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Exploring Student's Productive Thinking in Solving Algebra Problem

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Abstract – The purpose of this research is to describe student productive thinking in solving problem in algebra. The subject of this research is choosing four subjects which have different productive thinking. The first instrument is using self-regulated learning questionnaire, then the second instrument is giving a test and interviews. The result indicated that student with high self-regulated learning, thinks really critically, and his creativity has the ability of thinking productive. Students which have the ability to think productively have the following characteristics: they are able to identify problem well, they are able to write facts clearly and they are able to describe what is already known and what has been questioned in the question precisely, right in writing the mathematics model, and they are also able to make calculation and check the rightness which happen as well. They give more than one relevant idea and find more various ways dealing with the problems, give the answer in detail, clear and complex, make right conclusion and doing calculation precisely, double check their answers by using the known matter in the problem.

Keywords – Productive thinking, Critical thinking, Creative thinking, Self-regulated learning.

1. Introduction

The development of the globalization's era is followed by various problems which made many students did not know about how to response to some kinds of problems which needed smart action to solve them.

1
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4
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One of the ways to solve those problem is with mathematical thinking. Stacey [1] mentioned that: 1) mathematical thinking is an important goal of schooling, 2) mathematical thinking is important as a way of learning mathematics, 3) mathematical thinking is important for teaching mathematics. Thinking process is an activity occurring in human's brain [2]. Thinking skills is a must have thing for students so they are able to develop those thinking into a dynamic thinking and not a static one, refers to the available information and seek for latest information, not only to understand one problem, but also they are able to analyze it, and give an alternate solution from what they face. The ability to behave smart and habits of thinking which are needed in solving these problems is by thinking productively.

Researcher in cognitive psychology finds out that besides having the process of thinking, humans also have the ability to control their behavior, by using productive thinking effectively. Productive thinking is a person's ability to reconsider, reframe, rethink, or consider a problem from multiple points of view [3]. Thinking productively meant in this research refers to thinking productively which developed by Marzano & McTighe [4] and ThinkX [5] with three categories which are: self-regulation learning, critical thinking, and creative thinking. The category of self-regulation is: aware of own thoughts, making plan effectively, aware and using needed information, sensible to feedback and evaluate the effectiveness of every moves. Thinking critically includes: to be accurate and look for accuracy, clear and look for clearance, open, hold one's self from impulsive act, being able to place one's self when there is guarantee (beliefs in his/herself and being sensitive and know friend's ability). Creative thinking includes: being able to make his/her count even though the answer is soon clear, doing things which maximize his/her abilities and knowledge, using and improve his/her evaluation standard which s/he made, that also invents a new way in seeing the environment and the border view which is valued in the society.

The ability to think productively by an individual can be taught, trained, developed, and make it to be better. Various strategy to seek, train, develop, and shape the productive thinking of people, he alleged that the habit of thinking productively happens

because of habituation during the learning process [6]. Productive thinking is the highest characteristic of intelligent thinking behavior to solve problems and it is an indicator of success in academic, work, and social relationships. In the process of finding problem, students are able to explore facts, identify patterns or relationship in between which is related, they are also able to use creative reconsidering, conceptual or inductive. After that students are trained to look for creative solution and make it real in a productive result. The finding of problem cannot be separated from the learning process, that is why place to implement it is needed.

Some research still separates self-regulation learning, critical thinking, and creative thinking [7],[8]. Therefore research needs to be done to understand students' productive thinking skills in solving mathematical problems, such as algebraic material. Why algebraic material? The purpose of algebra learning is that students gain confidence about their mathematical abilities, become good problem solvers, can communicate mathematically, and can reason mathematically. This ability has an important role in learning mathematics that is relatively complex. Thus, understanding algebraic concepts is important as a basis for understanding other mathematical material concepts. Stand on the explanation above the researcher wants to research more deeply about the analysis of student productive thinking in solving mathematical problem. The aim of this research is to describe the productive thinking of high school student at senior high school related to the mathematic problem in algebra matter.

2. Literature Review

Thinking is the source of all knowledge; on the contrary knowledge provides feedback to thinking, the higher level of knowledge, the higher level of thinking from a person. Thinking requires two main components, namely the incoming information and the scheme that has been formed and stored in the mind of each individual. In connection with Piaget's cognitive scheme who states the mental or cognitive structure of an individual intellectually adapts and coordinates the surrounding environment. The Gestalt psychologist was the first to provide a phenomenological description of what happens when people face problematic situations [9]. He identified two processes namely reproductive thinking (consisting of applying a chain of mechanical relationships that have been studied and reinforced by experience and habits) and productive thinking (a process that involves creating something new). Gestalt theorist introduced the term productive thinking [10]. Productive thinking is problem solving including a complex reasoning process for humans.

Productive thinking starts from a deep understanding of the structure of phenomenal problems. Productive thinking was developed by Marzano & McTighe [4] in five dimensions of learning, which included: 1) positive attitudes and perceptions of learning, 2) acquisition and integration of knowledge, 3) expansion and smoothing of knowledge, 4) knowledge use meaningful, and 5) productive thinking habits. The learning dimension model is a metaphor of how the brain works while people learn. Learning with the dimension learning model approach is learning that uses the dimensions of learning as the premise of learning. Learning that is centered on these five dimensions will undoubtedly provide better results. The first and fifth dimensions are important factors that have to be considered in the learning process, because these two dimensions determine the success of the other dimensions. Therefore, the habit of productive thinking is an important thing to consider in this study.

Researchers in the field of cognitive psychology have found that in addition to having the ability to think, humans also have the ability to control their behavior, by using productive thinking effectively. Productive thinking is thinking that includes problem solving. Solving problems is not only used in working on science, but also it is used in all aspects of life from simple to complex aspects [11]. In problem solving, people think creatively in the conclusion process [12]. An act of creative thinking can occur if the thinker gets a sudden conclusion which is new to him, which can be artistic, mechanical, or administrative production. Productive thinking can occur or be owned by anyone, even though what has been produced by someone else.

Good thinking ability is not automatically owned by someone, but it has to be taught [13]. The ability to think productively can be explored, trained, developed, and shaped for the better. Carter [6] revealed various strategies to explore, develop, and shape one's productive thinking. The ability to think productively is trained and developed through habituation during the learning process. Depending on some of these opinions, productive thinking is the ability to carry out complex reasoning processes in an effort to solve problems in all aspects of life.

3. Method

The method being used in this research is qualitative descriptive method so the researcher herself/himself becomes the main research instrument in this research. The new instrument in this research are scale sheet and interview guidelines. Thirty-eight high school students agreed to be respondents in this research. Moreover the researchers choose four students stand on students'

communication skills and class teacher considerations as well. The first instrument that is being used is scale sheet to consider student's self-regulated learning. This sheet was used to consider that the research subject the students are having high, mediate, or low self-regulated learning. The second instrument are critical thinking and creative thinking question test sheet. Question sheets which are used in this research are in the form of description test. The questions presented algebraic stories. This answer sheets are used to consider the critical level thinking (TBKs) and the level of creative thinking (TBKf) of the students. The level of critical thinking (TBKs) which was being talked here is the level of critical thinking based on Rasiman [7] which is divided into 4 levels that is, very critical, critical, less critical, uncritical. While the question sheet which is being used to measure the level of thinking creatively (TBKf) of the students refers to the level of creative thinking according to Siswono [8] is divided into 4 levels that is, creative, quite creative, less creative, and uncreative. In this research interviews depended on the test used to examine deeply about the ability of thinking productively of the students. The techniques used to validate the data in this research are using triangulation method. Triangulation method is done by comparing the results of written test and the result of interview. If the answer between written test and the result of interview test of the students there are the same whose answer is valid. Student is said to have the ability of thinking productively if the student has high self-regulation, thinking very critically, and that he is creative.

4. Results

Figure 1 is grouping level of students' self-regulated learning from 38 students are obtained 31.58% (12 students) with high self-regulated learning, 52.63% (20 students) with mediate self-regulated learning, and 15.79% (6 students) with low self-regulated learning.

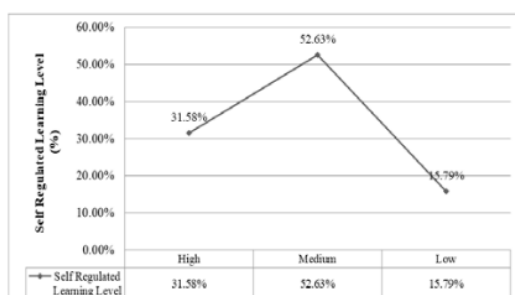


Figure 1. Student's self-regulated learning level

Figure 2 illustrated the indicator of critical thinking from 38 students obtained 60.53% students are able to think high critically which in 23 students, 31.58% (12 students) are students who think critically, 5.27% (2 students) think almost less critically, and one student uncritically.

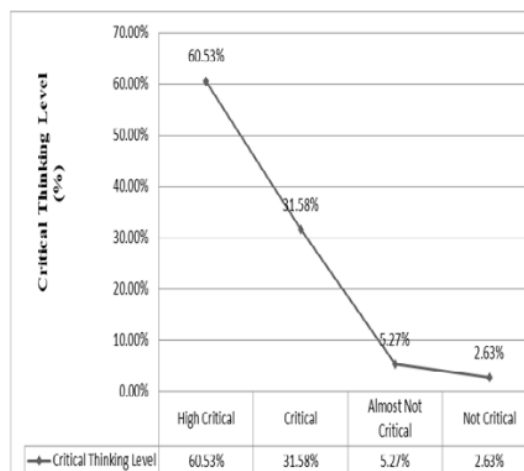


Figure 2. Student's critical thinking level

Figure 3 show 38 students in total obtained 5.27% (2 students) are creative, 15.79% (6 students) are quite creative, 63.16% (24 students) are quite creative, and 15.79% (6 students) uncreative.

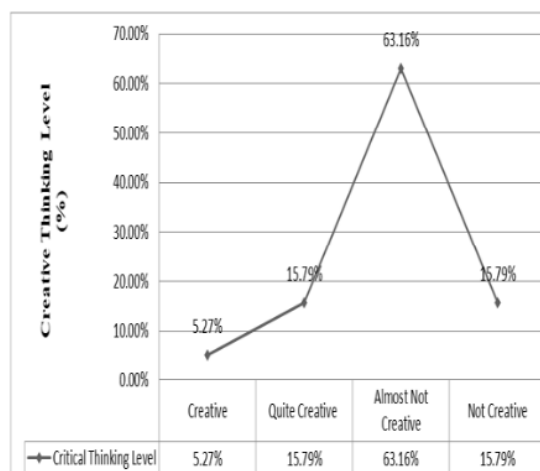


Figure 3. Student's creative thinking level

Table 1. Categorized Productive Thinking

Self-Regulated Learning	Critical Thinking	Creative Thinking	Initial Subject
High	Very critical	Creative	DF*
High	Very critical	Quite creative	LA
High	Very critical	Less Creative	AH, DE, R
High	Very critical	Uncreative	AAW
High	Very critical	Quite creative	DWS
High	Very critical	Less Creative	AY, KK, LNP, SM, SNA
Moderate	Very critical	Creative	FH
Moderate	Very critical	Quite creative	M
Moderate	Very critical	Less Creative	BHI, JA, NRM, NAS, NNW, NRAS, NAK, NR, OE, SA
Moderate	Very critical	Uncreative	MHK, RDP
Moderate	Critical	Quite creative	GIP, MNA*
Moderate	Critical	Less Creative	LS
Moderate	Critical	Uncreative	RAK
Moderate	Less Critical	Less Creative	BAW
Moderate	Less Critical	Uncreative	AA
Low	Very critical	Quite Creative	YS
Low	Very critical	Less Creative	EP, Y
Low	Critical	Less Creative	LMH
Low	Less Critical	Less Creative	DA*
Low	Uncritical	Uncreative	RIL*

The mark (*) is the chosen subject.

Depending on the number of subjects of the above research, researchers selected a number of subjects to be the focus of the research. The selection of this subject is also placed on the teacher's consideration by paying attention to the students' ability to express their opinions. Students' communication skills are also taken into consideration in determining the subject. From the Table 1 which deals with the subjects to be analyzed involved 4 students consisting of one student with high self-regulated learning, very critical and creative. Then one student with moderate self-regulated learning is being critical and quite creative. Furthermore, one student with low self-regulated learning, was less critical and less creative. And the last one student with low self-regulated learning, was uncritical, and uncreative.

5. Discussion

5.1. The Ability of Student's Productive Thinking in the Subject of High Self-Regulated Learning, Thinking Very Critically, and Creative

Subjects can identify problem well. Subjects are able to write facts which are given clearly, formulate the main problem of the matter and they are able to mention facts/theorem/prerequisite material needed to solve the problem, explains what is already known and what is questioned in the question precisely. Subjects are also able to write facts, data, and concepts that relate it. When understanding problems, they have to be able to identify what they have identified and what questions require them to do and whether what has been identified are sufficient to respond to the question [3],[14]. Identification of mathematic problem includes the known material, what is being questioned, and the adequacy of the required elements. In solving problem, subject can do calculations and check the validity relevantly, accurately, and precisely. Solving problem means answering question by using methods that look for solution from the question presented. In order to find a solution, student has to use material that have been taught before and through the process by which they will develop the understanding of new math [7],[15]. Moreover, the subject is able to give more than one relevant idea and find out more than one way. Also, subject can give a new answer in detail precisely and profoundly with correct answer. Subject made right conclusion and does calculation precisely. Subject can believe on the righteousness of its answer. Subject is also able to double check their answer by using known information in that question. After the participants got their results, they control the process from the start solution to the end of the solution [8],[16],[17].

5.2. The Ability of Student's Productive Thinking in the Subject of Mediate Self-Regulated Learning, Critical, and Quite Creative

Subject can identify the problem in the test well. Subjects are able to write facts which are given clearly, formulate the main problem from the subject matter, mention facts/theorem/prerequisite material which are needed to solve a problem. Subjects are able to detect problem in the test well. Subject are able to found facts, data, concepts, and they are able to relate it correctly by making mathematic model. When solving a problem, subject is able to make calculation correctly even though the written answer is not detailed. Wardhani [18] said that the cause of the weakness of students' ability in solving the problem is that students are not accustomed with the

process of solving problem correctly. In completing solving planning, subject cannot give relevant idea when they calculate, the result of the answer is correct but not in detail/complex. Subject are not able to write how to get those answer. The finding of Siswono [8], claim that students on that level are likely made mistake and there is no awareness of thinking, to investigate or look for something “new”. In this level student cannot fill the capability, novelty or flexibility in either solving or propose a problem.

5.3. The Ability to Think Productively Regarding the Student as the Subject of Low Self-Regulated Learning, Less Critical, and Uncreative

Subjects are able to write facts which are given clearly, formulate the main issue of the problem and they are able to mention facts/theorem/prerequisite material needed to solve problem. They also explain what is known and what is being questioned in the question precisely. In the steps of relating, subject is not able to relate the data collected from the question. A good problem solver, in order to change one representation to the other, always coordinate his/her experience and knowledge that she/he has, known representation, conclusion patterns, and their intuition [19]. In calculating, subject can check the validity of the relations that happen depend on the data given even though they cannot write it into mathematic model. Moreover, subject is not precise in making conclusion which is why the difficulty of recalculating the result are obtained to make sure whether the answer is correct or not occurs. Sriyati et al [20] asserts that almost some students are not writing conclusion because students are most likely to abbreviate the answer (make it short) and they are not accustomed in writing the conclusion.

5.4. The Ability to Think Productively Regarding Student as the Subject of Low Self-Regulated Learning, Uncritical, and Uncreative

Subjects are able to write facts which are given clearly, formulate the main problem of the matter and they are able to mention facts/theorem/perquisite material needed to explain a problem. Subjects are not able to detect problem on the question yet. Subject are not able to figure out the situation yet and give the right answer. In the steps of solving problem, subject is not able to make a mathematic model based on the data in the question. As a result, subject is not able to give answer. The steps that are being taken also do not leads to completion. This resulted in that subject cannot make a right conclusion because he is not able to do calculation.

Based on the result of the research it can be seen that the better the level of self-regulated learning, the higher the level of critical thinking and creative are accomplished by the subjects, which leads to better habit of thinking productively id permormed by the subject. Subjects who have high self-regulation, thinking very critical and creative can be said as subject who have the habit of thinking productively. Its in line with the research done by Sriyati et al [20] at High School which has results that there are three component which influence the habit of thinking productively (habits of mind) regarding the student there who are involved in self-regulated learning, critical thinking, and creative thinking.

6. Conclusion

Students with self-regulated learning are high, very creative and critical. They can identify the problem well. The subject matters the fact that is given clearly, the formulation of the matter enables him to mention the theorem / prerequisite material needed to solve the problem. The subjects also explains what is known and what is questioned in the question precisely. This illustrates that productive thinking skills are very important in developing complex problem solving abilities. However, in this study very few students who met the productive criteria of thinking who had high self-regulated standards, were very critical and creative. Therefore the teacher needs to design mathematics learning especially algebraic concepts by exploring aspects of self regulated learning, critical thinking and critical thinking skills to improve students' productive thinking skills. Other researchers can deepen and complement the research that has been done by deepening the specific study by creative students do not necessarily have high self regulated learning and critical thinking skills. Other researchers can also conduct research on mathematical concepts other than algebra.

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