LEVELING OF CRITICAL THINKING ABILITIES OF STUDENTS OF MATHEMATICS EDUCATION IN MATHEMATICAL PROBLEM SOLVING

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Abstract

This research aims to determine the leveling of critical thinking abilities of students of mathematics education in mathematical problem solving. It includes qualitative-explorative study that conducted at University of PGRI Semarang. The generated data in the form of information obtained problem solving question and interview guides. The results are: (1) students who are not critical (LCTA-0) only able to identify the given facts clearly, (2) students are less critical (LCTA-1), students can identify the facts in problems, (3) critical student (LCTA-2), students can identify the fact in problems, revealing the prerequisite knowledge appropriately, solve the problem but still less accurate in every stage, and (4) students are very critical (LCTA-3), students can identify the facts given clearly, mention the concept/ theorem/ prerequisite material. Based on these results, the leveling of students critical thinking abilities can be applied in a lecture at mathematics education.

Keywords: leveling, critical thinking, mathematical problem

Abstrak

Penelitian ini bertujuan untuk menentukan level kemampuan berpikir kritis mahasiswa pendidikan matematika dalam pemecahan masalah matematis. Penelitian yang menggunakan metode penelitian kualitatif eksploratif ini dilakukan di University of PGRI Semarang . Data diperoleh dengan cara mengumpulkan informasi melalui cara mahasiswa menjawab soal pemecahan masalah baik melalui tulisan maupun lisan dengan wawancara terbimbing. Hasil penelitian ini adalah: (1) mahasiswa yang tidak kritis dalam berpikir sama sekali (LCTA-0) hanya dapat mengidentifikasi fakta secara jelas tanpa, (2) mahasiswa yang kurang kritis dalam berpikir (LCTA-1), dapat can identify the facts in problems dan mengetahui pengetahuan yang tepat untuk menyelesaikan soal, (3) mahasiswa yang berpikir kritis (LCTA-2), dapat mengidentifikasi fakta dalam masalah, mengetahui pengetahuan yang tepat untuk menyelesaikan soal, memecahkan soal tetapi kurang akurat dalm langkah-langkah, (4) mahasiswa yang sangat kritis dalam berpikir (LCTA-3), dapat mengidentifikasi fakta dalam masalah, mengetahui pengetahuan yang tepat untuk menyelesaikan soal, memecahkan soal dengan akurat. Temuan tentang level kemmpuan berpikir kritis dalam pemecahan masalah ini dapat dijadikan rujukan dalam pembelajaran matematika.

Kata kunci: level, berpikir kritis, pemecahan masalah matematis

The ability for solving mathematical problems (Siswono, 2008) is influenced by some factors, such as internal or external factor. Internal factors include intelligence, motivation, interest, talent and mathematical ability or gender difference. External factors such as tools, infrastructures, media, curriculum, lecturer, learning facilities and etc. Students who have different background and different mathematical ability are also have different ability for solving mathematical problem.

Arend (2009: 1) mentioned in this paper that the thinking ability of students will not be developed without effort that explicitly and intentionally grown. A student will not be able to develop his high level thinking ability well without being challenged to practice in the use of learning. One of high level thinking abilities is critical thinking. The critical thinking can be owned by someone if he is consistently trained through focused discussion or facilitated by an instructor.

The critical thinking is mental process that is organized and play a role in decision making process to resolve the problem. The critical thinking includes analyze activities and data interpreting at scientific inquiry activities. In 1990, the *Secretary's Commission on Achieving Necessary Skills* said that competency of critical thinking, making decision, problem solving and reasoned as the important things at work achievement. Therefore, students of mathematics education are expected to have provision abilities: critical thinking, problem solving and making decision.

To asses whether a person including a good critical thinkers or less, can be seen from the abilities of interpreting, analyzing, evaluating, concluding, explaining what they are thinking about, making decision, applying the power of critical thinking to himself, and improve the ability to think critically about the opinions he made (Facione, 2009). A person who is able to do six cognitive abilities above then his critical thinking ability is far above a person who is only able to interpret, analyze and evaluation. Thus it can be said that there is a leveling of critical thinking ability of a person. The level of critical thinking abilities of each person is different and these differences can be viewed as a continuum that starts from the lowest to the highest degree.

To make an assessment of critical thinking abilities for mathematics education students in problem solving activity required a standard or criterion of critical thinking level. These criteria can be used as a guide to determine the quality of students' abilities in critical thinking and its development during the learning process in solving mathematical problems. Based on these criteria, a person can be categorized as critical thinkers or not critical thinkers. In Indonesia the research related to the leveling of critical thinking abilities in solving mathematical problems is still rarely done. The late research (Palinussa, 2013) is about different student critical thinking ability between students treated with Realistics Mathematics Education (RME) and student with no treated. Thus, this study seeks to formulate a leveling of students' critical thinking abilities in solving mathematical problems.

The problem of this study is how the leveling of critical thinking abilities and the critical thinking process of mathematics education students at University of PGRI Semarang in solving mathematical problems.

METHOD

This study includes qualitative-explorative study conducted at mathematics education student of PGRI Semarang University. This means that this study illustrate or describe events that become the center of attention (critical thinking level characteristics) qualitatively based on qualitative data.

The subjects were mathematics education students at university of PGRI Semarang. Subject

selection techniques with the snowball method namely the next subject selection conducted after results analysis were obtained from the previous subject. If there is no subject that meet criteria related to critical thinking process in accordance with the expected level of ability, then it is done repeatedly until the subject obtained.

The main instrument in this research is researcher himself and equipped by instruments of problem solving question and interview guides. Researcher as the main instrument, so that at the time of data collection in the field researcher participates during the research process and actively follow the research subject activities in accordance with data collection. Procedure of the leveling of critical thinking level follow the steps below

1. Formulate initial theory (draft of critical thinking level) based on theory study which is supported by empirical data.
2. Validate draft of critical thinking level to the experts.
3. Perform pre-study to prove the existence of critical thinking level.
4. Revise critical thinking level based on pre-study result.
5. Perform data collection.
6. Perform analyze.

RESULTS AND DISCUSSION

Data was collected by giving students of Mathematics education a sequence of proving questions. Students' activity while doing the task (prooving the quetions) was video-typed using *handycame*. Students' work was analized and became a based interviews data. To observe and attain the illustration of students critical thinking abilities, we implied the following steps: (1) students were given the task to solve the proving questions. (2) The researchers examined the results of students' work. (3) researchers provide questions related to the answers given by the students. Furthermore, from the results of the written and verbal data (data from interviews) were collected and then examined its provisions or it consistency. If there was data that was inconsistent, then the second interview conducted in order to obtain the data according to the research questions.

By doing all of the research stages which are: 1) formulation of the theory in the form of the initial (draft level critical thinking) based on the study of theory supported by empirical data, 2) validate the draft level critical thinking to experts to determine the validity of the construct and empirically according to the theory developed, 3) pre-research to prove the existence of levels of thinking critically revised the draft level critical thinking based on the results of pre-research, 4) data collection to determine the existence of level critical thinking skills in mathematics according to the hypothetical theory is made, 5) the method of comparative analysis to determine the reliability hierarchy, we generated critical thinking skills that are formulated (LCTA- 0 until LCTA-3).

The discussion of the study, a hierarchy of critical thinking skills of students is presented as follows:

1. Level of Critical Thinking Ability (LCTA-0)

   Students have not been able to resolve the problem and are at LCTA-0 (not critical). At this level, the students have the following characteristics:

   a. Students are less clear in identifying the facts in issue.

      Figure 1 shows that student mentioned information on a question and whether the information is clear enough.

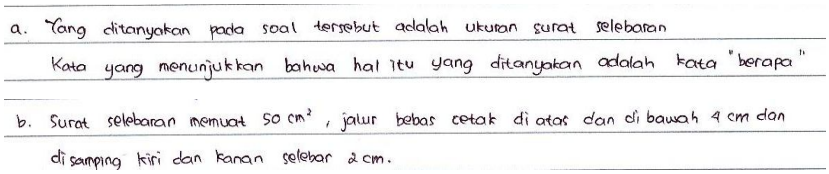

a. Yang ditanyakan pada soal tersebut adalah ukuran surat selebaran
Kata yang menunjukkan bahwa hal itu yang ditanyakan adalah kata "berapa"
b. Surat selebaran memuat 50 cm^2, jalur bebas cetak di atas dan di bawah 4 cm dan
di samping kiri dan kanan selebar 2 cm.

Figure 1. Student LCTA-0 Response On Information In A Question

In Figure 1 student wrote all information in the question: 50 cm2- square leaflet with 4 cm bottom, left and right margin, and 2 cm for the right in point b. By mentioning all information on it, he is know the question mean. However All information he mentioned did not sufficient for answering the question, as shown in Figure 2.

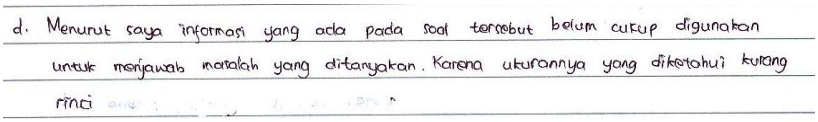

d. Menurut saya informasi yang ada pada soal tersebut belum cukup digunakan
untuk menjawab masalah yang ditanyakan. Karena ukurannya yang diketahui kurang
rinci

Figure 2. Student LCTA-0's Believe On Information In A Question

Figure 2 illustrates that student thought informations in question did not sufficient to solve the problem because the size of paper is not in detailed. From those two, it can be seen from the low ability of students to formulate the basic problem with the information known to the problem.

   b. Students are not precise and less clear in expressing the prerequisite knowledge (definition/ theorem/ data) that can be used in solving problems and in the end the students are not able to make plans based on knowledge preconditions problem solving. In this case, the data can be drawn from the Fragment 1 from dialog of interview.

Researchers-20 : *Why would you use all information on it?*
AIL-20 : *Because only 2 known information sir.*
Researchers-21 : *Is there any another reason?*
AIL-21 : *None.*
Researchers-22 : *With these two informations, what the knowledge should be use? What formula is possible to imply?*
AIL-22 : *Maybe if I look for letter size, I can use the area of the plane. But*

because of its size has not been detailed, so, I do not know what to do sir.

Fragment 1. Dialog Between Students LCTA-0 And Researcher On Preparing Answering Question

Fragment 1 mentions student was lacking knowlegde in planning the answer based on two informations. He did not know which formulae or theorem fits to this problem.

c. Students in solving problems based on concepts and ideas in the form of definitions, concepts, theorems, principles and procedures that are not clear, inaccurate, irrelevant and depth. Experiencing difficulty in implementing problem solving.

By checking student's response in Figure 3, it can be seen that student was having difficulty solving the problem.

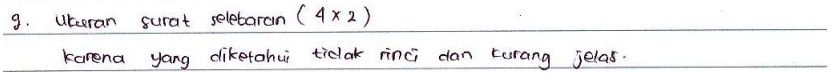


Figure 3. Student LCTA-0' Final Anwers

d. Students are vague and lacking in evaluating logical arguments used in solving the problem. It can be drawn also from Figure 3 that student was naot doing an evaluation on his answer.

Based on this analysis, it can be concluded that the students were able to identify the fact that there is the problem specially to the data in questions, but still having difficulty uncovering the facts in question. This results in imprecise students and less clear in expressing the prerequisite knowledge (concept/ theorem) in the solution of problems. In addition, to resolve the problem has not been based on the concept of the right-theorem, the procedures used to implement the settlement of the problem is also less precise and less ambiguous and in evaluating logical arguments used in examining the steps to solve the problem.

2. Critical Thinking Ability level - 1 (LCTA - 1)

Students are able to solve problems and suspected to be at LCTA-1 (Less Critical). At this level, the students have the following characteristics:

a. Students clearly identify the fact that there is a problem, well known facts or facts in question. Figure 4 shows that student mentioned informations on a question and knew the relationship between them.

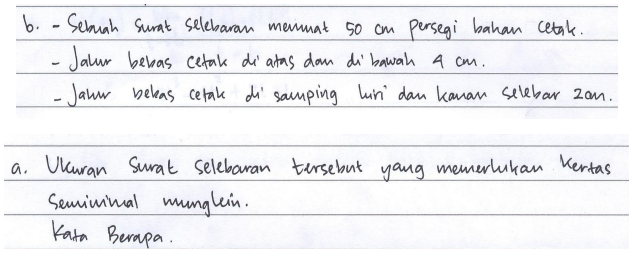


Figure 4. Student LCTA-1 Response On Information In A Question

In Figure 4 student wrote all information in the question: 50 cm^2- area of paper with 4 cm top and bottom free print area, and 2 cm left and right free print area. By mentioning "how wide area of leaflet with a minimum paper size, student really understood the meaning of the question. He also understood the relationship between these information. He mentioned that all information were sufficient for answering the question, as shown in Figure 5.

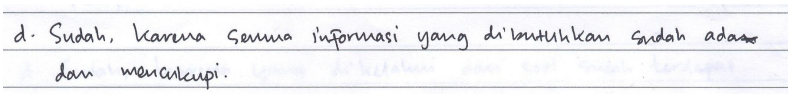


Figure 5. Student LCTA-1's Believe On Information In A Question

Figure 5 illustrates that student thought informations in question were sufficient to solve the problem.

b. Students are less precise and less clear in expressing the prerequisite knowledge (definition / theorem / data) to be used in solving the problem so that students are not exactly in a problem-solving plan based on prerequisite knowledge.

In this case, the data can be drawn from the Fragment 1 from dialog of interview.

Researchers-10	*: To resolve this problem the knowledge of what you need?*
AH-10	*: To resolve this problem, I will use knowledge of algebra, because it mention about variables and It also use knowledge about derivatives.*
Researchers-11	*: Algebra and derivatives yes. The information was that 50 cm2, free print area 4 cm and 2 that used not to solve all this?*
AH-11	*: Used all.*
Researchers-12	*: Knowledge of algebra and derivatives before, what would you use for that?*
AH-12	*: Still the same ..... as I know.*
Researchers-13	*: To solve the problem number 1, what the process do you use?*
AH-13	*: First we create a model of the image,, then from the model that we're looking for, we suppose that the length x then width y. Once it has been able to similarities yes.*

Fragment 2. Dialog Between Students LCTA-1 And Researcher On Preparing Answering Question

Fragment 2 mentions student applied all available information because the information relates to other information, but not quite right in mentioning the prerequisite knowledge that can be used to solve problems. He mentioned used the wrong knowledge for solving problem.

c. Students in resolving the problem has not been based on concepts and ideas in the form of definitions, concepts, theorems, principles. The procedure used to solve the problem too vague and imprecise.

From the dialog of Fragment 2 line AH-13, it is clear that student is not fit to solve problem

d. Students are vague and lacking in evaluating logical arguments used in examining the steps to solve the problem.

Based on the analysis of these characteristics, then the conclusion can be drawn as follows: the student can identify the fact that there is in fact well known problem and being asked, but less precise and less clear in expressing the prerequisite knowledge to resolve the problem. In addition, students are less precise in making the settlement plan and the steps do not resolve the problem accurately. Similarly, in implementing the settlement, less conscientious students and not give reasons based on logical thinking in examining steps to resolve the problems that have been done.

3. Level of Critical Thinking Ability - 2 (LCTA- 2)

Students are able to solve problems and suspected to be the LCTA-2 (Critical). At this level, the students have the following characteristics:

a. Students identify clearly the fact that there is the problem. It can be seen from the students' ability to formulate the basic problem with the information known to the problem. Figure 6 shows that student mentioned informations on a question and knew the relationship between them.

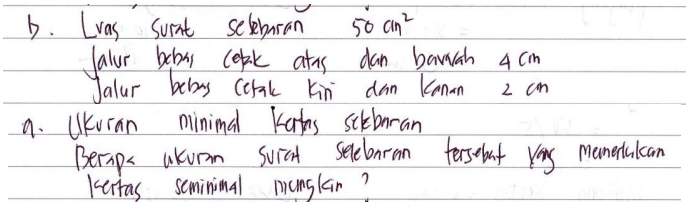


Figure 6. Student LCTA-2 Response On Information In A Question

In Figure 6 student wrote all information in the question: 50 cm^2- area of paper with 4 cm top and bottom free print area, and 2 cm left and right free print area. By mentioning "how wide area of leaflet with a minimum paper size, student really understood the meaning of the question. He also understood the relationship between these information. He mentioned that all information were sufficient for answering the question, as shown in Figure 7.

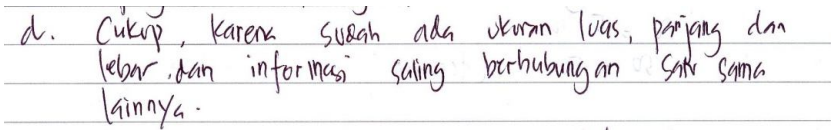


Figure 7. Student LCTA-2's Believe On Information In A Question

Figure 7 illustrates that student thought informations in question were sufficient to solve the

problem.

b. Students precise and clear in expressing the prerequisite knowledge (definition / theorem / data) that can be used in solving the problem, so that ultimately the student is able to make a plan solving the problem based on the facts given, prerequisite knowledge, clear procedures. In this case, the data can be drawn from the Fragment 3 of dialog between student and researcher.

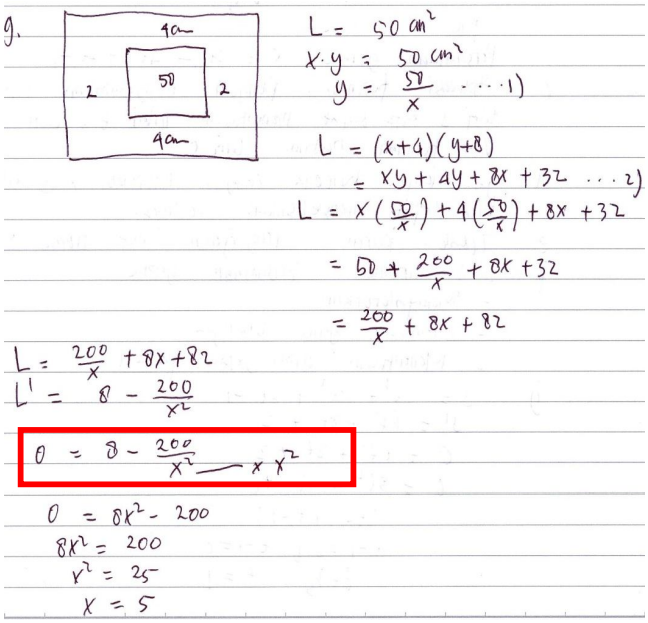
Researchers-12 *: Formula of area and derivatives. Try to explain the sequence of problem-solving way to this number.*

PDW-12 *: First I need a sketch. Then it is easy to make equation from the model, And then, The formula is derived using derivatives.*

Fragment 3. Dialog Between Students LCTA-2 And Researcher On Preparing Answering Question

Fragment 3 shows that student clearly mention all steps in solving problem: making a sketch, creating the equation from the model, and deriving formula. These steps is clear and fit to solve problem.

c. Students can solve the problem but it is less clear in each stage are implemented, yet deep in the provision of argumentation steps undertaken and less profound in making modeling a given problem. Even the student was clearly established step of solving problem, he missed the argumentation. Student only wrote mathematical equation with no note and argumentation why he used the procedured as mentioned in Figure 8.



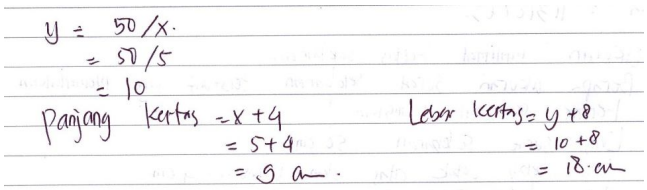


Figure 8. Student LCTA-2's Work

Figure 8 tells student's work without stage note and information. It is right in final, but lack of argumentation and confueble to the reader.

d. The student has not been able to distinguish between conclusions based on valid logic.

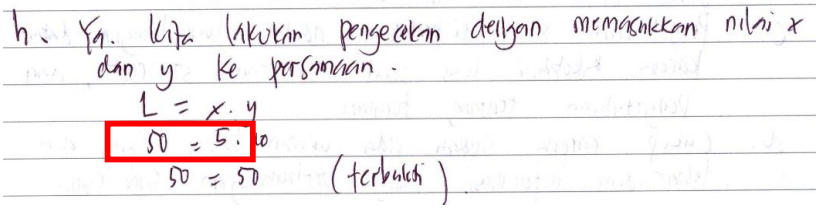


Figure 9. Student LCTA-2's Evaluation.

Figure 9 above, tells that student made a wrong proving shown in red box. Here, he should not write 50 before he finished knowing the area.

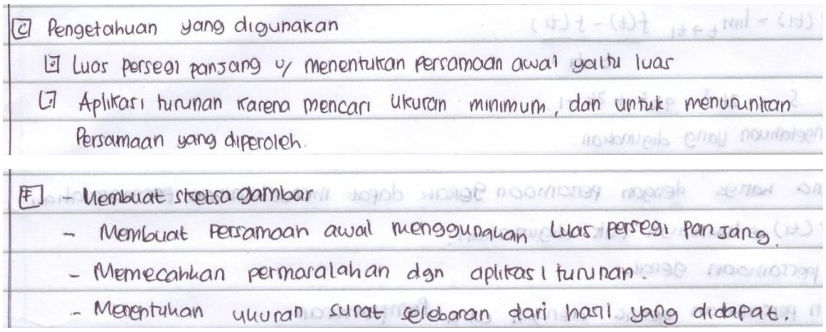
Based on the analysis of these characteristics, then the conclusion can be drawn as follows: the student can identify the fact that there is in fact a problem either problems or known facts, precise and clear in expressing the prerequisite knowledge, capable of solving problems in making plans, and can solve the problem but less careful in every step undertaken. In addition, students are also not able to distinguish between conclusions based on valid logic, when examining the steps work.

4. Level of Critical Thinking Ability - 3 (LCTA - 3)

Students are able to solve problems and suspected to be the LCTA-3 (Very Critical). At this level, the students have the characteristics:

a. Students identify clearly the fact that there is the problem. It can be seen from the students' ability to formulate the basic problem with the known information in the problem and can provide a logical reason. Student with this level, rose the same response to the Figur 6 and Figure 7 at the point mean of question and infomation inside.

b. Students precise and clear in expressing the prerequisite knowledge (definition / theorem / data) that can be used in solving the problem, and ultimately the students are able to make a plan solving the problem based on the facts given, prerequisite knowledge, clear procedures with stages logical. Student of this level preparing all stage in very clear and detailed as we can see in Figure 10 below.



Figur 10. Student LCTA-3's Stage In Detail.

c. Students in solving problems based on concepts and ideas in the form of definitions, concepts, theorems, principles and procedures that are clear, precise, relevant and insightful as we can see in Figure 11

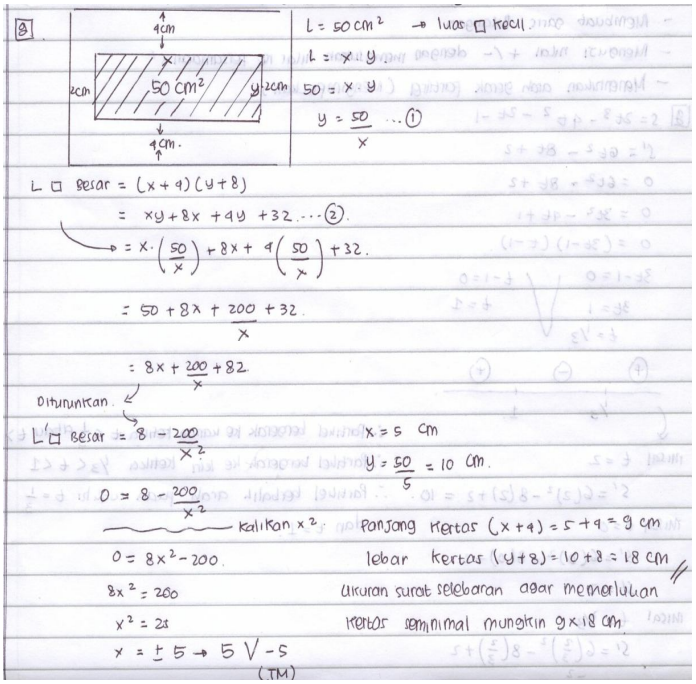


Figure 11. Student LCTA-3's Work

d. At the time of check steps work, students can not distinguish between conclusions based on valid logic. As student with LCTA-2 level, student LCTA-3 level also do the same mistake as mention in Figure 9.

Based on the analysis of these characteristics, then the conclusion can be drawn as follows: the student can identify the fact that there is a problem with either the complete data is known and the data in question. Precise and clear in expressing the prerequisite knowledge (definitions and theorems), to create a plan in order to resolve the problem, so the impact on the completion time of carrying out a problem, because students are always based on the concept of the right-theorem, and procedures performed in implementing clear and precise problem solving and

able to provide logical reasons. However, students can not distinguish between conclusions based on valid logic, at the time check his work.

Based on the research results, the subjects for LCTA -3, was able to resolve the problems appropriately and able to distinguish conclusion with logical consideration. In revealing the used formula to solve the problem, the subject can perform appropriately. Similarly, when the calculation process, the subject can do it correctly and quick relatively, it indicates that the procedure of his thinking is good enough. This is in accordance with the opinion Hergenhahn and Olson (2009) said that a person responds to the world based on previous experience, but every experience includes different aspects of the experience that before.

Research subjects to LCTA-2, was able to resolve the problem and find a concept or rule with a fairly rational considerations. Existing knowledge on the subject of research quite well and had no difficulty in linking some of the information in the problem, so as to seek the proper relationship between the known to those asked. This is in accordance with the opinion of Piaget (Brooks & Brooks, 1993) which said that: the assimilation, the stimulus is interpreted based on the schema owned by someone. If the stimulus is entered in accordance with the existing schemes, then one can directly respond to the stimulus. But the research subjects are less accurate in problem solving stages, consequently the obtained final solution was not optimal.

Research subjects to LCTA-1, have not been able to resolve the problem or to find theorem-concept that will be used to solve the problem. Existing knowledge on the subject of research is not good so he had difficulty in linking some of the information in the problem. Thus, he has not been able to seek the proper relationship between the known to those asked.

Research subjects for LCTA-0, the subject has not been able to identify the facts that are given clearly and in detail of the problem. Similarly, the solution of the planned measures, the subject has not been fully revealed and detailed. In finding concepts or rules in order to resolve the problem, the subject has not been mentioned fully. This suggests that the existing knowledge on the subject of research is very limited, so he has not been able to look for the right relationship between the known to those asked.

CONCLUSION AND SUGGESTION

The results of research on the leveling of students' critical thinking abilities in solving mathematical problems can be summarized as follows: (1) students who are not critical (LCTA-0) can only identify the given facts clearly and formulate the subject matter of a given problem, (2) students are less critical (LCTA-1), students can identify the facts in problem, less appropriate in revealing prerequisite(concept / theorem / data), and solve problems based on the concept-theorem which is not appropriate, (3) critical student (LCTA -2), students can identify the fact in problem, revealing the prerequisite knowledge appropriately, can solve the problem but still less accurate in every stage

implemented, and (4) students are very critical (LCTA-3), students can identify the facts provided clearly, able to mention the concept / theorem / prerequisite material, able to plan and carry out planning accurately and properly. In addition, students are also able to distinguish between conclusions based on logic.

Based on these results, the leveling of students critical thinking abilities can be applied in a lecture at mathematics education, especially in mathematical problem solving. It also suggested to be used as a basic for further research that is both verification and modification.

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