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The Influence of Attitudes towards Mathematics, and Metacognitive Awareness on Mathematics Achievements

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Abstract

The aim of this study was to investigate the influence of attitudes towards mathematics and metacognitive awareness on mathematics achievement of high school students. In addition, this study interested in examining gender differences on mathematics achievement. The respondents of this study were 103 students of a senior high school in Tangerang, Indonesia. Attitudes Towards Mathematics Inventory (ATMI) was used to measure students' attitudes towards mathematics, and Metacognitive Awareness Inventory (MAI) was used to measure metacognitive ability, whereas mathematics achievement was measured from the value obtained in the school report cards of the semester when the research was being conducted. The results revealed that attitudes towards mathematics and students' mathematics achievement were significantly correlated ($r = 0.505$; $p < 0.001$). No significant correlations were shown between metacognitive skills and mathematics achievement ($r = 0.081$; $p > 0.05$), as well as between attitude towards mathematics and metacognitive skills ($r = 0.143$; $p > 0.05$). The regression model was fit in predicting the contribution of attitudes towards mathematics and metacognitive skills on mathematic achievement for 25.5%. However, looking at the p value of the t test it was shown that the attitude towards mathematics contributes to the model, but not the metacognitive skills. No significant difference was found on mathematics achievement.

Keywords

Metacognition, Metacognitive Ability, Attitude Towards Mathematics, Mathematics Achievement

1. Introduction

Mathematics is useful in helping students to understand other areas of study and

to be able to think logically, analytical, systematic, critical, and creative. Mathematics is a subject that is closely related to the development of science and technology. The more advanced science and technology of a nation, the more advanced the state anyway. In addition, because science and technology have a very valuable contribution to economic development and prosperity of the nation, the advancement in science and technology will also determine the welfare of the nation. Nowadays many professions need mathematical analysis and expect mathematical skills in solving novel problems. From this description, it is clear that mastery of mathematics will be very important for every individual as well as for every nation. In the case of Indonesia, the report of Program International Student Assessment (PISA) in 2012 (OECD, 2014), showed that the achievement scores of Indonesian students in mathematics are recorded very low to 375 which is below the OECD average of 494, and was ranked the 64th out of 65 countries.

Rice, Barth, Guadagno, Smith, & McCallum (2013) reported that the interest of students to the Science, Technology, Engineering and Mathematics (STEM) is very low due to three factors, i.e.: students' attitude towards STEM, students' perception on their ability to STEM, and social support on the development of abilities and careers in STEM. In comparison to other subject, students tend to be negative towards STEM (Rice et al., 2013; Goodykoontz, 2008), and perceptions of their ability in mathematics are closely linked to mathematics achievement (de Backer & Nelson, 2000; Rice et al., 2013). The study of Veloo, Noor, and Khalid (2015), reported that the relationship between students' attitude towards Physics and achievement in Physics was positively significant. Students who have positive attitude in Physics get good grades in Physics, and those who have negative attitude towards Physics get low grades.

In comparison to the female students, Asante (2012) reported that male students are more positive towards mathematics. The findings of Veloo et al. (2015) reported that there is gender difference in students' attitude towards physics. Male students are more interested in Physics than the female. Even though on the study of Guner (2012) gender differences did not influence the attitudes towards mathematics, the study revealed that the attitudes towards mathematics were different among students of schools that prepared students for a university education and vocational schools. Students of schools that prepare students for a university education have more positive attitudes towards mathematics than students of the vocational schools that prepare them to work.

From the above explanation, two research questions formulated. First, is there any relationship between attitudes towards mathematics, metacognitive skills and mathematics achievement among high school students? Second, is there any gender difference in mathematics achievement? Referring to this research questions this study aimed at showing that there is correlation between attitudes towards mathematics, metacognitive skills and mathematic achievement. It also intends to reveal the difference between male and female students on mathematics achievement.

Attitudes towards Mathematics

Lack of interests and negative attitudes towards mathematics were problems that should be encountered by students in learning mathematics, because mathematics is regarded as a difficult subject and obscure (Ganal & Guiab, 2014). According to Hart (Zan & Di Martino, 2007), student's attitudes towards mathematics is defined as the emotional response either positive or negative associated to mathematics, confidence to succeed in studying mathematics, and strategies in coping with mathematical problems. Previous studies on mathematics reported that attitudes towards mathematics have important role in determining learning achievement on mathematics, and students with positive attitudes towards mathematic will have high scores in mathematics achievement (Tapia & Marsh, 2004; Zan & Di Martino, 2007; Guner, 2012). Yet, studies also reported that many students have poor attitudes towards mathematics (Goodykoontz, 2008). In the study of Hamid, Shahrill, Matzin, Mahalle and Mundia (2013), mathematics achievement correlated with mathematics anxiety, self-esteem, proactive coping, and test stress.

Attitudes of the students affect their cognitive activities. By having a positive attitude towards mathematics, the students will feel that mathematics is important so that they will try to improve their mathematics learning achievement. Students who have negative attitudes tend to be difficult to pay attention in math. According Eshun and Zan, Mata, Monteiro, & Peixoto (2012), negative attitudes associated with negative emotional disposition. The disposition of these emotions have an impact on student behavior consider the useful of mathematics, and do not enjoy math. Therefore, a positive attitude is necessary for students to learn to voluntarily and obtain benefits.

Metacognitive awareness

Metacognition first introduced by Flavell as "any knowledge or cognitive activity that takes as its object or regulates any aspect of any cognitive enterprise". Metacognition is an important element in solving problems and learning process of the students, as well as being the main factor in determining learning achievement (Bedel, 2012). Wang, Haertel and Walberg (Bedel, 2012) stated that metacognition is a powerful predictor in predicting student learning. According to Swanson (in Schraw & Dennison, 1994) metacognition is the individual's knowledge about cognitive processes as well as the ability of individuals to control the cognitive processes performed when undergoing a learning process. While Kuiper (in Schraw & Dennison, 1994) defines metacognition as self-communication of individuals who are undergoing learning activities with respect to the requirements required by the cognitive activity and requirements for the learning tasks faced by students. Self-communication carried out, before the learning process, when the learning takes place, and after the learning process occurs. Thus, in metacognition thinking activities covered when learning takes place, as well as the revision of the learning process when learning is ongoing. In short, metacognition is awareness of how individuals acquire knowledge, and how to control the process in acquiring knowledge (Schraw & Dennison, 1994).

Flavell (in Schraw & Dennison, 1994; Surat, Rahman, Mahamod, & Kummin, 2014) suggests that metacognitive knowledge consists of three components, namely (1) declarative knowledge-knowledge about your own self or individuals, "knowledge about" or "knowledge concerning", (2) procedural knowledge-knowledge of the tasks or activities; and (3) conditional knowledge-knowledge of learning strategies. Included in the declarative knowledge are facts, beliefs, views, generalizing, theories, hypothesis, and attitude toward something or someone. All this knowledge is stored in the system memory, and in the process of learning, declarative knowledge related to the question. What do you want me to know? What information will I gain by studying this learning material? What actually I already know? What information should I look for?

Procedural knowledge is knowledge of "how to" do cognitive activities and includes how to control the cognitive processes. Procedural knowledge with regard to the question, how will the information and the knowledge gained be used? What steps should I do so that I can complete a given learning task? Conditional knowledge, meanwhile, is an activity that relates to the question "when" and "why" of a strategy or procedure performed in the learning process. So conditional knowledge is knowledge of the individual will be learning strategies for specific learning materials. This means that the strategy may change in accordance with the learning materials and the learning tasks be at hand.

Gender Differences in Mathematics Achievement

Based on research conducted by Pajares and Graham in 1999 (in Nicolaidou & Philippou, 2002), students of junior high school, both males and females have the same confidence in dealing with mathematics. Also, study by Scafidi and Bui (2010), found that there were gender similarities in math performance moderated by race, socioeconomic status, or math ability. However, when they are in senior high school, male students showing more confidence than the female (Tella, 2011). From the study of Frenzel, Pekrun and Goetz (2007) it was reported that less women enjoy and be proud of math. Instead, they are more prone to feelings of anxiety, shame and despair. Mathematics is often consider a male domain in terms of self-concept and attitudes associated with self-confidence of students, and can affect the learning achievement of mathematics students, especially in high school. As it is reported on Asante study (2012) with high school students in Ghana that boys get high scores on the subscales of ATMI than the girls, especially in the total scores of ATMI and on the self-confidence subscales.

Research Questions and Hypotheses

The focus of this paper is to answer the following questions 1) is there any correlation between attitudes towards Mathematics, metacognitive awareness, and Mathematics achievement, and 2) is there any gender difference in Mathematics achievement among high school students. Thus, this paper aimed to test the following two hypotheses:

1. There is significant correlation between attitudes towards Mathematics, metacognitive awareness and Mathematics achievement among high school stu-

dents.

2. There is gender difference in Mathematics achievement among high school students

2. Methods

The current study applied a quantitative approach, with two independent variables (1) attitude toward mathematics and (2) metacognitive awareness. The dependent variable of this study is Mathematics achievement

2.1. Sample

A non-random sampling technique applied in this study. In total 103 students (female n = 53 and male n = 50) of grade 10 (n = 40), grade 11 (n = 33), and grade 12 (n = 30) of one senior high school in Tangerang, Indonesia, participated in this study.

2.2. Research Instruments

Demographics data on gender, grade and age was collected based on a questionnaire distributed to students of senior high school.

In this study, the short version of Attitude towards Mathematics Inventory (ATMI) developed by Lim & Chapman (2013) was adapted into Bahasa Indonesia, and used to measure students' attitudes toward mathematics. In this inventory (in total 19 items) there are four sub-scales, i.e.: self-confidence in mathematics (5 items), perceived value of mathematics (5 items), mathematics enjoyment (5 items), and mathematics motivation (4 items). Scores of attitudes towards mathematics is the total score of the four domains in ATMI. The scores on self-confidence in mathematics describe students' self-esteem and self-concept on their performance in mathematical tasks. The scores on perceived value of mathematics describe students' beliefs on the usefulness, relevance and value of mathematics in the present life and the future. The scores on enjoyment of mathematics describe the pleasure of students in learning mathematics in class. The scores on motivation to do mathematics describe students' interest on mathematics and willingness to continue their study on mathematics. ATMI is a five point Likert scale from strongly disagree, to strongly agree. The students were asked to answer their degree of agreement with each statement. ATMI scores obtained by adding the entire item contained in ATMI scale.

Prior to the implementation of ATMI, the item was translated into Bahasa Indonesia and backed translated into English. A procedure of try-out was carried out with 265 students of five secondary schools in Jakarta and Tangerang City. The overall validity of ATMI was confirmed for 0.615, and the reliability or Cronbach α is 0.932. The Cronbach α of short ATMI as reported by Lim & Chapman (2013) is 0.97. The internal consistencies of the items ranging from 0.505 - 0.791 (see **Table 1**).

Metacognitive Awareness Inventory (MAI) developed by Schraw & Dennison (1994) was adapted—translated into Bahasa Indonesia and backed translated

Table 1. Validity and Reliability of ATMI.

		items	Items no	r	Cronbach α
1	self-confidence in mathematics	5	3, 7, 11, 15, 18	0.505 - 0.556	0.93 - 0.931
2	perceived value of mathematics	5	4, 8, 12, 16, 19	0.529 - 0.67	0.928 - 0.93
3	mathematics enjoyment	5	1, 5, 9, 13, 17	0.635 - 0.791	0.925 - 0.928
4	mathematics motivation	4	2, 6, 10, 14	0.557 - 0.708	0.927 - 0.93

into English, and used in this study to measure metacognitive skills. There are two factors measured in MAI, i.e. metacognitive knowledge and metacognitive regulations. MAI is a 5-point Likert Scale from strongly disagreement to strongly agreement, and constructed by 52 items. Including in metacognitive knowledge are procedural and conditional knowledge, whereas including in metacognitive regulations are information management strategies, comprehension monitoring, debugging strategies, and evaluation. Scores on metacognitive knowledge describe students' general knowledge of their cognitions in processing learning. Scores on metacognitive regulation describe students' ability in regulating and controlling their learning processes. The overall validity of MAI is 0.345, r Pearson product moment used to calculate the correlations of score item with the total score. The correlation is ranging from 0.115 to 0.518. The internal consistencies found the Cronbach alpha 0.869 (see Table 2).

Student academic achievement in mathematics is the student learning outcomes in mathematics, as it was show in the report card of the first semester in 2012/2013 academic year.

2.3. Statistical Analysis

Statistical analysis was performed through Statistical Package for Social Science/SPSS version 17.0. The analysis of correlation among variables–attitudes toward mathematics, metacognitive awareness and mathematics achievement, was executed through multiple regression, since this study is intended to predict the value of attitudes toward mathematics and metacognitive awareness as the independent variables on mathematics achievement as the dependent variable. Analysis of means differences on mathematics achievement between the male and female students was performed through analysis of variance. All results were considered statistically significant for a confidence of 95%.

3. Findings

1) Demographic characteristics of the students

Table 3 below shows demographics characteristics of the students participated in this study. Based on gender characteristics, it is shown that more female students than the males, and based on grade of the students, more grade 10 students involved in this study. Referring to their age, more students are 15 years old.

2) Goodness-of-Fit Test

Table 2. Validity and Reliability of MAI.

Domain	Sub-Domain	Item	r-pearson	Cronbach Alpha
Metacognitive Knowledge	Declarative Knowledge	5, 10, 12, 16, 17, 20, 32, 46	0.115 - 0.449	0.865 - 0.88
	Procedural Knowledge	3, 14, 27, 33	0.264 - 0.498	0.864 - 0.867
	Conditional Knowledge	15, 18, 26, 29, 35	0.252 - 0.391	0.865 - 0.867
Metacognitive Regulation	Planning	4, 6, 8, 22, 23, 42, 45	0.307 - 0.433	0.865 - 0.867
	Information Management Strategies	9, 13, 30, 31, 37, 39, 41, 43, 47, 48	0.184 - 0.433	0.865 - 0.868
	Comprehension Monitoring	1, 2, 11, 21, 28, 34, 49	0.283 - 0.474	0.864 - 0.867
	Debugging Strategies	25, 40, 44, 51, 52	0.251 - 0.388	0.865 - 0.867
	Evaluation	7, 19, 24, 36, 38, 50	0.185 - 0.518	0.863 - 0.868

Table 3. Demographic characteristics of the students.

No.	Characteristics	N = 103	%
1	Gender		
	female	52	50.5
	male	51	49.5
2	Grade		
	10	40	38.8
	11	33	32.1
	12	30	29.1
3	Age		
	15	31	30.1
	16	32	31.1
	17	33	32
	18	7	6.8

One-sample Kolmogorov-Smirnov test was used to test the goodness-of fit. The result indicated that scores of attitudes towards mathematics and metacognitive skills were normally distributed and can be analysed by using a parametric statistics (see Table 4).

3) Correlations between Students' Attitudes towards Mathematics, Metacognitive Skills and Students' Achievements in Mathematics

Table 5 below shows the correlation between attitude towards mathematics, metacognitive skills and mathematic achievement. The result indicated that the correlations between attitude towards mathematics and achievement on mathe-

Table 4. One-sample Kolmogorov-Smirnov.

		Scores of ATMI	Scores of MAI
N		103	103
Normal Parameters[a,b]	Mean	63.9029	167.9029
	Std. Dev	12.95657	16.76336
Most Extreme Differences	Abs	0.059	0.092
	Pos	0.059	0.046
	Neg	−0.054	−0.092
Kolmogorov-Smirnov Z		0.6	0.931
Asymp. Sig. (2-tailed)		0.864	0.352

[a]Test distribution is Normal; [b]Calculated from data.

Table 5. Correlations between students' attitude towards mathematics, metacognitive skills, and students achievement in mathematics.

		Achievement	Attitude	Metacognitive
Pearson Correlation	Achievement	-	0.505	0.081
	Attitude	0.505	-	0.143
	Metacognitive	0.081	0.143	-
Sig. (1-tailed)	Achievement	-	0	0.209
	Attitude	0	-	0.075
	Metacognitive	0.209	0.075	-
N		103	103	103

matics is significant (r = 0.505; $p < 0.001$), whereas the correlations between metacognitive skills and achievement is not significant (r = 0.081; $p > 0.05$) as well as the correlation between attitude to mathematics and metacognitive skills is not significant (r = 0.143; $p > 0.05$).

4) The influence of Attitude towards Mathematics, and Metacognitive Skills, on Achievement in Mathematics

Multiple regression analysis was conducted to examine the relationship between students' attitude towards mathematics, and metacognitive skills on students' mathematics achievement. The result gave the equation of the form $y = 56.051 + 0.298\ x_1 + 0.004\ x_2$.

Table 5 summarizes the result of multiple regression analysis. The result indicated that the R^2 values of attitude towards mathematics and metacognitive skills on mathematics achievement is 0.255, which can be interpreted that the contribution of attitude towards mathematics and metacognitive skills on mathematic achievement is rather poor (25.5%), however the overall correlations was significant ($F_{(2,102)} = 17.145$; $p < 0.05$). This regression model is fit in predicting the values of mathematic achievement for given values of attitudes towards mathematics and metacognitive skills. Looking at the p value of the t test, it is shown that the attitude towards mathematics contributes to the model, but not the metacognitive skills (see Table 6).

5) Gender Differences on Mathematic Achievement

The following table shows the result of Analysis of Varians between gender as predictors and mathematic achievement as dependent variables. Students achievement on mathematics is not significantly different based on gender differences ($F_{(1,101)} = 3.408$; $p > 0.05$) (see Table 7).

4. Discussion

The result of this study indicated that the independent variables, i.e. attitudes towards mathematics and metacognitive skills contribute to the changes of students' mathematics achievement for 25.5%, whereas 74.5% were contributed by other factors. Positive attitude towards mathematics is needed to affect one's willingness to learn mathematics. However, the contribution of metacognitive skills on mathematics achievement is not significantly fit to the model. It might be

Table 6. Multiple regression of attitude towards mathematics, metacognitive skills and mathematics achievement.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.505[a]	0.255	0.24	6.67169

[a]Predictors: (Constant), Scores on ATMI and Scores on MAI.

ANOVA[b]						
Model	Sum of Squares		Df	Mean Square	F	Sig.
1	Regression	1526.295	2	763.147	17.145	0.000
	Residual	4451.142	100	44.511		
	Total	5977.437	102			

[b]Dependent Variable: Mathematics achievement.

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig
	B	Std Error	Beta		
(Constant)	56.051	7.048		7.95	0
Attitude	0.298	0.052	0.504	5.78	0
Metacognitive	0.004	0.04	0.009	0.1	1

[a]Dependent Variable: Mathematics achievement.

Table 7. Gender differences on mathematic achievement.

	Sum of Squares	Df	Mean Square	F	Sig
Regression	195.09	1	195.09	3.408	0.68
Residual	5782.35	101	57.251		
Total	5977.44	102			

possible that students do not use all components of metacognitive skills in learning at school including in learning mathematics or do not yet develop their metacognitive skills. This means that they do not merely need metacognitive knowledge. Instead they also need to know how to regulate their learning when confronted with stressors in learning. As Zimmerman (1998) stated that in learning students do not just be enough to have metacognitive knowledge, but they also should have metacognitive regulation.

Relevant with the prior study (Ma & Kishor, 1997; Pajares & Graham, 1999; Nicolaidou & Philippou, 2002; Scafidi & Bui, 2010), the result of this study indicated that there is no significant difference on mathematics achievement between male and female students. Referring to the study carried out by Nicolaidou & Philippou, 2002, achievement motivation of female students is higher than the achievement motivation of male students. Such high achievement motivation will influence the development of positive attitude towards mathematics which then will influence the high scores of mathematics achievement among female students.

Students with high skills on metacognitive knowledge and metacognitive regulation will be motivated as they have intrinsic motivation, high self-efficacy, and orient towards understanding the task (Vrugt & Oort, 2008; Coutinho & Neuman, 2008). In this case, of course, students must learn how to use both aspects of metacognitive skills to improve their mathematics learning achievement. Previous studies show that metacognitive skills can be improved through training (Roll, Holmes, Day, & Bonn, 2012) for problem solving in geometry of the fifth grade students (Sahin & Kendir, 2013). Therefore, in developing their teaching-learning strategies teachers should not only focus on the accomplishment of knowledge. Rather teachers should also provide students with skills on how to process and to regulate their learning. Process oriented instruction that enhances positive attitudes toward mathematics and high metacognitive awareness will be the key success for the mathematics achievement of the students. Also, as Hamid et al. (2013) found in their study that negative dimensions of mathematic anxiety, self-esteem, and proactive coping were correlated negatively to mathematics achievement, it is important for the teachers to put attention on the educational intervention and counseling to help the at-risk and vulnerable students.

This study shows that metacognitive knowledge and metacognitive regulations are two important aspects of learning. Therefore, training on how to use both aspects is regarded crucial, thus, research on the effectiveness of the training can be planned for the future. This study supports the importance of mathematics for the quality of human life, however, not all students see mathematics as an enjoyable subject matter. Instead they see mathematics as stressor that should be avoided. It is therefore, essential to do research and training on how mathematics can be taught as interesting and enjoyable subject matter. This study does not take external factors that hinder the metacognitive knowledge and metacognitive regulations of the students.

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