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Mastery of Essential Mathematics Concepts : How it Enhances Students' Critical and Creative Thinking Skills

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Abstract: *This study is a descriptive and correlational study to investigate students' mastery of essential mathematics concept and find the connection to their critical and creative thinking. The subjects of the study consisted of 234 junior high school students from various schools in high, average, and low qualities. The results of the study indicated that 1) Students' mastery of essential mathematics concept are at average level; 2) The difficulties that encountered by the students come from internal factor (themselves), and external factors (teachers, the characteristics of mathematics, schoolmates and the facilities; 3) There is a significant relationship between students' mastery of essential mathematics concept and their critical thinking; 4) The correlation between the ability to be skilled in essential math concept and their creative thinking is at high level.*

Keywords: *creative, critical, essential concept, thinking*

1. INTRODUCTION

Critical and creative thinking become the most important aspect in order to succeed in globalized world, since those two are related to intelligence, capability in generating new ideas, and divergent thinking. According to Sukmadinata (2004), "critical thinking refers to the regular capability of our mind, systematic skills in assessing, solving problem, draw a decision, provides evidence, analyze assumptions and do scientific research" (p. 177). Meanwhile, creative thinking describes as a mental activity in order to increase originality and insight in generating particular matter.

Mathematics as one of universal knowledge which is discovered through thinking processed in ratio world by analyzing and synthesizing thinking in cognitive structure that is expected to improve students' thinking skills. The quality of mathematics materials in schools are viewed as elementary materials. Yet, it is a part of fundamental concepts as the requirement to master highest concept of mathematics. The properties of mathematics as argued by Ebbutt and Straker as cited in Depdiknas (2006) are1) The search pattern and math connection, it influenced students to find the pattern and decide the connection; 2) Activities that involve students' creativity in exploring and doing research in different possibilities. The implication through the activities is giving the students an opportunity to think otherwise; 3) Problem-solving activities to encourage students to think logically, consistently, systematically, and developing documentation system.

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Based on the aforementioned statements, this study aims to find out the connection between students' mastery of essential mathematics concept, involving mastering the basic concepts up to applying it with the critical and creative thinking abilities.

2. THEORETICAL FRAMEWORKS

James and James (1976) define mathematics as a logical knowledge regarding shape, structure, magnitude and other relational concepts. There are three bigger concepts of math namely algebra, analysis, and geometry. On the contrary, other opinion stated that math consists of four main concepts; arithmetic, algebra, analysis, and geometry. Arithmetic relates to theories concerning numerical calculations and statistics. In addition, personal learning experience and everyday concrete objects are suitable tools in teaching math concepts. Bourne as cited in Romberg (1992, p. 752) believes that math as the social constructivist can be understood by emphasizing the knowing how strategy which involve an active role from the students in enriching their knowledge by interacting with their surroundings.

Next, critical thinking starts from the process on human's left brain. Critical thinking skill is expressed by several capabilities. As stated by Harsanto (2005, p. 45) the criteria of critical people includes (1) The capability of knowing the truth; (2) The capability in discerning definitive conclusion and temporary conclusion; (3) Skills in verifying the belief; (4) The ability to sort information; (5) Skills in applying critical thinking toward the obtained materials; (6) Decision-making skills; (7) Cause-effect analysis skill; (8) Contemplating other sources; (9) Checking the questions. In addition to critical thinking that is processed by our left brain, creative thinking appears as the result of right brain processes. Creative thinking described by Musbikin (2006) involves human capability in dealing with generating new idea and concept, spotting new point of view, answer a common question in a new light and initiate new question to be answered.

Furthermore, it is stated that creative thinking should be supported by positive manner as a result of behavior and belief education. In addition, to become a creative person, one should pass through several phase. According to Yudha (2004, p. 1), 5 different stages of creative thinking comprise of; (1) Focusing on the problem, formulating the questions and identifying the problem; (2) Planning, involving gathering specialized and relevant information; (3) Incubating for ideas which occur occasionally when faced with a dead-end during problem solving period; (4) Illuminating some insights related with the problem; (5) Verification, testing the answers that are generated during the illumination

stage. If it turns out that the solution cannot solve the problems, it is better to repeat and start from the very first stage in order to find the perfect solution.

3. RESEARCH METHODOLOGY

This study takes descriptive and correlational study to investigate the students' mastery of essential mathematics concept and find the relationship between their critical and creative thinking. The total subjects of the study is 234 junior high school students consist of 82 students from prestigious school, 77 students from common school and 75 students from underrated school. All participants were given a math test including algebra (equations, inequalities, ratios, sets, relations and functions), geometry (two-dimensional space, three-dimensional space, and Pythagoras theorem) and arithmetic (numeral, statistics, and probability). After that, the students should follow mathematics critical and creative thinking test. The entire tests have passed the inspection concerning its validity, reliability, distinguished element, and difficulties index. All test results, then, are examined by adapting SPSS up to the point where the researcher can explain the correlation and condition among its variables.

4. FINDINGS AND DISCUSSIONS

The Analyses of Students' Mastery of Essential Mathematics Concepts

The result of the test shows the values of $\bar{x} = 20{,}96$ and s= 5,39 from the ideal value (SMI)= 35. From the result of the analyses, students' skills are categorized into 3 different levels; high, average and low. The criteria in which the level took place can be described as; if value $x_i \geq 26$, then the students belong to the high level group, if 26<x<15 then the students belong to the average level group, and if $x_i \leq 15$ then the students belong to the low group. From the criteria above, the spread of students' level can be presented in Diagram 1:

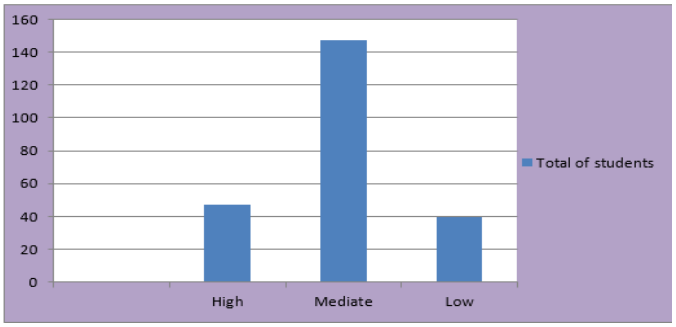

Diagram 1. Description of Student's Mastery Level of Essential Mathematics Concept

The result of the students and teachers interviews point out the several difficulties that influence students in understanding essential mathematics concepts. In general view, the difficulties can be classified into two different factors; internal factor and external factor. Internal factors emerge from the personal issue while external factor happened as the result of teaching methods and learning facilities. Further explanation regarding the difficulties are:

The characteristics of mathematics, which are abstract, tiered principles and concepts, and manipulation procedure which becomes the challenge for the students in understanding mathematics. A lot of students who are still concrete thinkers. That is to say, they are still in an instrumental understanding where they know the examples but they cannot explain the idea. Moreover, the students have not reached relational understanding where they can describe the relationship among each concept. As a result, students are facing more difficulties in understanding other concepts that are driven from the previous concept. This is where misconception happens due to the lack of understanding.

A lot of students are unable to understand where the origin of a principle. They know the formula and how to use it in mathematics operations; yet, they do not know the reason for using it. Therefore, the students are unfamiliar with the context where the formulas are being used. A lot of students cannot calculate math operation and procedure expertly. The inability to calculate using particular procedure in the previous problem leads to the same situation in the newer problem. The incomplete understanding issue. The incomplete understanding will obstruct students' ability in solving mathematics problems; whereas the learning will keep on going to the next level. The use of single textbook as the only source in defining a particular concept.

The teaching methods that are based on the chapters of the book which resulted on segmentation in understanding mathematics concepts. Therefore, the students are troubled in connecting one concept to another. Frequently, the learning material is not started from the contextual problems as the basic conception that guides students to the following chapter. In fact, in accordance to the latest curriculum, mathematics subject may be best if it is started from the contextual problem. As what stated by Depdiknas (2006, p. 1) the introduction of contextual problem constructs the understanding of the students little by little. Therefore, the process of teaching mathematics can result on a comprehensive and holistic understanding for the students. Besides, learning mathematics should be more meaningful by focusing on figuring out the concept and its application in real life situation.

The result oriented issue where the teachers are concentrated on solving the math problems based on a text book instruction without comparing to other sources. Moreover, they tend not to consider students' thinking process stages. Regularly, teachers avoided comparing methods. For instance, during teaching ratios concept, they will explain it separately, starting from equivalent ration then continue with proportions. The teachers did not use an example which contrasting two concepts. The monotonous teaching methods that is not suitable for the material and students' characteristics.

The Correlation between Students' Mastery of Essential Mathematics Concept and the Critical Thinking Ability Skills

The correlation between proficiency in essential mathematics concept and the critical thinking can be analyzed by adapting contingency table and association. Similar to students' mastery of essential mathematics concepts, the critical thinking skills are also labeled into different proficiency categorizes. The maximum ideal score (SMI) of critical thinking are 50, so the categorization can be described:

Value> 40 : high

30 < value <40 : average

Value<30 : low

The categorizations are illustrated in Table 2:

Table 1. The Quantity of the Students based on to Their Proficiency in Essential Mathematics Concept and the Critical Thinking Ability

		Critical Thinking Skills			
		HIGH	AVERAGE	LOW	Total
THE MASTERY OF ESSENTIAL MATHEMATICS CONCEPT	HIGH	40	7	0	47
	AVERAGE	0	137	11	148
	LOW	0	0	39	39
Total		40	144	50	234

The hypothesis:

H0: There is no relation between the proficiency in essential mathematics concept and students' critical thinking skills

H1: There is a relation between the proficiency in essential mathematics concept and students' critical thinking skills

Test Criterion: if sig > 0,05, H0 true

The result of the Chi-Square test:

Table 2. Chi Square Test Result

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	359.268[a]	4	.000
Likelihood Ratio	317.564	4	.000
Linear-by-Linear Association	191.016	1	.000
N of Valid Cases	234		

The result of the calculation showed the value of sig = 0,000, therefore sig< 0,05 means that H0 was declined. That is to say, there is a relation between the proficiency in essential mathematics concept and their critical thinking with the significant level of 5%. Afterwards, in order to find the level of association (dependency) among each variable, contingency table and association is taken. The result is described in the table below:

Table 3. Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.778			.000
Ordinal by Ordinal	Gamma	1.000	.000	16.343	.000
N of Valid Cases		234			

The criteria:

C=0 , no association

$0< C < 0{,}20C_{maks}$, weakest assosiation

$0{,}20C_{maks} \leq C<0{,}40C_{maks}$, weak association

$0{,}40C_{maks} \leq C<0{,}70C_{maks}$, somewhat association

$0{,}70C_{maks} \leq C<0{,}90C_{maks}$, strong association

$0{,}90C_{maks} \leq C<C_{maks}$, strongest association

$C= C_{maks}$, perfect association

$$C_{maks}=\sqrt{\frac{m-1}{m}}$$

$$C = \frac{C}{C_{maks}}C_{maks}$$

The result of the calculation is C=0,778 and C_{maks} =0,82, therefore the value that is earned is C= 0,95 C_{maks} and it belongs to the strongest association.

The Correlation between the Proficiency in Essential Mathematics Concept and Creative Thinking Ability

The maximum ideal score (SMI) of mathematical creative thinking are 60. Therefore, the categorization of students' proficiencies can be described:

Score > 48 : high

36 < score <48 : average

Score <36 : low

The result is showed in the Table 4:

Table 4. The Quantity of the Students based on the Proficiency of Essential Mathematics Concept and Creative Thinking Ability

		CREATIVE THINKING ABILITY			
		HIGH	AVERAGE	LOW	**Total**
THE MASTERY OF ESSENTIAL MATHEMATICS CONCEPT	HIGH	22	25	0	47
	AVERAGE	0	103	45	148
	LOW	0	7	32	39
Total		22	135	77	234

The hypothesis:

H0: There is no relation between the proficiency in essential mathematics concept and students' creative thinking skills.

H1: There is a relation between the proficiency in essential mathematics concept and students' creative thinking skills.

Test Criterion: if sig > 0,05, H0 is accepted

The result of the Chi-Square Calculations:

Table 5. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	146.381[a]	4	.000
Likelihood Ratio	140.221	4	.000
Linear-by-Linear Association	98.604	1	.000
N of Valid Cases	234		

The result of the calculation showed the value of sig = 0,000, therefore sig< 0,05 means that HO was declined. It can be concluded that there is a correlation between the proficiency in essential mathematics concept and creative thinking ability with the significant level of 5%. Next, in order to find the level of association (dependency) among each variable, contingency association is taken. The result is described by the table below:

Table 7. Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.620			.000
Ordinal by Ordinal	Gamma	.935	.026	11.429	.000
N of Valid Cases		234			

The result indicated C = 0,620 andC_{maks} =0,82, therefore C = 0,76. It means C_{maks} belong to the strong association rank.

Findings and Discussion

The following step after analyzing the data is findings discussion concerning the students' accomplishment in mastering essential mathematics concept and its correlation to their critical and creative thinking. The result of the study shows that the teaching methods have an important role in the process of understanding essential mathematics concept that relates to creative and critical thinking. It is in line with research conducted by Shihu and Jijian (2001), Lim and Pang (2002), Syukur (2005), Rohayati (2005), Pomalato (2005), Mayadiana (2005), Mira (2006), Fahinu (2007), and Ratnaningsih (2007) who reported that innovative teaching method has better influence rather than the common teaching method toward the students' mathematical creative thinking.

As a matter of fact, the raw inputs of the students in the underrated schools are lower than the students of prestigious and regular school. The number of students who have potential in mathematics than others can affect the effectiveness of learning activities in a classroom, since they can help each other. Harsunarko (Team of MKPBM, 2001, p. 233) argues that smarter students can act as tutors for their friends. What it means by tutors can be (1) same-age tutors, mean peers who are smarter (2) sister-tutor come from higher level. Furthermore, the facilities that are owned by prestigious schools are more sufficient than what underrated schools owed. The condition of the facilities is one of the teaching resources that can affect the result at the end of the period. According to Wijaya (Team of MKPBM, 2001, p. 233), the results of learning activities are influenced by several resources that cooperate in creating an integral system.

In accordance to the theory of cognitive development proposed by Piaget, that said the development of students' cognitive skills designated by the process of manipulating along with the process of social interacting among students and the surroundings. To put it simply, actions lead to knowledge. Moreover, Piaget believes that physical experiences and

environment manipulation are important to the cognitive development changing. On the other hand, social interactions among peers, in particular, arguing and discussion, contribute to the process of clarifying their perceptions which leads into logical thinking.

The statement concerning the contribution of mastering essential mathematics concept toward students' capability in critical and creative thinking are conforming to the definition of mathematics critical thinking stated by Glazer (2000). He defines critical thinking as the capability and disposition to connect basic knowledge, mathematical reasoning, and cognitive strategy in generalizing, validating, or assessing unfamiliar mathematics situation. Meanwhile, according to Musbikin (2006, p. 36), creative thinking relates to the process of creating something new by entailing present elements and experiences. Moreover, the research conducted by Oswald Kulpe as cited in Purwanto (1990, p. 49) is indicating similar result concerning the essentials mathematics concept and critical thinking ability. He used his students as the research subject. Then, he conducted the research by adapting introspection-experimental method. The results point out that during the thinking period, internal factor has an important role as an active actor in controlling all of the conscious actions.

Other than that, the result of the study indicates several requirements for the teacher to develop the students' mathematics abilities; constructing the problem, creating a hypothesis and made logical guess, solving problems; communicate mathematically, and connecting mathematical ideas to others concepts in real life situation. Utari (2002) mentions the requirements as a mathematics teacher involve (1) Selecting appropriate task for the students in order to increase their interest along with their intellectual side; (2) Increasing their understanding concerning math; (3) Creating discussion discourse to find and generate math ideas; (4) Utilizing technology and other supporting tools in order to solve math problems. At the same time, teacher should be helping the students to catch up with the technology; (5) Connecting the recent concept to the later one and help students in finding the correlation; (6) Guiding the students in doing all of their tasks. Due to that reason, Trianto (2007, p. 3) argues the importance of understanding the material and all the elements of teaching activities for teachers relates to the methods in order to make various, innovative and more constructive learning style in enriching the knowledge along with its implementation to increase students' creativity.

Based on the calculation of association contingency, the conclusions of the study found out the correlation between students' mastery of essential mathematics concept and their critical thinking is in the highest level, while for the creative thinking the level is on

high category. It means creative thinking is more challenging for the students rather than critical thinking. The results are in same notions with learning styles proposed by Gagne which said creative style is higher than problem solving style. It is suggested that creative thinking cannot be achieved by having critical thinking only without being supported by other factors. Coleman and Hammen as cited in Yudha (2004, p. 3) mention other factors outside the cognitive skills that can boost creative thinking, such as flexibility toward internal and external stimuli, open-minded way of thinking, independent way of thinking and confidence. Moreover, Musbikin (2006, p. 5) argues that creativity covers scientific discoveries, imagination, experiment, and exploration.

5. CONCLUSION

Students' mastery of essential mathematics concept is at average level; b) The difficulties that encountered by the students come from internal factor (themselves), and external factors (teachers, the characteristics of mathematics, schoolmates and the facilities).

There is a significant relationship between students' mastery of essential mathematics concept and their critical thinking. The correlation between the proficiency in mastering essential math concept and their creative thinking is at high level.

6. SUGGESTIONS

Considering the importance of critical and creative thinking in globalization era since those are related to the students' mastery of essential mathematics concept, it is better for mathematics theory to be understood and meaningful to make it can be applied in daily lives. Furthermore, it is essentials for teachers to be creative in providing the materials which are compatible with the characteristics of both of students and concepts, levels of thought, facilities, in addition it is important to avoid one-source material in teaching.

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