, $r < 0.001$).

Keywords: *Mathematical literacy, Mathematical attitude, PISA*

I. INTRODUCTION

Mathematical literacy is individual's ability to apply mathematical concepts in real life situation (Jablonka, 2003). Meaning, mathematical literacy is not restricted to the numerical ability. Rather, it is defined to a broader concept, the application of how people use mathematical knowledge in the context of human life. Mathematical literacy skill is considered as one of indicators of the success of someone in academic, professional, and social context. In a broader context, a system of country, this is a main skill needed for citizens that will give contribution to the development of a country (OECD, 2012a) as it is beneficial to solve a country's problems, such as population growth, finance, weather forecast, and so forth. Considering the significance of mathematical literacy skill for future generation, Organisation for Economic Co-operation and Development (OECD) in cooperation with ACER (Australian Council for Educational Research) have hold a global assessment called PISA (Programme for International Student Assessment) assessing mathematical literacy of 15-year-old students of OECD country members and other partner countries every three years since 2000 (OECD, 2014). Besides mathematical literacy, students' attitude toward maths was also assessed; it is considered important because the attitude toward the subject learned may affect students' learning positively (Bybee and McCrae, 2011). PISA data have been widely used by researchers or policy makers to get the depiction of global phenomena happened in relation to male and female students' mathematical literacy and attitude; however, only a few studies analysed them in Indonesian context (Nindya, 2015; Stacey, 2014). Therefore, this study aimed to fill that gap, investigating gender differences in Indonesian students' mathematical literacy and attitude as well as correlation between mathematical literacy and attitude.

a. Mathematical Literacy

Learning mathematics is crucial for human being because mathematical practices relate to many aspects of human life. For example, in cooking, correct proportions and ratios are applied when ingredients are added, or in crafting, the patterns on traditional craft are based on the geometry concept (Gerdes, 1999). Proportions, ratio, and geometry are the examples of how everyday life involves mathematical concepts. Mathematics is also a foundation of other branches of expertise, such as nursing, medicine, engineering, science, banking, and so on (Mullis & Martin 2014); therefore, OECD countries find it important to prepare the citizens to be math literate by holding PISA math assessing not only students' mathematical competence but also the insight of the application of mathematical concepts in real life; this refers to mathematical literacy. Mathematical literacy is someone's capability to use and apply the mathematical knowledge into life situations (Jablonka, 2003). In addition, Turner (2016, p. 3) claims that this skill refers to the ability to

connect math concepts in the "context" in which they are beneficial. Similarly, De Lange (2006) posits that mathematical literacy involves the use of knowledge of mathematics in real problems. From these three definitions of mathematical literacy, it is clear that the commonalities among them are life situations, context and real problem which all refer to living. Therefore, mathematical literacy means mathematical knowledge for living.

These definitions show that the construct of mathematical literacy consists of math knowledge, application, and real-life situation. This is in line with three main categories assessed in PISA math literacy: "content", "process", and "context" (OECD, 2013a, p. 27); "content" refers to mathematical knowledge assessed, such as algorithm, diagram, and so on, "process" means the application of mathematical entities they have to solve real life problems, and "context" deals with life situations where problems occur, for example personal contexts (sports, travel, shopping, and so forth) or society contexts (neighbourhood, public transport, and so on) (OECD, 2013a).Therefore, assessment items were developed based on these three sub-constructs: content, process, and context, to represent the construct of mathematical literacy.In relation to the results of this math assessment, the reports were distributed to participant countries, including to Indonesia. Indonesian students' score was low at 375 which was the second lowest of 65 countries. At this level, Indonesian students can do simple problem tasks which showed low mathematical achievement. However, the meaning behind the mean score of 375 might not be common for people who are not familiar with PISA. Hence, this inspired the researchers to report Indonesian's students in PISA math from different perspective, per cent correct answer, which is easily understood for readers.

b. Gender Differences in Mathematical Literacy

Some studies reported that there are gender differences in mathematical literacy; boys outperform girls. Rosselli, Ardila, Matute, & Inozemtseva (2009) found that boys show significant achievement in arithmetical subtests. Similarly, Royer, Tronsky, Chan, Jackson, & Marchant informed that high achievers of male students are more accurate and faster than female students on all of mathematical tasks (1999). Likewise, a longitudinal study of secondary school students conducted in Hong Kong showed that girls got higher marks in all subjects except mathematics (Wong, Lam, & Ho, 2002). So, these repeated investigations showed that gender differences in mathematical competence exist, and males do better than females in mathematical tasks.However, Hyde (2005) collected meta-analysis studies and found that 60% studies showed the effect size of gender differences was low which indicated that performance between male and female students is almost similar. Also, a study supported that the similarities in mathematical capabilities happen during childhood (Hyde, Fennema, & Lamon, 1990). Therefore, young males and females are slightly equal in terms of math competence. Nevertheless, other studies claimed that gender differences start growing in the early puberty and that disparity is higher at the last level of secondary education or in the early of senior high school (Cole & Willingham, 1997; Hyde et al, 1990; Maccoby & Jacklin, 1974; Mullis et al, 2000; Rosselli et al 2009; Wong et al, 2002). Therefore, age might play role regarding gender differences in maths competence. Considering that the changes in attitude might happen in adolescence, the writer aimed to replicate the previous studies to challenge it from different context, PISA 2012 mathematics of Indonesia.

c. Mathematical Attitude

Attitude is a response of someone toward something or somebody positively or negatively (Aiken, 1970). About attitude towards mathematics, Haladyna et al. (1983) identified that as an emotional nature toward mathematics and this feeling can be either positive or negative. Meanwhile, Neale (1969) specifically considered that mathematical attitude is classified into four categories: interest to mathematics which refers to liking or disliking, commitment which leads to engaging or avoiding mathematics, perception on the usefulness of mathematics and perception on one's competence: good or bad, toward mathematics. Therefore, it can be concluded that mathematical attitude is a construct defined as a tendency of someone toward mathematics consisting of some sub-constructs or sub-components: interest or motivation, self-determination, importance value and opinion on competence.These sub-constructs were, then, elaborated to measure math attitude. Baumert, Schnabel, & Lehrke (1998) associated the word interest in attitude to future learning achievement, while Nagy et al related it to future education and career choices (2004). Moreover, Fredricks & Eccles (2002) claimed interest as motivation value that drives someone to do something, and this value

consists of two sub-values: intrinsic value and usefulness value. Intrinsic value or intrinsic motivation is the willingness to do or to gain something while usefulness value or instrumental motivation refers to how one gets benefits for future plan, for instance learning mathematics in order to get specific job related to mathematics. In short, these studies have created indicators to predict someone's attitude to subject and PISA 2012 used them to measure math attitude.

d. Gender Differences in mathematical Attitude

Some studies showed similar reports that boys show more positive attitude to mathematics than girls (Eccles, 1987; Eccles et al., 1993; Frenzel et al., 2010; Frost et al., 1994; McLeod, 1994; Spinath et al., 2014; Wigfield et al., 1991). Specifically, boys feel more interested in math and the decline of girls' interest to math is sharper in upper grade (Frenzel et al., 2010). This is in line to the report of Wigfield et al. (1991) that although both genders like math in similar way, girls have less positive confidence toward their ability on math and this feeling even more negative when they are at level of senior high school (1991). Therefore, there might be a change with regard to attitude to math influenced by age; this change is similar to the one happened in math competence.The effect of age in girls' mathematical attitude was also reported by Eccles (1987) that the gender gap in mathematical attitude increases with age; the change of girls' attitude to math to negative is higher starting from adolescence. Therefore, it is not surprising that in higher level of education less girls take advanced mathematics (Spinath et al., 2014) as they might have negative attitude to math. In addition, boys are dominant at jobs dealing with math as they feel motivated in math and this motivation is a dominant factor for future orientation, for example future job or educational choice (Wigfield & Eccles, 1992). The disparity in gender does not only occur in math competence but also in math attitude which encouraged the researcher to replicate the study to verify previous studies' finding.

e. Relationship between mathematical attitude and competence

Positive attitude toward math is considered important to determine students' engagement in learning math and eventually will improve their achievement (Neale, 1969). Specifically, Neale (1969) further argued that attitude affects achievement and then achievement will influence attitude; therefore, the relationship is reciprocal. Ma and Kishor (1997) supported this by explaining that cognitive domain contributes to the affective domain and vice versa. In other words, it can be concluded that mathematical attitude might relate to mathematical achievement.Although these theories clearly described the rationale underpinning the relationship between math attitude and achievement, the findings of studies regarding this association are surprising; many studies showed that they failed to show evidence its relationship. Abrego (1966) investigated fourth grade school children in relation to their attitude toward arithmetic and the correlation coefficient was -.17 which showed evidence of no correlation. Similarly, Vachon (1984) made 23-item scale assessing fifth, sixth and ninth graders' math attitude and analyzed their relationship to math competence, but the correlation was low too. Interestingly, Anttonon (1967) did longitudinal study to test a scale measuring students' attitude to mathematics in 1960 and repeated administering the measure to the same students in 1966, and the result was, again, low correlation; this strengthens Abrego's (1966) and Vachon's (1984) findings of no correlation between math attitude and achievement.

However, a recent research's finding surprisingly contradicted to the previous studies. Larkin and Jorgensen (2016) conducted qualitative research by using iPads and video diary to collect information from the participants and they found that there is a correlation between attitude and math competence; students expressed their frustration because they did not understand to solve math problems. However, once they could tackle these math problems, they said that math was good, and they liked it. Positive attitude, feeling of liking toward math, reveals when they can succeed in math; meaning, it can be inferred that there is a correlation between attitude and math achievement.Contradictive finding was also found in a large-scale assessment of Trends in International Math and Science Study (TIMMS); 80% students from Cyprus showed their liking toward math although their math scores lower than average score, and vice versa, almost half of Japanese students showed negative tendency toward math although they have high math score (Beaton, 1996). This fact indicates that investigating attitude and its relation toward achievement is complicated, but this need replication in order to get more evidence about their correlation. Therefore, the researcher also investigated this correlation in this study.

f. Hypotheses

The hypotheses of this study are as follows.

1. There is a difference between Indonesian male and female students in mathematical literacy.
2. There is a difference between Indonesian male and female students in mathematical attitude.
3. There is a correlation between mathematical literacy and mathematical attitude of Indonesian students

II. METHODS

This is quantitative research which employed a PISA 2012 math data set obtained from official website of PISA. As the researchers did not directly carry out their own data, this is, then, called as secondary data. In relation to sample of this study, there were 5622 Indonesian students (2860 female and 2762 male) took part in PISA 2012. Regarding data analysis of identifying gender differences in Mathematical literacy, the authors did the following steps. Firstly, the descriptive statistics of number of participants and gender percentage were presented in form of a frequency table. Then, the calculation of per cent correct answer was conducted. Based on the raw data of PISA, the calculation of the scores are as follows: 2 for correct answer, 1 for nearly correct and 0 for wrong answer or no response. To get per cent correct answer, the total number of students' correct answer was multiplied by 100 and divided by the total correct answer of one booklet. After that, the mean of percent correct answer of mathematics score was calculated by using Independent Samples T-Test. This approach was used to calculate mean of PISA mathematical score as scale variable compared with two categories of the nominal variables: male and female (Connolly, 2007). Then, the comparative summary in tabular form was presented in table. The table indicated the mean score of male and female students, number of students and standard deviation.

In relation to analysis of gender differences in mathematical attitude, the steps are as follows. First, the summary of frequency of participant of this study was presented: this included those who gave responses and those who did not. Those who did not, then, were categorized as missing data. PISA mathematical attitude consisted of 8 indicators with the response for each item: 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree, 0 = missing. However, the researcher recoded the items for representing meaningful order of categories (4 = strongly agree, 3 = agree, 2 = disagree, 1 strongly disagree, and 0 = missing) (Connolly, 2007). After that, category of ordinal variable for math attitude was changed to scale variable in SPSS program; this is because this Likert-scale of PISA comprised 8 indicators to measure students' attitude which should be calculated by adding the responses students gave to find the tendency of students' attitude toward mathematics. This step adopted Connolly's (2007), Boone Jr's & Boone's (2012, p. 3) suggestion to calculate a Likert-scale which represent interval relationship rather than "greater than" relationship to calculate individual's tendency of attitude. After that, all indicators or statements responses were added; the overall score ranged from 16, indicating very little motivation toward math attitude, to 32, indicating the most motivated toward math. Then, the overall score was computed to find mean score for each individual. To find gender differences, the test used was Independent Samples T-test to compare two nominal variables: male and female, with scale variable of math attitude (Connolly, 2007).

Lastly, to start the analysis of correlation between Mathematical Literacy and Mathematical Attitude analysis, the descriptive statistics that comprised mean and standard deviation of both math literacy and attitude were displayed in table. Then, to find the early calculation correlation coefficient between these two variables, mathematical literacy and attitude, scatter plot was displayed. After that, to get more advanced analysis of correlation coefficient, Pearson Correlation Test was used to find association between these two scale variables (Connolly, 2007).

III. RESULTS AND DISCUSSION

Table 1 presented descriptive statistics of participants of PISA 2012 in Indonesia which was displayed into two columns based on gender differences. The total participants were 5622 with slightly different gender differences between female and male accounting for 50. 9 % and 49. 1 % respectively. This almost equal number of participants in gender shown in figure 1 is ideal to be sample of this research which focuses on gender differences in mathematical literacy and mathematical attitude.

Table 1. Gender Differences in PISA 2012

Participants of PISA 2012		
	Frequency	Per cent
Female	2860	50. 9 %
Male	2762	49. 1 %
Total	5622	100%

To test for the hypothesis 1, gender differences in mathematical literacy, the writers used Independent Samples T-Test. Table 2 shows that the difference between the mean per cent of correct answer on mathematical literacy of PISA 2012 of female and male students was found to be statistically significant ($p < 0.001$, $t = -1.630$, $df = 5542.617$). As $p < 0.005$ the writer can conclude that there is sufficient evidence to accept the alternative hypothesis (Connolly, 2007) that there is a difference between Indonesian male and female students in mathematical literacy.Meanwhile, mean scores of per cent correct answer of male and female students are 23. 2% and 22.6% respectively, indicating that 5622 Indonesian students (2860 female and 2762 male) of the distribution of the score, female students' score have more narrow range between the lowest and the highest score with narrower standard deviation, 14.8%. It indicates that 68% of female students in this study have correct answer between 7.8% (22.6%-14.8%) and 37.4% (22.6%+14.8%). Meanwhile, the standard deviation of male students' scores is 16.1%. Meaning, just over two thirds of all male students in the sample (68%) have per cent correct answer between 7.1 (23.2%-7.1%) and 39.3 % (23.2% + 16.1%). Therefore, although male students have higher average score than female students, two thirds of male students have a large range of score between the lowest to largest, 7.1% to 39.3%; in other words, more female students' scores cluster closely to mean score.

Table 2. Independent samples T-test: Mathematics Literacy by gender

	Gender	**N**	**Mean**	**Std deviation**	**Std error mean**
Per cent of correct answer Mathematics Literacy	Female	2860	22.6%	14.8%	0.28%
	Male	2762	23.2%	16.1%	0.30%

Independent samples test

		Levene's test for equality of variances		T-test for equality of means						
								95% confidence interval of the difference		
		F	Sig.	T	Df	Sig. (2-tailed)	Mean difference	Std error difference	Lower	Upper
Math literacy	Equal variances assumed	12.943	0.000	-1.632	5620	0.103	-0.67 %	0.41%	-1.48 %	0.13%

Equal variances not assumed	-1.630	554 2.617	0.103	-0.67%	0.41%	-1.48%	0.13%

The finding shows that Indonesian students have low mathematical literacy; the mean of percentage of correct answer is only 23. 2% and 22.6% for male and female students respectively. Consequently, Indonesian students' mathematical literacy position is on the 64th out of 65 countries (OECD, 2014). In relation to the hypothesis 1, the result indicates that there is gender difference in mathematical literacy in Indonesian context ($p < 0.001$, $t = -1.630$, $df = 5542.617$) which male students outperform females. This finding is in line with PISA 2012 assessment result across 65 countries in which girls underperform boys with the gap 11 points (OECD, 2014); this phenomenon does not only happen in Indonesia but also in other countries. The result of this study supports previous studies in terms of the superiority of male students in mathematic achievement (Rosselli et al, 2009; Royer et al, 1999; Wong et al, 2002). Furthermore, some studies found that during childhood there are no gender differences in math achievement, but the difference starts reveal at the early puberty (Hyde et al, 1990; Maccoby & Jacklin, 1974). Therefore, a slight difference of 0.6% in math literacy between male and female adolescents in Indonesian context supports previous finding that boys start being more math literate at the early puberty.

Hypothesis 2 was tested with Independent Samples T-Test. First, the summary of Indonesian participants at survey of mathematical attitude PISA 2012 was displayed (table 3). Of 5622 students, there were 3718 (66.1%) students who answered the questionnaire. Meanwhile, there were 1904 (33.9%) students who did not complete the survey; so, these were excluded in the analysis and categorized as missing data. The responses of students were categorized into four items: 1= strongly disagree, 2 = disagree, 3 = agree, and 4= strongly agree. The result showed that the highest percentage of students' responses was "agree" statement which accounted for 71 % (Table 5). The mean score of male and female attitude was 3.06 and 3.07 respectively which closely leaned to "agree" statement or positive attitude. The difference between male and female attitude to mathematics was not found to be statistically significant ($p = 0.73$, $t = 0.431$, $df = 3716$). It is clear that $p > 0.005$, so there was not sufficient evidence found of a difference between boys and girls in mathematical attitude (Connolly, 2007).

Table 3. Maths Attitude in PISA 2012

Participants of maths attitude Indonesia PISA 2012

		Frequency	Per cent
	Valid	3718	66. 1 %
	Missing	1904	33. 9 %
Total		5622	100%

Table 4. Summary of attitude to mathematics: all respondents

ALL

		Valid per cent
Maths attitude	Strongly disagree	0.2
	Disagree	7.4
	Agree	71.7
	Strongly agree	20.7
	N	3718

Table 5. Independent samples T-test: Mathematics Attitude by gender

Gender	N	Mean	Std deviation	Std error mean
Female	1886	3.07	0.46	0.01
Male	1832	3.06	0.47	0.01

		Levene's test for equality of variances		t-test for equality of means						
									95% confidence interval difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean difference	Std error difference	Lower	Upper
Maths Attitude	Equal variances assumed	0.126	0.723	0.431	3716	0.666	0.007	0.015	-0.023	0.037
	Equal variances not assumed		0.723	0.431	3711.524	0.666	0.007	0.015	-0.023	0.037

Mathematics Attitude

Independent samples test

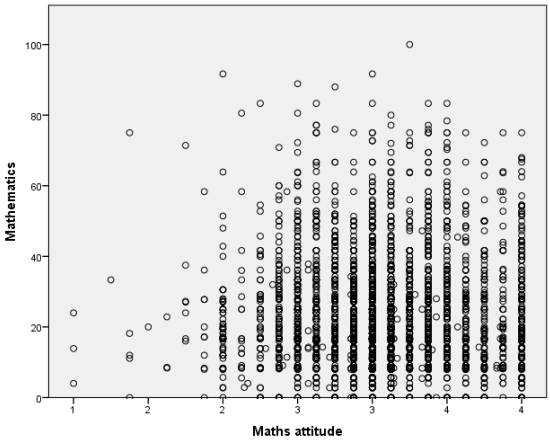
The result of this study highlights that Indonesian students in majority have positive attitude toward mathematics with 71.7% for "agree" and 20.7% for "strongly agree" responses. Meanwhile, negative responses account for 0.2% and 7.4 for "strongly disagree" and "disagree" response respectively. In relation to hypothesis 2, this study found that there was no difference between male and female students in mathematical attitude ($p = 0.73$, $t = 0.431$, $df = 3716$). The mean scores are 3.07 and 3. 06 for female and male students respectively which the scores are really closed with only 0.01 margin. This finding contradicts to PISA 2012 general result (OECD, 2014) and past studies finding that girls have more negative attitude toward maths than boys (Eccles, 1987; Eccles et al., 1993; Frenzel et al., 2010; Frost et al., 1994; McLeod, 1994; Spinath et al., 2014; Wigfield et al., 1991; Wigfield & Eccles, 1992); in other words, they showed evidence of gender differences in math attitude. In contrast, this study showed evidence that both male and female Indonesian students have slightly equal positive attitude to math.The test for hypothesis 3 is Pearson correlation. Table 6 shows the output that there was no linear correlation between mathematical literacy and attitude ($p = 0.982$, $r < 0.001$). As can be seen from figure 1, there was no linear relationship shown between two these variables. The $p > 0.005$ indicates that there was not sufficient evidence of correlation between maths literacy and attitude (Connolly, 2007).

Table 6. Correlation between mathematical literacy and attitude

Correlations			
		Maths Attitude	Maths literacy
Maths attitude	Pearson Correlation	1	0.000
	Sig. (2-tailed)		0.982
	N	11392	11392
Mathematics	Pearson Correlation	0.000	1
	Sig. (2-tailed)	0.982	
	N	11392	11392

** There is no linear correlation at the 0.982 level (2-tailed)

Fig 1. Correlation between Maths attitude and Maths literacy



This study found that there was no linear correlation between mathematical literacy and attitude ($p = 0.982$, $r < 0.001$). This supports other studies (Abrego, 1966; Anttonon, 1967; Beaton, 1996; Vachon, 1984) which found that correlation between these two variables ranging from no to low correlation. However, qualitative research conducted by Larkin & Jorgensen (2016) got contradictive finding; mathematical literacy relates to math attitude. This study does not apply quantitive approach so that this study cannot show statistical evidence to support his findings. Alternatively, Jorgensen used students' opinion as the data and the finding is that students show their liking toward math once they feel that they can solve the math problems (2016). This finding supports other theories that attitude, and achievement are correlated and have cause and effect each other (Ma and Kishor, 1997; Neale, 1969).Interestingly, studies which used quantitative method did not find sufficient evidence that the attitude and competence are correlated. Ajzen & Fishbein (1977) said that there was no theoretical basis that support the notion of consistency between preferable behaviour and performed behaviour. However, they argued that the consistency between attitude and behaviour can be measured if they are directed in the same action; therefore, the predictor or indicator of the measure should be closed to an action. Also, general measure is difficult to measure attitude. For example, it is measurable if a study investigates about attitude toward problem solving instead of investigating general attitude toward mathematics.

IV. CONCLUSION

This study focused on the investigation of the effect of gender in mathematical literacy and attitude among secondary school students in Indonesia. Besides. The authors also explored the association between mathematical literacy and attitude. Secondary data set of PISA Mathematic 2012 was used in this study. The participants of the survey were 5622 Indonesian secondary school students (2860 females and 2762 males). The findings of this study were as following. Firstly, the study found evidence that compared to females, male students had significantly higher scores in mathematical literacy. The second research finding was that there was no difference between male and female students in mathematical attitude. Finally, the authors found evidence that there were no linear correlations between mathematical literacy and attitude.

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