The Interaction of Meta-cognitive Strategy and Mathematical Disposition on Problem-Solving Ability

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Abstract
This study investigated the interaction effect of meta-cognitive strategy on mathematical disposition and problem-solving ability. This is a quasi-experimental study with 2 x 2 factor design. The subjects of this study were 138 students of 8th grade in Islamic Junior High School in Jombang, Indonesia which is divided into two groups i.e. control class and experiment class. There were 69 students in the experimental group with metacognitive strategy and 69 students in the control group with conventional strategy. Data were collected through mathematics questions test and mathematical disposition questionnaire. The mathematical disposition questionnaire was used to determine the students' mathematical disposition abilities. The data were analysed using analysis of variance. The study reports that there is no significant interaction effect of metacognitive strategy on the mathematical disposition and problem-solving ability.
Keywords-*Meta-cognitive Strategy, Mathematical Disposition, Problem-Solving Ability*

1. Introduction

The implementation of student learning is the main goal of educational institutions. This implementation requires several processes such as planning, application of knowledge, monitoring, regulation, and reflection (Azevedo, 2009), all of which are in the meta-cognition domain. The term meta-cognition was proposed by Flavel (1979). He considers that meta-cognition is a knowledge that involves assessing, monitoring, and controlling meta-cognitive processes and activities (Flavel, 1979). Meta-cognition is the main factor for predicting learning performance in the problem-solving domain (Jacobes & Harskamp, 2012). Heppner (1988) introduces three constructs for the problem-solving process. They are problem-solving beliefs (believing in one's ability to solve problems), personal control over emotions and behavior (believing a person can control their emotions and behavior while solving real-life problems), and coping styles in avoidance-orientation (the tendency or avoidance of individuals to solve social problems) (Chan, 2001). Following the work of Flavell (1979) and Brown (1987) on meta-cognition, there is a consensus among psychologists and educational researchers that meta-cognition is defined as knowledge of cognition and regulation of cognition. Further, according to Susilowati, Degeng, Setyosari & Ulfa (2019), conceptual understanding will increase if given maximum assistance. In other words, if students' problem-solving ability is improved, it will have an impact on learning outcomes and understanding of concepts.

Based on the results of the Program for International Student Assessment (PISA) 2016, which was carried out by the Organization for Economic Co-operation and Development (OECD), it was stated that the acquisition of the abilities of children aged 15 years in the fields of Mathematics, Science, and Literacy with Indonesian results was ranked 63 out of 69 countries evaluated and categorized in the poor tenure group with a mathematical average (M = 38.6) (OECD, 2016). However, the decline was reported in 2018 with an average value (M = 37.6) (OECD, 2018). In line with this result, the National Examination of Junior High School showed that there was no significant change in the average score of mathematics from 2017 to 2019, still below 55 that is the minimum National Examination standard score, (M = 43.15; M = 41.03; M = 45, 76) in Indonesia (Center for Educational Assessment, 2019). This low score is related to the lack of ability to solve mathematics problems (Suarsana, Lestari & Mertasari, 2019). According to Gok & Silay (2010), students often find difficulty in solving math problems related to contextual problems. An error arises when doing the stage of trying to understand the problem, communicate, and test the concept (Saleh, Yuwono, Rahman, & Sa'dijah 2016; Sumaji, Sa'dijah, Susiswo, & Sisworo, 2019). Besides the problems regarding problem-solving abilities that arise, there is also a lack of student interpretation of mathematics subjects. Math is considered a difficult and boring subject. Hence, a solution is needed to solve these problems, including choosing an inappropriate learning strategy that can lead to poor problem-solving abilities (Mabilangan, Auxencia, & Belecina, 2011). Besides, a suitable learning strategy can foster a sense of perception and interest in mathematics which is usually called the mathematical disposition ability.

One of the strategies that can be applied is a meta-cognitive strategy. According to Kramarski and Zoldan (2008), meta-cognitive strategies is a learning strategy that instills awareness of how to design, monitor, and control what students know; what it takes to do. It focuses on learning activities; help and guide students when experiencing difficulties as well as assisting students in developing their self-concept while studying mathematics. The meta-cognitive perspective assumes that there is a close relationship between learning ability and the meta-cognitive monitoring process. This relationship occurs concerning memory and reading. However, there is a lack of evidence in the field of mathematics. Based on research conducted by Daniela Lucangeli and Cesare Cornoldi, which examined 397 third grade students, and 397 fourth grade students using the standardized success rate of mathematics tests and awareness of the control process i.e. prediction, planning, monitoring, and evaluation, the results showed that numerical and geometric problem-solving abilities were strongly associated with meta-cognitive abilities. In arithmetic, this relationship is valid only for third graders. (Cornoldi, 1997). Another factor that can encourage the quality of student learning in learning mathematics is mathematical disposition. Katz (2009) argues that mathematical disposition is related to how students can solve mathematical problems, whether students have self-confidence, are diligent, interested, and think flexibly to explore various alternatives in solving problems. Further, a mathematical disposition is the main factor in determining student learning success in mathematics (Kilpatrick et al, 2001, pp.131) Maxwell (2001) mentions several parts of mathematical disposition i.e : a). Inclination, how the students respond to the assignments given; b). Sensitivity, how the readiness of the students in an assignment; c). Ability, how the students focus on completing the task completely; d). Enjoyment, how the students' attitude when completing a given task.

Problem-solving is an important component of mathematics education because it is a useful medium for students to understand the function of mathematics for a practical role for individuals and society. Through a problem-solving approach, mathematical aspects such as functional, logical, and aesthetic can be developed because presenting the problem and developing the abilities needed to solve the problem is more motivating than teaching abilities without context (Taplin, 2020). Such motivation gives special value to problem-solving as a tool for learning new concepts and abilities or strengthening acquired abilities (Stanic and Kilpatrick, 1989, NCTM, 1989). Learning mathematics through a problem-solving approach can create contexts that simulate real-life and therefore can justify mathematics instead of treat mathematics as an aim. The National Council of Teachers of Mathematics

(NCTM, 1980) recommends that problem-solving be the focus of teaching mathematics because it includes abilities which an essential part of everyday life. Moreover, it can help people to adapt to unexpected changes and problems in their career and other aspects of their life. Recently the Council supported this recommendation (NCTM, 1989) with the statement that problem-solving should underlie all aspects of mathematics teaching to give students experience the power of mathematics in the world around them. Problem-solving is also a vehicle for students to construct, evaluate, and refine their theories of mathematics and the theories of others. (Taplin, 2020). Meanwhile, Polya (1973, pp 5) states that "Solving a problem means finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately understandable". Many researcher and educators consider problem-solving only as a design which is too restrictive consideration. Some use the terms “problem-solving” and “design” interchangeably. However, problem-solving can be divided into three categories: design, problem-solving, and technology assessment (e.g. impact evaluation).

Problem of Study

The purpose of this study was to figure out the interaction of meta-cognitive strategies and mathematical disposition abilities on student’s problem-solving abilities. Thus, this study seeks to figure out the following issue:

- Are there any interaction of meta-cognitive strategies on mathematical disposition abilities and student's problem-solving ability?

2. Method Research

The method of this study is quasi-experimental which adopted a 2x2 factorial design. The control and experimental class used in this study were not recreated for the research purpose which means the subjects enroll in class settings they usually in. The randomization class process did not carry out in the experimental class or the control class because the character of the quasi-experimental research findings is more suitable to be applied in real learning (Creswell, 2012). Further, Fraenkel, Wallen, & Hyun (2012, 275) state that if researchers cannot carry out random sampling, the research is included in quasi-experimental research. The data analysis used a 2x2 factorial design since the fact that the research implementation has two or more independent variables that affect the dependent variable (Fraenkel, 2012). The two independent variables will also be examined together for their effect on the dependent variable which is called the interaction. Interaction is the existence of cooperation or mutual influence (accelerate or slow down) two or more independent variables on one dependent variable (Cohen, Manion, & Morrison, 2007).

Table 1. Design Factorial 2x2 of Quasi-Experimental Research

	Type Mathematical Disposition	**Instructional Strategies**	
		Meta-cognitive	**Conventional**
Mathematical Disposition	High	Group 1	Group 2
	Low	Group 3	Group 4

Table 1 describes the effect of the variables used in this study. The main effect is divided into two effects as follows:

- the consequence of the learning strategy without considering the mathematical disposition ability
- the consequence of the mathematical disposition without considering learning strategies.

The interactional effect provides information in terms of the relationship between learning strategies and mathematical dispositions to problem-solving ability.

2.1 Participants

This research was conducted at MTs (Junior High School) Negeri Jombang with a total of 138 eighth grade students who were selected using cluster random sampling technique. The distribution of research subjects is shown in Table 2.

Table 2. Distribution of Research subjects

Class	Number of Participant	Total
Treatment(with metacognitive strategy)	69	69
Control (with conventional strategy)	69	69
Total (n)		138

2.2 Instrument and Procedures

The instruments used in this study were problem-solving ability test consisted of 5 items questions and mathematical disposition questionnaires. While the mathematical disposition questionnaire used was adopted to find out students' interpretations of mathematics consisting of 23 questions with 16 favorable questions and 16 unfavorable questions. Score answers to favorable numbers (strongly agree = 4, agree = 3, disagree = 2, strongly disagree = 1) while scores for unfavorable numbers (strongly agree = 1, agree = 2, disagree = 3 strongly disagree = 4). In determining of high and low categories using the cut off method which introduced by Maggie C. Y. Tam (2001). The measured problem-solving indicator refers to the Polya stage (Polya, 1973) outlined in Table 3.

Table 3. Indicator of Problem-solving

No	Process for Problem-solving by Polya	Indicator
1	Understanding the problem	The questions asked by the teacher can be answered in writing or orally by the students
2	Devising a plan	The problems solved by the students are done through problem-solving planning using mathematical models and solving strategies
3	Carrying out the plan	The problems solved by students using strategies until they get the right results
4	Looking back (checking and interpreting)	The answers can be checked for correctness by students

While the mathematical disposition indicators are stated in Table 4.

Table 4. Mathematical Disposition Indicator

Component / Aspect	Indicator
Confidence	• There is a sense of confidence in solving mathematics problems • Conveying ideas and provide arguments or reasons
High interest and curiosity	• Showing interest and curiosity by trying to complete a mathematics problem. • Able to come up with ideas when doing mathematics
Flexibility	• Flexibility when developing mathematical ideas • Applying various alternative methods as a solution or problem-solving
Persistent	• Persistent and serious in mathematics lessons as well as in dealing with mathematics problems and assignments
Appreciation	• The role of mathematics as both a tool and a language in its culture and value.

2.3 Instrument Validity and Reliability

Before collecting the data, a test instrument of problem-solving ability was conducted to a total of 30 students. The content validity criteria were authenticated by two experts and were revised until they were suitable for data collection. The construct validity and reliability indices were Correlation ≥ 0.30

and α ≥ 0.70, respectively (Fraenkel, Wallen, & Hyun, 2014). The results of the validity test are shown in Table 5.

Table 5. Item-Total Statistics

Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item 1	46.10	66.162	.876	.610
Item 2	46.13	66.395	.863	.615
Item 3	46.13	73.016	.806	.649
Item 4	46.73	88.823	.224	.855
Item 5	46.23	99.082	.173	.839

Table 5 shows that the correlation score is greater than (0.30), which means that the 5 test descriptions of problem-solving ability are valid and can be used (Guilford, 1956). The reliability test was carried out using Cronbach Alpha as shown in Table 4 which shows that Cronbach's Alpha score (0.773> 0.70) indicates that the instrument has high reliability.

Table 6. Realibility Statistic

Cronbach's Alpha	**N of Items**
.773	**5**

2.4 Data Analysis

In this study, the data analysis technique used to test the hypotheses to find out the truth is two-way analysis of variance (ANOVA) which includes ANOVA test, test of between subject effects, and graph of the interaction between independent variables on the dependent variable (Hair et al., 2006). The hypotheses null proposed in this study is that there is no interaction between meta-cognitive strategies, and mathematical dispositions on students' problem-solving abilities in mathematics.

2.5 Procedure

The learning activities are divided into two groups i.e. the control group using conventional strategies and the experimental group using meta-cognitive strategies. There are three components to the meta-cognitive experience, namely planning, evaluation, and monitoring (Moshman& Schraw, 1995).

2. Results and Discussion

After having the data analyzed, the results are obtained. The results of data analysis are described in Table 5 concerning the test of between subjects' effect.

Table 7. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17.639[a]	78	.226	1.239	.195
Intercept	153.055	1	153.055	838.721	.000
Mathematical Disposition	12.984	55	.236	1.294	.166
Metacognitive Srategy	1.069	1	1.069	5.861	.019
Mathematical disposition * meta-cognitive Strategy	4.089	22	.186	1.018	.458
Error	10.767	59	.182		
Total	258.000	138			
Corrected Total	28.406	137			
a. R Squared = .621 (Adjusted R Squared = .120) Problem-solving ability as dependant variable					

The results of the analysis obtained the value of Sig. Count 0, 458> 0.05, stated that Ho is accepted (there is no interaction between meta-cognitive strategies and mathematical dispositions on students' problem-solving abilities in mathematics). While the value of F counted 1.018> 3.07 (F table), it was stated that Ho was rejected (there was an interaction between meta-cognitive strategies and mathematical dispositions on the problem-solving abilities of students' mathematics subjects). From these results, the significant value of Ho is accepted, but for the value of the F coefficient with the result Ho is rejected, it means that there are requirements that are not met. From the results of the resulting calculation analysis, it can be concluded that there is no interaction between meta-cognitive strategies and mathematical dispositions on problem-solving abilities.

Table 8. Learning Strategy

Learning Strategy	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Metacognitive Strategy	1.358[a]	.058	1.241	1.475
Conventional Strategy	1.211[a]	.059	1.092	1.330
a. Based on modified population marginal mean. Dependent Variable: problem soving ability				

It is based upon the results of statistical calculations obtained from Table 6 shows that the average problem-solving ability with the application of meta-cognitive strategies is 1.358, while with conventional strategies the average value of problem-solving abilities is 1.211. This shows that the mean ability of meta-cognitive strategies is higher than the ability with the application of conventional strategies.

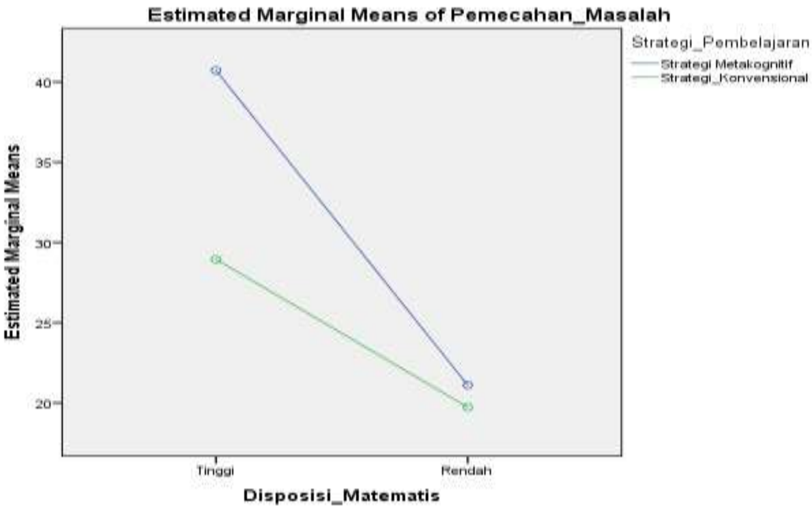

Figure 1. Estimate Marginal Means of Problem-solving.

In the figure 1shows that there is no intersection lines between high mathematical disposition line and low mathematical disposition line through both meta-cognitive and conventional strategies for problem-solving abilities. Hence, the graph states that there is no interaction between meta-cognitive strategies and mathematical dispositions on problem-solving abilities (Karunia E.L. and M. Ridwan, Y., 2015).The percentage of components between strategy variables and mathematical dispositions with problem-solving abilities is:

$$\frac{4098}{28.406} \times 100\% = 14.39\%$$

Thus, the combined effect between strategy and mathematical disposition on problem-solving ability is 14.39%.The pilot analysis was conducted to determine the parametric feasibility before testing the hypothesis. The pilot analysis for univariate analysis consisted of a normality test and a homogeneity test. The data about the results of statistical calculations for the application of meta-cognitive strategies and mathematical dispositions are described in the Table 7 and Table 8 , as well as the graphs in Figure 1 to illustrate the relationship of the two variables to problem-solving abilities.

Discussion

The meta-cognitive strategy has been widely used by researchers to determine its relationship to other aspects including problem-solving abilities as well as mathematical disposition and problem-solving abilities. The main objective of this study is to analyze the interaction of meta-cognitive strategies on mathematical dispositions and problem-solving abilities. Problem-solving abilities can be stated how capable a person in solving problems (Heppner, 1988). Besides meta-cognitive strategies, other factors affect learning such as monitoring and self-planning (Derry & Hawkes, 1993). These factors are part of the meta-cognitive component in which spontaneously the application is possible as a result of the experiences formed in students. Meta-cognitive strategy and mathematical dispositions in this study did not show any interaction between the two problem-solving abilities, this was due to the significant influence of each variable on problem-solving abilities. Meta-cognitive strategies have a significant effect on problem-solving abilities, as well as mathematical disposition variables significantly influence problem-solving abilities. These two variables do not have a more dominant influence than the others. Likewise, from the results of the calculation of the combined effect shown, a small percentage figure is also obtained. This shows that the two variables do not significantly influence each other. This is as with what Kerlinger (2000) stated that an interaction does not occur because two or more independent variables have a very strong (significant) effect on the dependent variable. The influence of each of the independent variables is not collectively called the main effect. It is based upon the calculation of the combined effect of meta-cognitive strategies and mathematical dispositions on problem-solving abilities shows a very small result which means that the two variables do not influence each other. Thus, these two variables have a non-dominant effect the two.

Several research findings are in line with this result (e.g. Ramesh (2014) and Anandaraj and Kapa (2001)). They state that there is a significant correlation between meta-cognition and problem-solving abilities. Brown (1982) states that meta-cognitive strategy regulation of the process of learning activities and students' solving abilities. Further, meta-cognitive strategies can significantly improve the results of problem-solving performance in the experimental group in learning indicated by the results of the post-test and pretest problem-solving abilities, which are better for the post-test than the pretest. The strong influence of meta-cognitive strategy on students' thinking styles is reinforced by Shanon (2008) who states that most students initially do not have thoughts about how they learn and what learning styles they have. However, after being introduced to learning using meta-cognitive strategies, they were interested in trying to survey their learning styles by thinking about the results of their thought processes. Further, Young and Fry (2008) found a significant relationship between meta-cognition and academic ability. The academic achievement of students with different academic abilities - both high, medium, and low ability - is influenced by meta-cognitive activities.

Several research results that support the strong influence of students' problem-solving abilities such as the results of research conducted by Zaozah, E. S. & Maulana, M., Djuanda, D. (2016) who explain that there is a significant relationship between mathematical dispositions and problem-solving ability. Mathematical disposition is one of the main factors that can support student success in learning mathematics to study persistently, full of enthusiasm, and continue to seek solutions to a mathematical problem. The higher this ability is owned by students, the more confidence in solving problems and this is different from students with low mathematical disposition abilities. So, it can be concluded that if the mathematical problem-solving ability is high, the students' mathematical disposition will also be high. Also, based on research from Mayratih, G. E., Leton. S. I & Uskono, I.V. (2019, pp.5) state that there is a significant effect of mathematical disposition on students' mathematical problem-solving abilities. This can be seen from the percentage of attainment of the disposition indicator (Hartati, Bilqis, & Rinaldi, 2020).

Meanwhile, the research conducted by Carly Rosenzweig, Jennifer Krawec and Marjorie Montague (2011) examined the differences of verbal meta-cognitive between students with and without based on limitations. The results show that students with learning disabilities (LD) have weaknesses in control and limited meta-cognitive resources when compared to students who have average abilities. As the complex problem increases, students with LD tend to use non-productive meta-cognitive strategies more often and unable to adapt their productive meta-cognitive strategies. Students with such conditions have deficiencies in meta-cognitive strategies and may not be able to use their strategies effectively and efficiently. Therefore, improvement needs to emphasize explicitly learning to students with meta-cognitive strategies so that they can assist in completing tasks that require higher-order thinking. (Rosenzweig C, 2011).

4. Conclusions

The findings of this study explain that there is no interaction of meta-cognitive strategy on mathematical dispositions and problem-solving ability. Futher, between meta-cognitive strategy and mathematical dispositions in this study do not show any interaction, this is because the influence of each of these variables is equally strong. Meta-cognitive strategies have a strong influence on problem-solving abilities, as well as mathematical disposition variables have a strong effect on problem-solving abilities. This is in line with what Kerlinger (2000) stated that an interaction does not occur because two or more independent variables have a very strong (significant) effect on the dependent variable. The effect of each independent variables which is not simultanously is called the main effect.

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