Constructing Means Ends Analysis Instruction to Improve Students' Critical Thinking Ability and Mathematical Habits of Mind Dispositions

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Abstract: This article presents research findings on how to construct a Means-Ends Analysis (MEA) instructional model to improve students' critical thinking ability and Mathematical Habits of Mind (MHM) dispositions. It adopted a quasi-experimental method with the pretest-posttest control group design. The population consisted of the whole students of state junior high schools in Subang Regency, West Java Province. The sample involved 158 of 8th grade students of two junior high schools with a high and medium level, respectively. The instruments used were a test of students' initial mathematical ability, a test of critical thinking ability, and MHM disposition scale. The data were analyzed with the non-parametric Mann-Whitney test and the post hoc test of One-Way ANOVA. The findings show that the students who were taught with MEA instructional model had significantly greater improvements in their critical thinking ability than those who were taught with the conventional instructional model. The findings also demonstrate that there was no interaction between students' critical thinking ability and MHM dispositions.

Keywords: Mean ends analysis, critical thinking ability, mathematical habits of mind dispositions

INTRODUCTION

Refer to opinions of Ennis (2008), Thompson (2011), Ruggiero (2012) and Stacey (2013), that critical thinking ability defined as process of using thinking ability effectively to help someone to arrange, evaluate and apply decision about what is believed or done. Whereas, according to Pithers and Soden (Suryadi, 2012) that people who think critically has good ability in doing and controlling their emotion, because they are critical and aware that the idea they deliver and the decision they take had been correct and will not raise another new problem. Similarly with Sabandar (2010) who said that someone who had possessed critical thinking ability always careful and conscientious .in making a decision thoughtfully. It means that critical thinking ability give right direction in thinking and working, and in acting or making commonsense decisions about something whose the truth can be believed.

In NCTM (2003), it is said that the world which is increasingly complex demand individual to posses higher order thinking ability. This is in accord with the goal of National Education Standard Board (2006) that through mathematics learning, all students started from elementary school need to be equipped by logical, analytical, systematical, critical and creative thinking ability, and ability in cooperating. Hamid (2016) said that critical thinking ability need to be developed in all students, because each human has potential to think critically, so that potential can be developed. According to Duron, Limbach and Waugh (2006) that thinking is natural a process, but if thinking is ignored, it is often biased, distorted, partial, lack of information and potentially become prejudice, so the strength in thinking should be developed. This is in accord with Cotton (Umar, 2013) who said that even though many people believe that human was born with or without critical thinking

ability, researches had been shown that critical thinking can be taught and can be learned. Therefore, critical thinking ability need to be trained and taught to students through learning mathematics, because it will much help them in solving the problems faced.

Critical thinking ability is cognitive aspect which always become center of attention and studied in research, but affective aspect such as mathematical habits of mind also begin to be studied by researchers. Because it is expected that mathematical habits of mind disposition will stimulate students' creativity and interest, and their positive attitude toward mathematics. Sumarmo (2013) expressed that mathematics learning not only intended to develop cognitive aspect only, but also affective aspect, such as mathematical habits of mind disposition. Mathematical habits of mind dispositions related to how students perceive and solve a problem; whether they are self-confident, persevere, interested, and open-minded to explore various alternative of strategies in solving the problem. Mathematical habits of mind disposition also related to students' tendency to reflect on their own thinking (Mahmudi, 2013). Therefore, in mathematics learning, students are need to be given much opportunities to develop mathematical habits of mind and strong MHM dispositions and smart behavior. Through strong MHM dispositions and smart behavior then they will be able to solve various life problems from simple until very complex independently and with self-confident.

The study result of Noer (2013) and Sharadqah (2014) indicate that critical thinking ability of 8^{th} grade students of Junior High School had not been optimal because only few students (less than 15%) who are able to solve various academic tasks, only reach indicator of ability in identifying the given assumption; ability in formulating the main problems; and ability in determining the consequence of decision taken. Particularly for ability in detecting bias based on different point of view; ability in expressing a concept/definition or theorem in solving the problem; and ability in evaluating relevant argument in solving the problem, only (5%) students who are successful to solve various academic tasks given by teacher.

According to Noer (2013) it is supposed that students' critical thinking ability which is less optimal caused by inappropriateness of learning model and strategy used by teacher in mathematics learning. Whereas, Sharadgah (2014) said that most of students not take the meaning of solution process that make process of constructing the material is less success. Furthermore, Sharadgah expressed that students had not master fully the knowledge in problem solving activity. On the one side, learning process which is done by teacher less support development of critical thinking ability. On the other side, therefore the author try to construct a learning model called means ends analysis (MEA) with expectation that it can optimize the enhancement of critical thinking ability and mathematical habits of mind (MHM) dispositions in students.

Eysenck (2003) expressed that there are four steps of means ends analysis (MEA) learning with syntax as follow: (1) initially, the material is presented by problem solving approach based on heuristic, (2) the material is elaborated into sub-problems which are simpler, (3) sub-problems are arranged to become connectivity, and (4) the solution of strategy is chosen. In the other word, in the process to solve a problem by using MEA learning model, a problem can be broken down into sub-problem. Before arranging sub-problem, students first should understand and interpret current state and goal state. Then, students collect the information through the knowledge possessed to form/arrange sub goal in order to reduce the difference between current state and goal state. After that, the right operator is chosen to solve sub-problem in order to achieve sub- goal. According to Glass & Holyoak (1998) that in MEA learning model., students are given opportunity to use their own strategy, to construct their own knowledge, to solve a problem intended from a problem and do it repeatedly until a mathematical proof is found. Furthermore, the study result of Fitriani (2012) reported that the application of MEA learning can give positive influence to enhancement in

communication ability and mathematical problem solving ability of 8th grade students of Junior High School.

The aim of this study is as follow: (1) To construct means ends analysis (MEA) learning model which had been developed by O'Neil (1987), Glass & Holyoak (1998) and Eysenck (2003) as the effort to optimize the enhancement of students' critical thinking ability; (2) to analyze whether the enhancement of critical thinking ability in students who receive Means Ends Analysis (MEA) learning model is more excellent than students who receive conventional learning model.

METHOD AND DESIGN

This study use quasi-experimental method with exploratory and explanatory strategy during one year. In outline, design which is used in this study is pretest-posttest control group design by using two different learning models. Experiment class use means ends analysis (MEA) learning model whereas control class use conventional learning model. To find out whether there is enhancement of students' critical thinking ability and mathematical habits of mind (MHM) dispositions, design of study can be illustrated as follow:

O X O O = pretest posttest
O O X = MEA learning
--- = experiment class and control class

Population of this study are all 8th students of Public Junior High School in Subang Regency, West Java Province. As for samples involved in this study are 158 students of 8th grade, each of two classes from high school level and two classes from medium school level. Instruments used are initial mathematical ability test, critical thinking ability test and students' MHM dispositions scale. To answer the problem of this study, data processing and analysis are done by using Mann-Whitney Non Parametric test and post hoc test from One-Way ANOVA, but before it normality and variance homogeneity are tested.

RESULT AND DISCUSSION

1. Critical Thinking Ability

As for indicators of critical thinking ability which are measured comprise: ability in identifying the assumption given; ability for formulating the main problems; ability in determining the consequence of decision taken; ability in detecting bias based on different point of view; ability in expressing concept/theorem/definition and using it to solve the problem, critical thinking ability based on learning model, school level, and category of initial mathematical ability (IMA) is presented in Table 1 below.

Table 1. Data of Critical Thinking Ability Gain based on Learning Model, School Level, and IMA Category

School Level	IMA	Statistical Measure	Learning Models					
			MEA			CLM		
			Pretest	Postest	Gain	Pretest	Postest	Gain
High	High	*N*	8	8	8	7	7	7
		Mean	**12,5**	**36,5**	**0,65**	**6,00**	**28,29**	**0,51**
		SD	3,34	7,84	0,19	2,58	9,41	0,22
	Moderate	*N*	25	25	25	24	24	24
		Mean	**7,52**	**26,08**	**0,45**	**6,17**	**20,17**	**0,31**
		SD	3,23	10,46	0,23	3,33	7,05	0,18
	Low	*N*	7	7	7	7	7	7
		Mean	**4,00**	**17,14**	**0,29**	**3,14**	**10,29**	**0,15**
		SD	4,00	7,38	0,12	1,57	4,23	0,09
Moderate	High	*N*	7	7	7	8	8	8
		Mean	**7,14**	**32,86**	**0,60**	**4,25**	**24,25**	**0,46**
		SD	3,44	5,98	0,15	1,67	7,96	0,20
	Moderate	*N*	23	23	23	23	23	23
		Mean	**7,04**	**24,09**	**0,40**	**4,52**	**19,22**	**0,33**
		SD	4,08	6,37	0,12	1,50	5,93	0,15
	Low	*N*	10	10	10	9	9	9
		Mean	**6,20**	**18,60**	**0,28**	**4,89**	**14,00**	**0,20**
		SD	3,19	7,24	0,15	2,26	5,10	0,11

Note: makximum ideal score 50; SD (standard deviation); N (a statistical measure)

Data in Table 1 above shows that viewed from two school level and mathematical initial ability particularly students with high and low IMA who receive MEA model is outperformed students who receive conventional learning model (CLM) in critical thinking ability. Whereas students with low IMA who receive MEA model in moderate level school achieve N-Gain of critical thinking ability which is better (18.60) than students in high level school who achieve N-Gain (17.14). For MEA model, the enhancement of students' critical thinking ability is achieved in indicator of "Student is able to identify the assumption used to solve a problem." If it is viewed from Meltzer's classification (2002), then the enhancement achieved in that indicator is included in medium category. Whereas for CLM model, the lowest student's enhancement in critical thinking ability is achieved in indicator of "Student is able to express a concept and use it in solving the problem', and included in low category. This fact almost conformed with study result of Noer (2013) who said that student's weakness which is most frequently found is aspect of formulating the problem and testing the correctness of answer. Nevertheless, if it is seen in a whole, in fact the higher of IMA category in two school level, the higher of N-gain of students' critical thinking

ability. In the other word, even though there are some indicators which are qualified or included in low category, but the learning outcome achieved by students should be appreciated because they have strong wiliness so they capable to solve the problem in critical thinking ability post test.

Based on result of descriptive and inferential statistic analysis above, it can be concluded that before learning treatment, critical thinking ability of students from two school levels is significantly different. After learning, critical thinking ability of students both from high school level and medium school level who receive MEA model is higher significantly than students who receive conventional learning (CL) model. This fact corroborate the statement that MEA model is better significantly compared to CL model and category of low MEA toward enhancement of critical thinking ability. The strength of MEA model also corroborated by analysis result of Non Parametric statistic test by using Mann-Whitney test and post hoc test from One-Way ANOVA about the influence of interaction between learning model, school level, and category of students' IMA toward N-gain of critical thinking ability. Theoretically, this is happened because of quality of MEA model teaching material is better, and accompanied by learning process which is more interactive and meaningful compared to CL model. Chamot (2012) said that an ideal teacher is she/he is able to choose the right assignment, encourage students to meaningful learning, arrange the discourse to create learning atmosphere and class situation analysis. Therefore, it seems that MEA model learning had been able to help students moving toward Vigotsky' Zone of Proximal Development (ZPD).

Another theoretical reason is that MEA learning is based on constructivism philosophy in which students should mentally active in constructing their knowledge structure based on their cognitive maturity. Furthermore, these four principles of MEA learning conformed with Piaget's cognitive development theory that learning is assimilation and accommodation process. Assimilation process in MEA learning is based on principle of "the material is presented by heuristic and reality approach", whereas accommodation process in MEA learning is based on principle of "elaboration of problem; documentary; reusability and ability-sharing'; and effective prototype. In general, the process of MEA learning is more emphasized on student activeness. So learning is not teacher-centered but students are actively learn, delve their knowledge independently. Constructivism view assume that students should construct their knowledge by themselves (Suparno, 1997). Whereas, theorem of construction from Bruner (Umar, 2012) said that the best way of thinking for students to start learning concept and principle in mathematics is by self construct. The reason is if students construct the knowledge by themselves, then they will easily remember and can apply it in appropriate situations.

2. The Influence of Interaction between Learning Factor and Students IMA toward Enhancement of Critical Thinking Ability

Based on result of descriptive statistic analysis about critical thinking ability of students who receive MEA model and students who receive conventional learning model which is presented in Appendix, shows that data about mean of enhancement of students' critical thinking ability and students' IMA is not normal distributed, so two-way ANOVA test cannot be done. Therefore, analysis toward the influence of interaction data of enhancement of students' critical thinking ability is done descriptively from the graphic resulted. Graphic of the influence of interaction between learning model and students' IMA toward enhancement of students' critical thinking ability can be presented in Diagram 1 as follow.

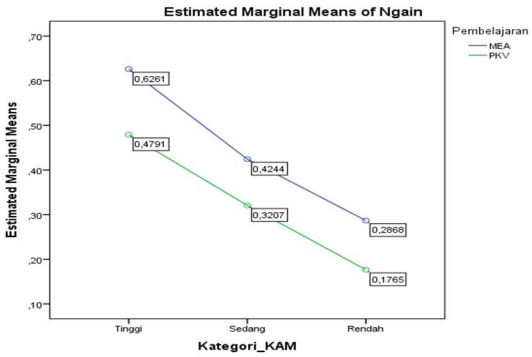

Diagram 1: Interaction between Learning Factor and Students' IMA toward Enhancement of Critical Thinking Ability

From Diagram 1 above, it is seen that mean line graphic of critical thinking ability enhancement of students who receive MEA model is above mean line graphic critical thinking ability enhancement of students who receive conventional learning (CL) model. From graphic line, it is shown that all students with category of high, moderate and low initial mathematical ability (IMA), who receive MEA model get enhancement of critical thinking ability which is higher than students who receive CL model. Nevertheless, the enhancement difference of students' critical thinking ability between MEA model and conventional learning (CL) model in three categories of IMA is different. In category of high IMA, the enhancement difference of critical thinking ability between students who receive MEA model and students who receive CL model is (0,147). Whereas, for category of moderate IMA and low IMA, the enhancement difference of critical thinking ability between students who receive MEA model and students who receive CL model is (0,1037) and (0,1103) respectively. This indicate that MEA model has big influence on enhancement of critical thinking ability compared to CL model for each category of IMA.

If it is seen from mean line graphic for two learning model, it is seen that students with category of high IMA is higher from students with category of medium and low IMA, and it is similar for category of moderate IMA toward category of low IMA. Besides, it is also seen that the two line graphics have positive gradient, which shows that the two learning models and the three categories of IMA give real influence toward enhancement of students' critical thinking ability. From the distance from two line graphics, it is seen that for each category of IMA tend to be relatively different and not intersected. It means that there is influence of significant interaction toward enhancement of students' critical thinking ability based on learning model and students' IMA. Therefore, it can be concluded that the influence of interaction between learning model and students' IMA result in enhancement difference which is quite significant toward enhancement of student critical thinking ability, compared to CL model for each category of IMA. This finding is in accord with study result of Fitriyani (2012) who reported that the application of MEA learning can has positive influence on enhancement of communication ability and mathematical problem solving ability of 8^{th} grade students of junior high school.

3. Mathematical Habits of Mind (MHM) Dispositions

Data analysis of students' attitude search toward questionnaire of Mathematical Habits of Mind (MHM) disposition is obtained from result of filled questionnaire of students' MHM disposition and from data of normalized gain. As for MHM disposition scale used to know students judgment toward their ability, their success, and their appropriateness in learning mathematics

comprise sixteen aspects, among others: (1) defensive and never give up; (2) regulate the conscience; (3) listen the opinion of others people and have sense of emphatic; (4) think flexibly; (5) think metacognitive; (6) try to work conscientiously and appropriately; (7) ask and pose the problem effectively; (8) utilize new experience to create new knowledge; (9) think and communicate clearly and appropriately; (10) use the senses to collect and process data; (11) create, imagine and innovate; (12) enthusiastic in responding; (13) dare to be responsible and face the risk; (14) humorist; (15) thing interdependently; and (16) learn continuously (Costa & Kallick, 2010). That data is analyzed descriptively and inferentially. Data analysis of students' MHM disposition which is done based on learning model, school level, and category of students' IMA is presented in Table 2 below.

Table 2. Data of Students' MHM Dispositions Gain based on Learning Model, School Level, and Category of IMA

School Level	IMA	Statistical Measure	Learning Models					
			MEA			CLM		
			Pretest	Postest	Gain	Pretest	Postest	Gain
High	High	*N*	8	8	8	7	7	7
		Mean	**87,88**	**104,75**	**0,31**	**87,71**	**94,29**	**0,111**
		SD	7,97	14,14	0,16	12,079	11,280	0,698
	Moderate	*N*	25	25	25	24	24	24
		Mean	**86,48**	**98,68**	**0,21**	**81,38**	**94,17**	**0,197**
		SD	5,46	7,95	0,11	8,692	9,111	0,100
	Low	*N*	7	7	7	7	7	7
		Mean	**86,00**	**102,86**	**0,29**	**81,86**	**90,57**	**0,135**
		SD	5,97	11,48	0,16	4,811	6,347	0,083
Moderate	High	*N*	7	7	7	8	8	8
		Mean	**89,57**	**101,14**	**0,22**	**85,63**	**97,63**	**0,201**
		SD	10,75	14,57	0,14	5,502	6,948	0,066
	Moderate	*N*	23	23	23	23	23	23
		Mean	**87,48**	**97,17**	**0,17**	**87,52**	**97,61**	**0,171**
		SD	8,56	10,45	0,18	6,052	7,584	0,107
	Low	*N*	10	10	10	9	9	9
		Mean	**86,40**	**96,90**	**0,29**	**83,00**	**96,00**	**0,194**
		SD	5,32	9,89	0,10	13,528	10,137	0,139

Note: makximum ideal score 146; SD (standard deviation); N (a statistical measure)

Based on data in table 2 above, it shows that the strength of MEA model compared to conventional learning (CL) toward enhancement of students' MHM dispositions in a whole and

viewed from two school levels and initial mathematical ability (IMA) of students. The strength of MEA model is more real when it is viewed from students finding, in which students with high and low MEA in high school level obtain enhancement mean in MHM dispositions of (0.31) and (0.29) respectively. For MEA model, the highest mean of students' MHM dispositions is achieved in indicator of "Capable to be defensive" with aspects measured comprise: I am focused to do the problem whose result had not been found, and I try to do again when I had not been able to solve the problem correctly. The mean of enhancement from the two aspects if it is viewed from Meltszer's classification (2002), is included in medium category.

Furthermore, students in high school level with high IMA who receive conventional learning (CL) model obtain mean of enhancement in MHM dispositions of (0.17). The lowest mean of enhancement in students' MHM disposition is achieved in indicator of "Being responsible and dare to be take a risk" with aspects which are measured comprise: I decide a way without considering the result achieved, and The score I get is not proportional with working outcome which I had done. Mean of enhancement in these two aspects, if it is viewed from N-gain mean is included in low category. Therefore, students who receive conventional learning (CL) model is outperformed students who receive MEA model toward enhancement of MHM dispositions. This fact is seen from result of post hoc test from One-Way ANOVA about the influence of interaction between learning model, school level and category of students' IMA toward N-gain of students' MHM dispositions. Clune (Stacey, 2010) said someone who develop the capacity in certain domain tend to be influenced by habits of mind and accompanied by productive attitude. Productive attitude according to Sumarmo (2012) is positive attitude and the habits which is grown in seeing mathematics as a logical thing, self-confidence which is grown and high metacognitive ability.

4. The Influence of Interaction Between Learning Factor and Students' IMA on Enhancement of Students' MHM Disposition

The result of Two Way ANOVA test for influence of interaction between learning factor and students' initial mathematical ability (IMA) on enhancement of students' MHM dispositions is presented in Diagram 2 below.

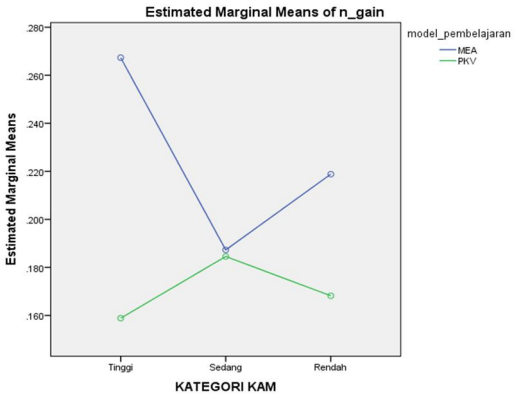

Diagram 2: Interaction between Learning Model and Students' IMA toward Enhancement of Students' MHM Dispositions

From Diagram 2, it is seen from mean line graphic for MEA model that students with high IMA is higher than students with medium and low IMA, and also for moderate IMA toward low IMA. Besides, it is seen from mean line graphic for conventional learning (CL) model that students with high IMA is lower than students with low IMA toward enhancement of students' MHM

dispositions. The mean of two line graphics shows that students in two learning models have significant influence on enhancement of students' MHM disposition.

Even though two line graphics are not intersected, but shows that two learning models and three categories of students' IMA give real influence to enhancement of students' MHM dispositions. From the distance of two line graphics, it is seen that for each category of IMA tend to be relatively different and not intersected. It means that there is influence of significant interaction toward learning model and students' IMA. This fact indicate that students in category of high IMA tend to get more benefit from MEA model toward enhancement of students' MHM dispositions for category of moderate and low IMA. Therefore, it can be concluded that the influence of interaction between learning model and students' IMA result in enhancement difference of students' MHM disposition which is quite significant, but there is no significant interaction between two learning models and category of students' MHM toward enhancement of students' MHM dispositions. This finding is in contrast with theoretical literature and finding of another researchers. Goldenberg (2009) said that mathematical habits of mind is strongly related to the success of each student in learning mathematics. Student with high habits of mind shows higher achievement and perseverance on difficult problem (Cuoco, 2010).

CONCLUDING

Conclusion and Implication

Based on result of data analysis and discussion, it can be concluded that Means Ends Analysis (MEA) model has more important role compared to conventional learning (CL) model, and category of initial mathematical ability (IMA) in enhancement of critical thinking ability and students' Mathematical habits of mind (MHM) dispositions. Whereas in high school level, there is no difference in critical thinking ability and MHM disposition between students who receive MEA model and CL model. Similarly, there is no interaction between two learning model and category of IMA toward enhancement of students' MHM disposition.

The implication of this study is that MEA model give more benefit to students with moderate mathematical ability, and students in high school level in enhancement of critical thinking ability and MHM dispositions, compared to CL model for each category of IMA.

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