

The Influence of Numerical Ability, Mathematical Communication, Metacognition, and Self-Efficacy on Students' Critical Thinking Skills in Solving Mathematical Problems

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ABSTRACT

The purpose of this study is to discover the extent of the influence of numerical abilities, mathematical communication, metacognition, and self-efficacy on students' critical thinking skills in solving mathematical problems. The type of research is ex-post facto. The research population was all students of grade XI MIPA at SMAN 10 Gowa with 122 students. The technique of determining the sample was done by using saturated sampling. The instruments used were numerical ability test, mathematical communication ability test, metacognition perception questionnaire, self-efficacy questionnaire, and critical thinking skills test. The data analysis technique used was descriptive statistical analysis and inferential statistics using path analysis. The results of descriptive research show that (1) the students of grade XI MIPA at SMAN 10 Gowa have an average numerical ability 64.47 which is in high category and a standard deviation of 17.92, an average mathematical communication ability is 83.95 in very high category and standard deviation of 8.78, the average of students' critical thinking skills is 88.67 in very high category and standard deviation of 10.69 with an ideal score of 100, the average of metacognitive skills is 58.8 in moderate category and the standard deviation 9.8 with an ideal score of 81, while the average of self-efficacy is 53.9 in moderate category and the standard deviation 7.75 with an ideal score of 73; (2) the results of inferential analysis show that numerical ability has a significant positive influence directly on students' critical thinking skills in solving mathematical problems by 0.039 with a path coefficient of 0.171, and an indirect positive influence through self-efficacy by 0.048, mathematical communication ability has a significant positive influence directly on students' critical thinking skills in solving mathematical problems by 0.000 with a path coefficient of 0.303, and an indirect positive influence through self-efficacy by 0.047, Metacognition has a direct positive influence on students' critical thinking skills in solving mathematical problems by 0.209 with a path coefficient of 0.109 and an indirect positive influence through self-efficacy by 0.077.

Keywords: Numerical, Mathematical communication, Metacognition, Self-efficacy, Critical thinking.

1. INTRODUCTION

From the pre-school to university level, informal education, mathematics is the one subject that everyone must study. Mathematics also became one of the main subjects and became the required subjects in elementary and high schools. Mathematics also is one of three subjects that was tested in the National Examination. In everyday life as well, mathematics ability is a life skill that everyone should have. That is why mathematics

holds an exceptional role as a tool to develop systematic, critical, logical, and creative thinking. According to [1], there are two visions of mathematics Education. The first, for modern needs. Mathematics learning is in line with the conceptual understanding that is needed to solve not only mathematics problems but also other related subjects. The second, for future needs. It has a broader meaning: mathematics learning gives students logical, systematic, critical, and accurate thinking. It also offers

students the ability to be open-minded and to think objectively.

Based on the visions of mathematics education, we know that creative thinking cannot be separated from mathematics education. It is because creative thinking will be able to sustain students' understanding in terms of mathematics problem-solving. Critical thinking is a guided and clear process used in mental activities such as problem-solving, decision making, persuading, analyzing assumptions, and experimenting [2]. Critical thinking aims to achieve certain skills such as analyzing facts, creating and organizing ideas, defending an argument, comparing, making a conclusion, evaluating a statement, and solving problems. According to Anderson in [3], if we develop critical thinking, someone will be prone to search for the truth, be open-minded to new ideas, analyze a problem, think systematically, be full of curiosity, mature, and think independently. According to Costa [4], the goals of critical thinking in the teaching-learning process are: 1) Developing the individual ability to the maximum level, physically, emotionally, aesthetically, and intellectually. 2) Preparing the students to fulfill their economic needs independently and ready to compete in the working world, teaching students to get and produce needs and services which is required, and organizing resources efficiently; and 3) Prioritize responsibility to actively participate in the society to create a suitable environment for other people and use it effectively for the welfare of the community.

Besides that, in mathematics learning, critical thinking becomes one of the standards that must be owned by the students [3]. Mathematics and thinking skills are related because mathematics can be understood through critical thinking ability, and critical thinking ability can be trained using mathematics [5]. The mathematical critical thinking ability is to solve a mathematical problem that involves mathematics knowledge, mathematic thinking, and mathematical proof. But in reality, the mathematical critical thinking ability of the students in Indonesia is still considered poor. Most students memorize formulas whenever they face exams; many don't repeat what they have studied and done their assignments at home. Students with good critical thinking skills will easily organize and use the information they find to solve the problem. But students are generally only able to apply and develop mathematical critical thinking skills in terms of understanding and application. As a result, the mathematical critical thinking skill of the students is still considered poor. This result can be seen from the competence that students have at the high school level.

The factors that contribute to student's critical thinking viewed from teacher and student are: (1) the kind of questions that teachers ask do not trigger student's

opinion or question, (2) teacher cannot improvise the materials so that they appeal difficult for the students, (3) teacher is discriminating students during lesson period, (4) the lesson is not suitable for all students, the students who are left behind feel reluctant to pay attention, (5) the lack of willingness and preparation from students to learn mathematics, (6) students are afraid to voice their opinion and stand in front of the class, and (7) the lack of students' motivation and enthusiasm. According to [6], one of the failures of mathematics teachers is the inability to make students think critically. Mathematical Critical thinking can develop optimally through two ways of communication and not only one form of communication, for example, between students, students and teachers, and students with the environment [7]. This can happen because of the miscommunication between students and teachers. From this problem, the researcher concludes that communication is one factor that influences the students' critical thinking underdevelopment in solving a mathematical problem.

Mathematical communication ability needs to be the focus in learning mathematics. Through communication, students can organize and consolidate how they perform mathematical thinking, and with it, students can explore mathematical ideas. The lesson planning should be designed to give stimuli to the students so that they can communicate well. Mathematical skill is the ability of the students to use mathematics as a communication tool, and mathematical communication skill serves a function as the content of the message that must be delivered [8]. A good communication process is expected to give stimuli to the students to develop their mathematical ideas. The communication process will happen only if there is interaction in learning. Mathematical communication skill is one of the basic skills that must be possessed by the students and teachers inside the teaching-learning process, especially in mathematics [1].

For some students, the difficulties of learning mathematics make them reluctant and lazy to do it. Mathematics is considered difficult and tedious because learning mathematics always involves numbers and formulas. Students often find problems in making solutions in the learning process because of the lack of understanding and explanation about the mathematical problem. That is why a self-realization from the teacher is very important to create a fun environment and make students enjoy learning mathematic. Besides that, the absence of measurement for students to help them realize what is lacking makes it harder to decide where they need to start. The problem occurs when students cannot follow the learning process conducted by the teacher because of the limitation possessed by the students. For example, the lack of basic mathematical operations like multiplication, addition, subtraction, and distribution will hinder the learning process in the class.

Mathematical critical thinking skill is also helped by numerical skill. One way to improve the students' critical thinking skills is to find out the numerical skill owned by the students [9]. Numerical skill is the ability that is related to observation and quickness in using the mathematical function [1]. Numerical skill is a basic skill that is required for students to solve problems in Mathematics. Numerical skills can ease the thinking process of skill students and make them able to explain information. Students will try to use their whole thinking ability to understand the core of the material or problem to find solutions. Mathematical Characteristics are mostly abstract, but abstract materials must be studied and is important for students. One of them is the numerical method or numbers. Numerical Skill is the students' ability to use numbers involving addition, subtraction, multiplication, and distribution [10].

Another factor that contributes to critical thinking is metacognition skills. With metacognition skills, the students will know how they learn, understand their learning ability, and find out the most effective learning strategy to optimize the result of their learning. Critical thinking relates to metacognition skills. Flavell in [11] states that metacognition is knowledge and cognitive realization of someone and the ability to observe, organize and evaluate thought processes. Schoenfeld defines metacognition as: *"metacognition is thinking about our thinking and compares of the following three important aspects: knowledge about our thought processes, control or self-regulation, and belief and intuition."* It means metacognition is thinking about our thought process, which is an interaction of three important aspects: the insight of thought process: self-control and self-regulation, and faith and intuition [12].

Students' critical thinking skill is affected by their cognitive potential and their self-trust that they can complete/solve the problem given to them. One of such factors is self-efficacy. Self-efficacy is one of the aspects of knowledge about one-self that influence human life. The concept of self-efficacy is defined as self-faith and the ability to perform given tasks. Self-efficacy determines how people should think, behave, and motivate themselves [13]. Students need to put faith in themselves in solving problems because that faith will determine their actions, and eventually, it will select the result. Bandura in [14] states that someone who has strong confidence when a problematic situation arises will think of it as a challenge that must be conquered, they can defend their commitment, they can struggle when facing failure, they can control themselves when facing dangerous situations, reduce stress as well as not easily fall into depression and all of this lead the desired result.

While students who do not feel confident about themselves tend to think of problems as a threat, they lack confidence and commitment about their own goals. They

give up easily and show no sign of struggle when facing difficult situations. They are slow to bounce back after facing failure. It makes them fall into stress and depression quickly. In this case, when students have good self-efficacy, they will plan, organize, and take a step by step to get their learning goal, such as striving harder to complete the tasks given by the teacher. This set of behavior will make learning Mathematics for students better. Students with good self-efficacy will consider tasks provided by the teacher as challenges and not threats or even burdens that must be avoided. This is in line with what Schunk in [15] states that students with good self-efficacy would likely participate in completing tasks and lessons, while students with low self-efficacy will probably abandon duties and assignments. Besides that, students with good self-efficacy will likely have excellent critical thinking skills as well. With good self-efficacy, students have a great possibility to achieve success and solve mathematical problems.

2. RESEARCH METHOD

This research uses a quantitative method with *an ex-post-facto* approach, which has a casuistical character. This research is conducted in SMA Negeri 10 Gowa, XI MIPA academic year 2020/2021. This research is conducted from the 5th of February 2021 to the 26th of April 2021. The sample count is 122 students of SMA Negeri 10 Gowa. The sampling technique is called Saturated Sampling.

The instrument used in this research is a questionnaire and multiple answers questions. To measure the variable score of the study, there are in total five instruments which are: (a) metacognition questionnaire; (b) self-efficacy questionnaire; (c) numerical ability test; (d) mathematical communication skill test; (e) critical thinking skill test.

The method of data collection is by distributing the questionnaire and the written test. The test subject is given a written test about their numerical test, mathematical test, and critical thinking skill test. Then they are also given the metacognition questionnaire and self-efficacy questionnaire. The technique of data analysis is called descriptive statistical and descriptive inferential.

3. RESULT AND DISCUSSION

3.1. Variable Characteristics

As discussed in the research aim, they describe the students' numerical skills, mathematical communication skills, metacognitive, self-efficacy, and critical thinking skills to solve the mathematical problem of Class XI MIPA SMA Negeri 10 Gowa.

The result shows that the average numerical skill of the students can be categorized as high from the five categories. The number of students with high numerical skills is 45 students from a total of 122 students. Numerical skill is built on six indicators: the ability to perform numerical calculation, calculation of algebra operation, connecting concept with real-life usage, understanding problem, searching for approaches or methods to solve the problem, problem-solving.

The average score of mathematical communication skills is also considered high. The number of students with high mathematical communication skills is 41 students with a total of 122 students. Mathematical communication skill is built on six indicators which are: describing a situation, picture, diagram, or real things into language, symbol, idea, or mathematical model, explaining the concept, situation, mathematical relation orally or written, the ability to connect the concept to a real condition, reading with the ability to understand written mathematical representation, making a conjecture, organizing an argument, formulating definition and generalization, expressing with own words an explanation or mathematical paragraph.

Metacognition is reconstructed from several indicators: a) metacognition knowledge, the sub-components are declarative knowledge, procedural knowledge, and conditional knowledge. b) regulation or metacognition experience, the sub-components are planning, monitoring, and evaluation. The result of the research shows that the average score of students' metacognitions is considered moderate. The number of students with this score is 39 students from a total of 122 students.

Self-efficacy is a reconstruction of several indicators, which are: a) Level, students' confidence in how difficult the tasks are given, b) Generality, students' confidence in performing tasks in several activities, c) Strength, students' level of confidence or level of hope about their skill. The result of the research shows that the average self-efficacy level is low; the number of students with this level is 39 students from the total of 122 students.

Students' critical thinking is constructed from six indicators: analyzing questions, focusing on the questions, deciding the plan used to solve problems, deciding and writing solutions for the problem, writing conclusions, finding other alternatives in solving the problem. The average number of students' critical thinking skills is categorized high, with the number of students with this score being 95 from 122 students. From all the variables under research which are numerical skill, mathematical communication, metacognition, self-efficacy, and critical thinking skill in solving problems, the average score of the students is varied. Numerical and mathematical communication skills are scored high, self-efficacy is scored low, metacognition is scored average, and critical thinking skill is scored high. This result is still far from the researcher's expectation, considering that this school is one of the most favorite schools in the Gowa Region.

The researcher observes the main cause of these variables having a varied score. Based on the research instrument used, questionnaire, and test, the researcher

finds that the self-efficacy score is low caused by how students fill the questionnaire. When doing the questionnaire, most students check the wrong positive statement; for example, they are not confident that they can finish a complicated task. It shows that the students' self-efficacy in mathematic is still low. This is one of the reasons why the self-efficacy score is considered low.

3.2. Direct correlation between numerical skill and critical thinking skill of the students in solving a mathematical problem

The hypothesis result shows that the numerical skill correlates significantly positively with the students' critical thinking skill in solving a mathematical problem. Even though theoretically, several factors can influence students' critical thinking skills, but in this research, it is proven that numerical skills correlate significantly positively.

Numerical skill is one skill that the students must own in using numbers and solving a mathematical problem. Numerical skill as basic skills about numbers is necessary for learning mathematics and generally in everyday life. Students with good numerical skills will be able to think critically in solving a mathematical problem. This is also true in learning mathematics; it is nothing that many students consider mathematic difficult, making them too lazy to try learning it. However, with good numerical skills, students will be able to pass through that. From many types of research about students' numerical skills, it is known that the higher the students' numerical skills, the higher the student's critical thinking, and vice versa.

3.3. Direct correlation between mathematical communication skills with critical thinking skills of students in solving a mathematical problem

The hypothesis testing results show that the students' mathematical communication skills positively correlate with students' critical thinking skills in solving a mathematical problem. Even though it is true, from many factors that contribute to students' critical thinking skills, mathematical communication skills also improve students' critical thinking skills. It is proven by the test that stated mathematical communication skill has a positive influence on the students' critical thinking skill in solving mathematical problems. An excellent mathematical communication skill is marked by active participation in asking a question, discussion, and the ability to solve mathematical problems. Mathematical communication skill is a personal aspect based on students' ability to interact with other students, students with teachers, and students with the environment. It is very important to learn and develop Mathematical communication skills. If what is stated before is true, then mathematical communication skills will influence the learning frequency of the students to go deep dive into the material, specifically mathematics.

It will eventually lead to critical thinking skills and student achievement. In other words, students with good communication skills tend to have good critical thinking skills.

3.4. The correlation between metacognition with the student's critical thinking skills in solving mathematical problems

The hypothesis shows that metacognition does not positively correlate with critical thinking skills in solving a mathematical problem. Even though theoretically, metacognition is one of the factors that influence the students' critical thinking skills. Still, in this research, it cannot be proven that metacognition significantly affects the students' critical thinking skills in solving mathematical problems.

Metacognition is students' awareness about their thought process in solving problems. It helps students to perform self-introspection. It also allows students to recognize their weakness and their strength. This will eventually help students to control their behavior. This self-awareness that students can do mathematic assignments is beneficial. When students have good metacognition skills, they will think critically because there will be many challenges when studying mathematics. The first important thing to have is the confidence that we can do the assignment perfectly; with this attitude to keep striving for the best, the students' critical thinking will improve.

3.5. Indirect correlation of numerical skill with critical thinking skill to solve a mathematical problem through self-efficacy

The sixth hypothesis tested in this research is numerical skill has an indirect positive influence on students' critical thinking in solving mathematical problems through self-efficacy. The result of hypothesis testing shows that numerical skill positively impacts critical thinking skills through self-efficacy. The research indicates that self-efficacy is an intervening variable between numerical skills and critical thinking skills in solving mathematical problems. Even though many factors contribute to students' critical thinking, numerical skill does not always directly influence students' critical thinking skills. It can also be through self-efficacy. Then after that, it will affect critical thinking skills.

Numerical skill helps students in deepening their knowledge about mathematic. Numerical skill is a skill that students must own in using numbers and solving mathematical problems. It covers: performing number calculation, counting algebra, connecting concept with the real situation, understanding problems, and looking for approaches or methods to solve problems. Numerical skills improve self-efficacy because confidence can be built when someone has good numerical skills, so a high critical thinking skill comes from a high self-efficacy.

3.6. Indirect influence mathematical communication skill toward the critical thinking skill of the students to solve a mathematical problem through self-efficacy

The hypothesis tested in this research is the influence of mathematical communication skills toward the critical thinking skill of the students to solve a mathematical problem through self-efficacy. The testing results show that mathematical communication skills correlate positively but indirectly toward the critical thinking skill of students to solve mathematical problems through self-efficacy with coefficient numbers as big as 0,064. Even though many factors influence students' critical thinking skills, mathematical communication is also one factor. However, mathematical communication skill does not always influence critical thinking skill directly. It can also be through self-efficacy first.

Mathematical communication skill gives a significant stimulus to students to deepen their knowledge. In learning, students will always face difficulties. Students' self-efficacy is useful to watch over the process of learning itself when solving problems. The students with good mathematical communication skills are helped to get good critical thinking skills, high achievement, and deep understanding through self-efficacy.

3.7. Indirect correlation metacognition toward the critical thinking skill of the students through self-efficacy

One of the hypotheses tested in this research is the influence of self-efficacy toward the students' critical thinking skills in solving mathematical problems through metacognition. Based on testing by using PSS, the result shows that metacognition positively influences the students' critical thinking skills through self-efficacy, with the number of coefficients 0,077. It means that even though many factors contribute to improving students' critical thinking, the metacognition factor is also one such factor. However, metacognition does not always directly correlate with the students' critical thinking; sometimes, it can come through self-efficacy first, then in the end, it will influence students' critical thinking.

Metacognition gives stimulus to the students to deepen their knowledge. In learning, we cannot deny that students sometimes find difficulties. Metacognition skill that the students own is useful to watch over the students' thought process when they need to solve problems. The students who have good metacognition skills are helped to get good critical thinking skills, good achievement, and deep understanding with the help of self-efficacy.

4. CONCLUSION AND SUGGESTION

4.1. Conclusions

Based on the result of data analysis and discussion, here is the conclusion of the research:

1. The average score of numerical skill and critical thinking skills of XI MIPA SMA Negeri 10 Gowa about mathematics is considered high.
2. The average score of mathematical communication skills of XI MIPA SMA Negeri 10 Gowa about mathematics is considered moderate.
3. The average score of self-efficacy of XI MIPA SMA Negeri 10 Gowa about mathematics is considered low.
4. The numerical skill correlates significantly positively toward students' critical thinking skills in solving mathematical problems with coefficients of 0,171. On the other hand, it influences positively indirectly through self-efficacy as big as 0,048 with a significant influence of 0,219.
5. The mathematical communication skill numerical skill correlates significantly positively toward students' critical thinking skill in solving a mathematical problem with the number of coefficients 0,303 on the other hand. It influences positively indirectly through self-efficacy as big as 0,047 with the total influence as significant as 0,367.
6. The metacognition influence positively indirect way toward the critical thinking skill of students in solving the mathematical problem with the number of coefficients 0,109 and on the other hand, its influence positively in an indirect way toward the critical thinking of the students to solve mathematical problems as big as 0,077 with the total impact as significant as 0,186.
7. All of the variables under the research, numerical skill, mathematical communication skill, metacognition, and self-efficacy, influence the critical thinking skill in solving mathematical problem variables. The most dominant factor in mathematical communication skills. From the multiple-linear regression equation, we can conclude that the most dominant variable that influences the students' critical thinking in solving mathematical problems is mathematical communication skill with the number of coefficient 0,367.

4.2. Suggestions

Based on the result of the research, several recommendations can be used as considerations and inputs to all the stakeholders. Here are those suggestions:

1. For the research, it is very important to pay attention to other variables that might influence students' critical thinking in solving a mathematical problem.
2. For teachers and school stakeholders, placing special care in students' affective sides and self-efficacy can produce students who are mature cognitively and can motivate themselves. This will eventually lead to the improvement of students' critical thinking in solving a mathematical problem.
3. For students, in improving thinking skills, specifically critical thinking skills, several sub-skills need to be improved: numerical skill, mathematical communication skill, metacognition skill, and self-efficacy. All of these skills can contribute to the improvement of critical thinking in solving a mathematical problem.

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