

# Critical Thought Processes in Solving Problems Reviewed from the High Level Mathematical Ability

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**Abstract-**This research is based on efforts to recognize students' critical thinking processes in solving algebraic problems, hopefully it can be used to design appropriate models or strategies in an effort to improve students' abilities that are still low in terms of mathematical modeling and analyzing problems to prove theorems that really need critical thinking skills. This study is classified as a qualitative-exploratory study conducted at students of mathematics education at the Faculty of Science and Technology of UIN Walisongo. Data analysis techniques used in this study refer to the stages of qualitative data analysis namely data reduction, data presentation, and drawing conclusions. The technique of checking the validity of data using time triangulation. Results of this study conclude that subjects with high mathematical abilities can decide and apply problem solving strategies correctly and appropriately, but are less able to evaluate problem solving carried out with definitions, valid mathematical theorems. So in an effort to improve the critical thinking skills of students with high mathematical abilities, strategies or models that can accommodate this condition are needed. Scaffolding method can be an option to overcome this difference.

**Keywords:** *critical thinking, algebra problems, mathematical abilities*

## I. INTRODUCTION

The quality of human resources who are educated, critical and able to answer the demands of change in the rapidly developing industrial revolution 4.0 are the main aspects that must be owned and developed by countries that want to progress [1]. The demand is in the form of the ability to adapt, move quickly, and be able to find new alternatives in solving problems so that in anticipating these developments, it is necessary to have healthy, knowledgeable, creative, independent citizens who are able to think at a high level so that they can be critical. Based on this, Indonesia has made several improvements to the education curriculum to date as the curriculum 2013.

Critical thinking is an organized mental process and plays a role in analyzing, synthesizing, and evaluating the decision making process to solve problems. Gokhale defines the problem of critical thinking is a question that involves the analysis, synthesis, and evaluation of a concept [2]. Nickerson [3] and Bayer [4] suggest several indicators of critical thinking skills including: determining source credibility; distinguish between those that are relevant or valid from those that are not relevant or valid and between facts and judgments; identify and evaluate assumptions, biases, and points of view; and evaluating evidence to support treatment. In accordance with the opinion of Cotton [5] critical thinking is also called logical thinking and analytical thinking.

Good thinking skills will not develop by themselves, but must be taught [6]. In addition according to Johnson think critically is the ability essential that should be owned by good students in solving problems [7]. The most important part of learning is to help students develop thinking skills. This is in accordance with the opinion of Arend [8] which states that critical thinking can be possessed by students if students are consistently trained both through directed discussions and facilitated by instructors. This ability will help him learn about what is needed or what he wants to know, this process is called habituation of critical thinking. Based on the results of in-depth observations on the fourth semester students of Walisongo UIN mathematics education in the even semester of the 2018/2019 school year, information was obtained that students were still in a less critical condition due to difficulties in representing problems in other forms or manipulating symbols (sketches of images, algebraic equations), correlating some theorems to solve problems, solve problems that are not routine, evaluate the results of problem solving. Thus, learning in mathematics education at UIN Walisongo must emphasize one of the higher-level thinking skills, namely the improvement of critical thinking skills not only emphasizing mastery of content, in line with Santyasa opinion that learning is not enough on mastering content, learning that only emphasizes content will be very easily forgotten [9].

Johnson [10] that there is a strong relationship between critical thinking and how to solve problems.

The ability to think critically is influenced by two factors, namely internal and external factors. Internal factors include: intelligence, motivation, interests, talents, mathematical abilities, gender differences and personality types of students. External factors, including: facilities, infrastructure, media, curriculum, lecturers, learning facilities and so on. Mathematical ability is an important factor in influencing students' level of critical thinking skills. So that differences in the level of mathematical ability can be expected to cause differences in the critical thinking process carried out by students in solving problems. In accordance with the opinion Siswono [11] said that students who have different backgrounds and mathematical abilities, also have the ability to think in solving various mathematical problems. Knowing students' critical thinking processes is needed in formulating appropriate learning methods to improve critical thinking skills. This study aims to identify how students' critical thinking processes are viewed from differences in the level of students' mathematical abilities through the main elements of critical thinking expressed by Ennis [12] with some basic criteria or elements abbreviated with FRISCO (Focus, Reason, Conclusion, Situation, Clarity and Overview).

## II. RESEARCH METHODS

This type of research is a qualitative-exploratory study conducted on students of the mathematics education program UIN Walisongo Semarang. This study aims to explore the profile of students' critical thinking in solving problems in terms of differences in the level of students' mathematical abilities. The research subjects consisted of three fifth semester students. Students selected are students who have high, medium, and low mathematical abilities. Classification of students into high, medium, and low mathematical abilities is based on students' cumulative achievement index scores. Students who can communicate their ideas and meet the criteria of critical thinking processes in solving mathematical problems are considerations used in selecting research subjects.

The main instrument in this study is the researcher itself and is equipped with an instrument of questions and interview guidelines. The researcher is the main instrument, so that when collecting data in the field the researcher participates during the research process and actively participates in research subject activities related to data collection. The role of researchers is as an instrument because researchers function as planners, data collectors, analysts, data collectors, and become reporters of their research results. The problem solving instrument is a series of non-routine math test questions, in the form of story questions that require students to use understanding, while interview guidelines are used to uncover and

explore students' critical thinking processes in terms of various levels of mathematical ability.

In conducting interviews the interview guidelines are used or a list of questions as a guide. However, these guidelines or questionnaires are not standardized, meaning they can change according to the circumstances at the time of the interview. Because the interview guidelines function as guides and can change according to the conditions at the time of the interview. This is consistent with Sunandar stated that the position of the questionnaire is a guide and is always open and flexible. The instrument of questions and interview guidelines were validated by experts.

Data from problem solving tasks and interview data obtained were then analyzed about their critical thinking processes through data analysis techniques that refer to the stages of qualitative data analysis namely data reduction, data presentation, and drawing conclusions. Techniques for measuring data validity are using source triangulation and time triangulation methods. Questions of the same type or relative are given back to the subject of research in different time periods and how consistency of written answers with the results of the interview.

The main element of critical thinking used is the opinion of Ennis [12] people who think critically should ideally have some basic criteria or elements abbreviated as FRISCO (Focus, Reason, Inference, Situation, Clarity, and Overview). The problem solving strategy used is in accordance with the opinion of Sternberg [13], which offers strategies to solve problems in the form of problem solving cycles as follows: identify problems, determine problem boundaries, plan strategies and formulate them, organize information, allocate resources monitoring and evaluation.

## III. RESULTS AND DISCUSSION

In this study, the problem solving test was followed by 59 prospective subjects, consisting of 10 male students and 49 female students. Based on the magnitude of the student achievement index with a scale of four data presented with descriptions; 10 prospective students with high mathematical ability ( $3.50 \leq \text{score} \leq 4$ ), 29 students with moderate mathematical ability ( $3.0 \leq \text{score} \leq 3.49$ ), and 10 students with low mathematical ability ( $0 \leq \text{score} \leq 2.99$ ). Then through the purposive sampling method, two people with high mathematical abilities were selected, namely S1T with an achievement index of 3.62 and S2T with an achievement index of 3.93 as the research subjects. The next stage is an in-depth interview as an attempt to uncover how the subject's critical thinking process in solving problems with the problem solving strategies that are delivered stenberg. Supporting instruments in the form of problem solving test questions and interview guidelines that have been developed are validated by four validators of mathematics education experts.

Expert validation was conducted in May 2019 with an average score of 3,72 so that the instruments in the criteria were suitable for use with a slight revision. The purpose of this validation is to see the validity of the content, and is used as a basis for revising and perfecting research support instruments. The results of the validation of the supporting instruments are stated; (1) information provided in a mathematical problem, enough to solve a mathematical problem, (2) every information provided to solve a problem, clearly has its benefits, (3) sentences do not lead to multiple interpretations, (4) mathematical problems use language in accordance with good and right rules, (5) Mathematical problems using words known by students. The four validators stated that the interview questions and guidelines were appropriate for use after the researcher made several revisions in accordance with the directions.

Problem solving test questions consist of three questions that have an equivalent degree. The credibility test of research interview data is carried out by time triangulation and source triangulation, which uses repeated interviews to find the suitability of data sourced from problem-1 and problem-2 or problem-3 if needed.

The results of the data analysis state that at stage F (Focus) subjects with high mathematical abilities are able to do well. This ability can be described as follows; able to recognize problems that must be resolved clearly and logically (expressly state that there is a problem in the information provided), clear and complete in identifying information provided in the problem, able manipulating symbols (sketch drawings, algebraic equations), and able to formulate the main problem appropriately. Stage R (Reason) subjects are able to do well. This ability can be described as follows; clearly organizing facts or information in a problem to support the solution steps, can link all available information to arrange the planning steps in solving mathematical problems accurately.

Subjects in stage I (Inference) are able to correlate several theorems to determine the steps used in solving problems correctly and carry out plans in solving mathematical problems correctly. Stages S (Situation) Subjects are able to perform well even though stimulus questions are needed to decide correctly. This ability can be described as follows; able to decide on the use of axioms, theorems that support an efficient and precise settlement process, although they must be assisted with stimulus questions and are relatively precise in predicting the time needed.

In stage C (Clarity) the subject needs more stimulus questions to check the certainty of the steps taken in the problem solving process in accordance with the strategies compiled in the proper planning. Stage O (Overview) the subject is able to do precisely in drawing conclusions based on information / facts

but the subject has not been able to evaluate the steps that have been done carefully, because the subject only reread the steps one by one. This shows that the process of evaluating completion steps has not been thorough.

The above research results are in line with research conducted by Moh Zayyadi and Agus Subaidi (2017) which states that subjects with high mathematical abilities can decide and implement problem solving strategies correctly and appropriately, but are less able to evaluate problem solving done with definitions, theorems valid mathematics.

#### IV. CONCLUSIONS

The results of this study concluded that the critical thinking process of subjects with high mathematical abilities had the following characteristics; able to recognize problems that must be resolved clearly and logically; clear and complete in identifying and information provided in this matter; able to formulate the main problem carefully; reveal facts or information clearly in the problem to support the solution step; able to correlate all available information to arrange planning steps in solving mathematical problems accurately; subjects are able to correlate several theorems to determine the steps used in solving problems correctly and carry out plans in solving mathematical problems correctly; able to decide on the use of axioms, theorems that support an efficient and appropriate settlement process; the subject is less able to ensure the steps taken in the problem solving process in accordance with the strategy compiled in careful planning; The subject is able to do precisely in drawing conclusions based on information / facts but the subject has not been able to evaluate the steps that have been done carefully.

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