Critical thinking skills of junior high school female students with high mathematical skills in solving contextual and formal mathematical problems

1Ismail, 2St. Suwarsono, 3A Lukito
1 Universitas Negeri Surabaya
2 Universitas Sanata Dharma Yogjakarta
3 Universitas Negeri Surabaya
e-mail: ismail@unesa.ac.id

Abstract. Critical thinking is one of the most important skills of the 21st century in addition to other learning skills such as creative thinking, communication skills and collaborative skills. This is what makes researchers feel the need to conduct research on critical thinking skills in junior high school students. The purpose of this study is to describe the critical thinking skills of junior high school female students with high mathematical skills in solving contextual and formal mathematical problems. To achieve this is used qualitative research. The subject of the study was a female student of eight grade junior high school. The students' critical thinking skills are derived from in-depth problem-based interviews using interview guidelines. Interviews conducted in this study are problem-based interviews, which are done by the subject given a written assignment and given time to complete. The results show that critical thinking skills of female high school students with high math skills are as follows: In solving the problem at the stage of understanding the problem used interpretation skills with sub-indicators: categorization, decode, and clarify meaning. At the planning stage of the problem-solving strategy is used analytical skills with sub-indicators: idea checking, argument identification and argument analysis and evaluation skills with sub indicators: assessing the argument. In the implementation phase of problem solving, inference skills are used with sub-indicators: drawing conclusions, and problem solving and explanatory skills with sub-indicators: problem presentation, justification procedures, and argument articulation. At the re-checking stage all steps have been employed self-regulatory skills with sub-indicators: self-correction and self-study.

Keywords: Critical Thinking Skills, contextual mathematical problem, formal mathematical problem

1. Introduction

Critical thinking is a skill that is very important in the 21st century besides the other skills such as creative thinking, communication skills and collaboration skills (The Partnership for 21st Century Skills, 2009). Those skills are recognized as an integral part of students who are prepared to stock the more complex life and in the environment work on the 21st century. Critical thinking is a skill that is needed by everyone. Why is critical thinking important that need to be learned? There are several reasons, among others: Critical
thinking is a skill that is required in any job, when studying any field of science, to solve any problems, and is a valuable asset to one's career. According to Huit (1998), critical thinking is very important in the 21st century, because this is an era of information and technology. One must respond to changes quickly and effectively, thus require a flexible intellectual skills, the ability to analyze information, and integrate multiple sources of knowledge to solve problems. According to Krulik and Rudnik (1999), critical thinking is analytic and reflective. Critical thinking can improve verbal and analytical skills. Think clearly and systematically can improve ways of expressing ideas, useful in learning how to analyze the logical structure of a text, improves the ability to understand. Mathematics is a discipline that is supposedly appropriate to develop a correct and logical thought processes. But the question arises, whether to teach math to students' automatically teach critical thinking in their students or not? The reality is not the case, often the teacher has not successfully teach critical thinking skills to the students. Teachers prefer to teach the content of the subject matter alone. Based on Ismail’s observations (2012a) of the study of mathematics in seven, eight, and nine grade junior high of 7 math teachers from several different districts in Ponorogo, on December 10th, 11st, 12nd, and 3rd of October and the 1st of November 2012, showed the following results: seven teachers try to teach mathematics with a variety of learning strategies based on PAIKEM like STAD cooperative learning, direct instruction, guided discovery, CTL, discussion method, or methods of administration tasks. Teachers who implement cooperative learning, cooperative learning for learning syntax has been followed correctly, but the questions posed by math teacher for learning still not to the questions that develop higher-level thinking such as critical thinking, and creative thinking of students. From the seven new teachers who have been observed, three teachers have developed a good learning device and already constructivist, and on student learning process, they were given the opportunity to present ideas to the class group. But when the representative group of students express ideas / opinions in front of the classroom, teacher is not empowering answers from other groups but the teacher directly gives the correct answer to the student. Four of the seven less teachers provide opportunities for students to express ideas in front of the class, so students do not get space to convey his ideas to the class. Only 2 of 7 teachers who have developed the questions that involve higher order thinking such as critical and creative thinking. The questions that were developed by other five teachers, have not come to the question that develop higher-level thinking such as critical thinking, and creative thinking of students.

2. Literature Review

2.1 Thinking

Viewed from the perspective of education, thinking is usually used for the process of goal-directed conscious, such as remembering, forming concepts, plan what to do, imagine the situation, reasoning, problem solving, remembering opinion, make decisions and judgments, and generate new perspectives. It shows that that thinking is a mental activity whether done consciously or not related to our daily activities.

Thinking is an internal mental processes that build and operate the mental representation of information. This is in line with the statement Solso (1995), thought is defined as the process of generating a new mental representation, through the transformation of information that involve complex interactions between mental attributes such as ratings, abstraction, reasoning, imagination, and problem resolution. Based on some of the above opinion, thinking is required in decision making and problem solving. Thus, in this study is meant to think is all mental activity can be observed from the behavior that appears in the form of statements and results of problem resolution.
2.2 Critical Thinking

There are some examples of attempts to define critical thinking: (a) Ennis (1992) says that critical thinking is a process that is reasonable and reflective thinking that is aimed at making a rational decision directed to decide whether to believe or decide anything. Critical thinking aims to consider and evaluate the information in the end to make a decision, (b) by Angelo (1995) critical thinking is the application of deliberate, rational thinking skills high level, has the following characteristics: analysis, synthesis, problem solving, inference and evaluation, (c) Krulik and Rudnik (1999) defines critical thinking is thinking that test, linking / connecting, and evaluate all aspects of a problem. Critical thinking involves the ability to classify, organize, and recall and analyze information. Critical thinking is analytical thinking and reflexive, (d) according to Beyer (1995) critical thinking means making a reasoned assessment. In critical thinking using the criteria for assessing the quality of things, ranging from the processing of information leading to the conclusion. In essence, critical thinking is a disciplined way of thinking someone is used to assess the validity of something, and (e) according Facione (2011) critical thinking is no cynical skepticism. Critical thinking is an open-minded without vacillating. Critical thinking is analytical thinking. Critical thinking is judging without judgment and strong without dogmatic.

According Facione (2011) critical thinking skills is the main interpretation, analysis, evaluation, inference, explanation, and self-regulation. Interpretation means to understand and express the meaning of a variety of experiences, situations, data, events, assessments, conventions, beliefs, rules, procedures, or criteria. Analysis of means to identify the purpose and the true relationship between statements, questions, concepts, description, or other forms of representation of the other, is intended to express the conviction, judgment, experience, reason, information, or opinions. Including checking ideas, detecting arguments, and analyzing arguments as a sub-analysis skills. Evaluation means assessing the credibility of statements or other representations, intended to reveal the perception, experience, situation, judgment, belief, or opinion of someone, to assess the strength of logic, purpose and the true relationship between the statements, descriptions, questions or other forms of representation. Inference means to identify and secure elements needed to withdrawal reasonable conclusion; to form conjectures and hypotheses; to consider the relevant information and the consequent data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation to another. Explanation means capable of reassuring things and the way that is coherent with the results of reasoning. This means to express and justify reasoning in terms of evidence, the conceptual, methodological, criteria, and contextual based on the consideration, and to present one's reasoning in the form of a convincing argument. Self-regulation means self-awareness to monitor the activities of a person's cognitive, elements that are used in these activities and the results, particularly by applying skills in analysis and evaluation of the self-assessment with a view to asking, confirm, validate, or correct any of the results or reasoning someone.

2.3 Examples of Critical Thinking in Mathematics Problem

Fadhil wants to lay 3 pieces shelf above his desk, each rack 30 cm long. Then he went to the store to buy the board to be used as a shelf. In the store that sold the board with a size of 90 cm for every longjorinya, therefore it is necessary to cut the board into three equal parts. Stores provide a price of Rp. 18000.00 per board and cut costs Rp. 2.000,00 per cutting board. On payment bon listed as follows:

Bon Payments
1 stalk board with a length of 90 ........ Rp 18000.00
3 fare cut @ Rp.2000.00 ...............Rp. 6000.00
Taxes (6%) ...................................... Rp 1,440.00
Total ............................................. Rp 25440.00

Fadhil angry and said that the amount to be paid is too expensive, what's wrong?
For solving the first step that must be done is to identify the problem. On the question, students were asked to identify any errors in the calculations contained in the bill payment. After the students were asked to define the problem clearly whether an error occurred in the concept or in its calculations. After the students were asked to explore where the problem and at the same time the correct solution. Then evaluate the application, in this step the students are asked to explain what went wrong, why it went wrong and how the right answer. In the final step to try to integrate with the understanding that there is an understanding to answer / troubleshooting.

2.4 Problem Solving and Critical Thinking Skills

By Polya (1985) problem solving is an attempt to find a way out of the difficulties in order to achieve a goal that is not so easy to be reached soon. Polya (1985) proposed four steps to resolve the problem, which is to understand the problem, problem-solving strategies to plan, the implementation of problem-solving strategies, and check back all the steps that have been undertaken. Phase understand the problem, without any understanding of the given problem, students may not solve the problem correctly, then the students should be able to plan problem-solving strategies. Completion of the problem, in this phase is very dependent on the student experience more creative in preparing the resolution of a problem, if the plan for settlement of the problems has been made either in writing or not. The next step is the student is able to solve the problem, in accordance with the plans that have been prepared and considered appropriate. The final step of the process of resolving the problem by Polya is checked back all the steps that have been done starting from the first phase up to the third phase. With this model it is unnecessary errors occur can be corrected so that students can find answers that really correspond to a given problem.

3. Methods

3.1 Kind and Approach

Based on the research objective, that is getting description about critical thinking skill profile of junior high school female students in solving contextual math problem and formal mathematics problem. To achieve this is used qualitative research. A qualitative research approach is used with the aim of understanding the phenomenon of what subjects experience in a holistic way in a specific, natural context and examining what is behind the symptoms.

3.2 Research subject

The subject of research was selected by a high school student of eight grade Junior High School Luqman Al-Hakim. How to choose subjects that match the criteria that have been set is the first grade of junior high school students who were asked to solve the problem of mathematics ability test. The test results were assessed using a score from 0 to 100.

Based on the results of the tests and the results of discussions with teachers of mathematics in eight grade junior high school, selected a student with high mathematical ability is with a score of 90. The next step is the SBKM test and in-depth interview.

3.3 Instrument

The instrument in this study consists of the main instrument, the researcher himself and the supporting instruments that include audio visual recorder, math test, math critical thinking and interviewing guidance. The Mathematics Capability Test developed is a matter of almost all the material in class VII with consideration of the material already obtained when seven grade junior high school. Problems developed related to the matter of integers and fractions, social arithmetic, set, equations and linear inequality one
variable, comparison, and triangle and quadrilateral: properties, circumference and area. Problems of multiple choice in accordance with the standard contents of the mathematics curriculum for seven grade junior high school. The completed questionnaire was validated by 3 mathematics education experts.

3.3.1 Contextual mathematical problem
Fadhil wants to put the 3 pieces of shelves on his desk, the length of each shelf is 30 cm. Then he went to the store to buy a board to be used as shelves. The store sold board with the size of 90 cm for each, therefore it is necessary to cut the board into three equal parts. The stores gives Rp 18,000, per stalk boards and the costs to cut Rp 2,000 per cutting board. On the receipt of payment are listed as follows:

| Bon Payment                                      |
|--------------------------------------------------|
| 1 sheet of board with a length of 90 cm .... Rp 18,000,00 |
| 3 pieces @ Rp 2,000 fare, ........................ Rp 6,000,00 |
| Tax (6%) ................................................ Rp 1,440,00 |
| Total ................................................... Rp 25,440,00 |

Fadhil angry and said that the amount to be paid is too expensive, what's wrong?
On that issue, there is a problem and solving, but there is an error. Errors may occur in concept or in its calculation. Students are required to locate the fault and the completion at the same point. And they were asked to explain what went wrong, why it was wrong, and how the correction is. In the question: What went wrong? Students are required to use critical thinking skills.

3.3.2 Formal mathematical problems
Here are 6 circles arranged to form a triangle. Fill in the circles using the numbers 1, 2/3, 1/3, 1/6, 5/6, and 1/2 such that the sum of numbers on each side of the triangle is the same. Use each of these numbers exactly once. Explain your answer!

3.4 Data and Analysis
Based on the data that has been credible, then analyzed with flow model consisting of three activities that occur simultaneously that is: data reduction, data presentation, and conclusion, that is critical thinking process of female students of eight grade junior high school with high level of math ability in solving the problem critical thinking math problem.

Data collection on this subject is based on the task of Mathematical Critical Thinking Problem I and the task of Mathematical Critical Thinking Problem II. The critical thinking skills used in this study are adapted from the opinions expressed by Facione (2011): interpretation, analysis, evaluation, inference, explanation and self-regulation -regulation). Critical thinking skills are described as indicators and sub indicators as follows: (1) Interpretation: categorization, decode, clarification of meaning, (2) Analysis: examination of ideas, identification of arguments, argument analysis, (3) Evaluation: , argument assessment, (4) Inference: questioning claims, alternative thinking, conclusions, problem solving, decision making, (5) Explanation: problem presentation, proclaimed outcomes, justification procedures, argument articulations, and (6) Self-regulation: research and self-correction.

Result of subject’s test describes the analysis of the test results and interviews, the credibility of the data, and the analysis of the subject's profile on the completion of the Mathematical Critical Thinking Problem, the question with what critical question is wrong? explain the correction!

Transcription of interview result and observation of researcher to subject related critical thinking skill in solving critical thinking problem of mathematics of contextual problem as follows:
**Kode Interviews and observations result**

**P**: I have two problems to try one by one.

**S**: Yes (the students start working on problem no 1, the answer sheet starts to explain that there is something wrong with the cost of cut, it should cost Rp 4,000 instead of 3x, then calculate the tax from the new price After finished the students say :) finished.

**P**: Look at her work Aulia. (The researcher looks at the students' work) Try Aulia about the question 1 about what? Try to explain!

**S**: In the store there is a wooden board size of 90 cm, butuhnya it 3 pieces of wood, but cut it not 3x but 2x

**P**: Why 2x

**S**: Because if cut 2x result 3 pieces

**P**: If cut 2x produces how many pieces?

**S**: 3 pieces

**P**: Continue the actual question in the matter?

**S**: The one on the payment bill

**P**: What went wrong on the bill.

**S**: Cut costs.

**P**: Try what just the wrong fare in the matter?

**S**: The taxes are also somewhat reduced (less than those listed in the question)

**P**: Try if less can fix?

**S**: Can not (students rather hesitate then continue :) Taxes 6% of the purchase of goods and fare cut

**P**: Where's the purchase of the goods?

**S**: 24 thousand

**P**: There on the first line of the bill, the purchase of goods or taxes?

**S**: Purchase of goods

**P**: What is the cost of cutting?

**S**: The bottom (meaning the second line on the payment bill)

**P**: So if 6% of the purchase of goods and the cost of cut, from which price?

**S**: From 18,000 and 6,000

**P**: Cut cost was 2x or 3x?

**S**: The true 2x here is written 3x

**P**: So the price is still there?

**S**: Must be metabolized

**P**: What is the cost of the cut?

**S**: 4,000

**P**: Purchase goods and the cost of cut so how should it be?

**S**: 22 thousand

**P**: Continue 6% from purchasing goods and cut costs can be calculated?

**S**: yes I can

**P**: Try counting!

**S**: (Start working on calculations on blurred paper) Look at the answer paper When finished he says :) Already
Take a look (See the student's work, then say :) how much is this?

S : 23.320

P : Already sure with this answer?
S : (Students again try to recalculate on blurred paper then say :) Yes
P : Tell me again what Aulia is doing so the answer is like this.
S : Which one
P : What has just been done
S : That multiplied it not with 24 thousand more but became with the 22,000
P : 22,000 from where?
S : From 18,000 plus 4,000
P : How many results
S : 1.320
P : Continue after that?
S : Added everything
P : How many results?
S : 23.320
P : Try to guess what it takes to answer the question?
S : Meaning? (Students appear unclear with the questions asked)
P : What mathematical concepts are used
S : Percentage
P : Any operation used?
S : Increase
P : Multiplication is used what is not?
S : There is
P : The way that has been done earlier what the best way, what other ways
S : That's it

4. Result And Discussion

Based on these results obtained a profile of students' critical thinking skills.

a. The first step: Understanding the Problem

In solving the problem at the stage of understanding the problem used interpretation skills are characterized by the existence of sub-indicators: categorization, decode, and clarify the meaning.

Categorization: disclose information, information, statements, or data needed in relation to the matter.
Decode: read the information, information or data needed and can express what is known and asked about the problem.
Clarification of meaning: disclose or clarify statement, description or data related to the proposed matter.

![Critical thinking skills of Understanding the Problem](image)

b. Step two: Plan a Problem Solving Strategy

In solving the problem at the planning stage of problem solving strategy used analytical skills: the examination of ideas, the identification of arguments and argument analysis and evaluation skills: assess the argument.

Examination of ideas: revealing arguments and various statements that will be used to make claims regarding the proposed matter, only on contextual math problems, and formal mathematical problems do not arise.
Identification of arguments: states the arguments or basics needed in making a conclusion about the proposed problem, only on contextual math problems, whereas on formal mathematical problems does not arise.
Argument analysis: states the arguments or the basics of the calculation of the proposed problem required in making a conclusion in the next step that is the implementation of the related problem solving strategy.
Assessing arguments: confirming the truth of the arguments related to the proposed problem and expressing confidence in the conclusions made, after several counts.
c. Step three: Implementation of Problem Solving Strategies

In solving problems at the problem solving stage, inference skills are used: drawing conclusions, and problem solving and explanatory skills: problem presentation, justification procedures, and argument articulation.

Presenting of conclusions: express presenting conclusions based on the results of the analysis of existing information on the problem and based on the results of calculations related to the problems posed.

Problem solving: Specifies the additional information needed to resolve the issue.

Problem presentation: explains the relationship between the information contained in the problem and the interpretation of the proposed problem to convince the argument used in drawing the conclusion.

Justification procedure: describes the steps taken to obtain a solution answer to the problem posed.

Articulation of arguments: explains the arguments or reasons for the answers used in drawing conclusions regarding the proposed problem.

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**Figure 2.** Critical thinking skills in Planning a Problem Solving Strategy

**Figure 3.** Critical thinking skills in Implementation of Problem Solving Strategies


d. Fourth step: Re-check All the Steps that have been done

In solving the problem at the re-checking stage all the steps that have been done are used self-regulation skill characterized by the existence of sub indicators: self-correction and self-study. Self-correction: review the results of calculations and analysis results that have been done before making a final decision. In formal mathematical problems, the student is aware of the miscalculation, and can correct it properly. Self-study: In a formal mathematical problem it can explain how well the method is used, but on the other three critical thinking questions this skill does not appear.

Figure 4. Critical thinking skills in Re-check All the Steps that have been done

5. Conclusion

The conclusions of this study indicate that critical thinking skills of female students of eight grade junior high school with high mathematical ability in solving problems of contextual math and formal mathematical problems are as follows: In solving the problem at the stage of understanding the problem used the skill of interpretation with sub-indicators: categorization, decode, and clarify meaning. At the planning stage of problem-solving strategy used analysis skills with sub-indicators: idea checking, argument identification and argument analysis and evaluation skills with sub-indicators: assessing arguments. In the implementation phase of problem solving, inference skills are used with sub-indicators: drawing conclusions, and problem solving and explanatory skills with sub-indicators: problem presentation, justification procedures, and argument articulation. At the re-checking stage all steps have been employed self-regulation skills with sub-indicators: self-correction and self-study.

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