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Mathematics Representation Ability Based on Self-Efficacy and Non-Cognitive Variables

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ABSTRACT
This study aims to describe the mathematical representation ability in terms of self-efficacy and non-cognitive variables of student grade 10th of Senior High School 14 Makassar. The study is descriptive research with a qualitative approach. This study is intended to determine the mathematical representation ability in terms of self-efficacy dimensions, namely magnitude, generality, and strength-based on students' non-cognitive variables, gender (male and female), and parents' socioeconomic status (high social status and low social status) by describing it in words. The instrument in this study was the self-efficacy questionnaire, parents' socioeconomic status questionnaire, mathematical representation ability test, and interview guidelines. The results show: (1) The subjects of the self-efficacy dimension based on non-cognitive variables (gender) can make linear equations of three variables, use mathematical expressions, and present tables and graphs correctly even though one subject could not use visual representations in solving problems. (2) Subjects of self-efficacy dimensions based on non-cognitive variables (social status) can make linear equations of three variables, involve mathematical expressions, and provide tables and graphs correctly even though one of them cannot use visual representations in solving problems. (3) Subjects of non-cognitive variables (gender) based on self-efficacy dimensions can make mathematical models, involve mathematical expressions, and provide tables and graphs correctly even though female subjects cannot use visual representations to solve problems. (4) Subjects of non-cognitive variables (social status) based on self-efficacy dimensions can make linear equations of three variables, involve mathematical expressions, and make tables and graphs even though one of them with high social status cannot use visual representations to solve problems.

Keywords: *Mathematical representation, Self-efficacy, Non-cognitive variables (gender and social status)*

1. INTRODUCTION

Education is one aspect that is very important and prioritized for humankind since it is a lifelong science. A good education will create quality Human Resources (HR) that can compete globally. As a national system, education is organized in three forms, namely formal, non-formal and informal. Constitution No. 20, chapter 37 of 2003 concerning the National Education System, stated that one of the components must be included in the education curriculum. Therefore, students need to understand mathematics subjects from elementary school to high school.

One of the goals of mathematics education in primary and secondary education is to help students solve problems by designing mathematical models, completing models, and interpreting the solutions obtained [1]. NCTM stated that one of the mathematical abilities students must have is the representation ability [2]. This ability helps students to understand mathematics concepts. Furthermore, students can also apply mathematical representations in their real lives, such as in the workplace and in further studies [2]. These show that mathematical representation ability is essential for students.

Related to mathematical representation ability, Miladiah et al. stated that students' mathematical

representation abilities were still in the moderate criteria, both visual representation abilities and verbal representations, with a percentage of 64.08% [3]. In the mathematics learning process, students must have the ability to express and represent mathematical statements or ideas to make it easier to clarify and solve a problem in daily life [4]. This statement shows that learning mathematics requires the ability to interpret and construct a representation. Based on interviews with some teachers and students at SMA Negeri 14 Makassar, we find that most students still have difficulty representing a mathematics problem. Sometimes, students can only make equations or inequalities but are weak in making a graph or table based on a mathematical problem.

One of the factors that affect students' mathematical representation ability is the students' self-efficacy. In terms of self-efficacy, affective behaviors include feelings, beliefs, and self-confidence related to their ability. Self-efficacy is an individual's belief in being able to master a particular activity or situation based on his own psychological and social functions [5]. Self-efficacy makes people have confidence in solving problems to achieve their goals. Bandura emphasized that measuring self-efficacy dimensions is believed to be the most accurate way to explain one's self-efficacy because it is specific in all tasks and situations [6].

Besides the self-efficacy factor, students' mathematical representation ability is also determined by several non-cognitive variables, namely gender and social status. Gender factors in the mathematics learning process can play a role in determining learning outcomes, especially in the representation ability of students [7]. The nature of men and women have different responses to what they learn. For example, Umaroh and Pujiastuti, in their study, showed that male students have high confidence in answering questions and describing the answers in detail but are less precise in writing units and symbols. In contrast, female students can use mathematical models properly and write symbols precisely but lack confidence in expressing their answers and cannot use pictures in solving problems [7].

Meanwhile, parental socioeconomic status influences student achievement. Several indicators affect the parental socioeconomic status, such as education level, job, income, position, or parent group. Nur et al., in their study, stated that parental socioeconomic status influenced student learning achievement by 77.3% [8].

Based on the description above, the authors are interested in conducting a study titled “Mathematical Representation Ability Based on Self-Efficacy and Non-Cognitive Variables."

2. METHOD

This study is descriptive research with a qualitative approach that aims to describe the ability of mathematical representation in terms of self-efficacy and students' non-cognitive variables. This study is intended to describe the students' mathematical representation ability in terms of self-efficacy dimensions, namely magnitude, generality, and strength-based on students' non-cognitive variables, gender (male and female), and parents' socioeconomic status (high social status and low social status) by describing it in words. This research was carried out at Senior High School 14 Makassar in class X MIPA 1. This class was selected because the students had studied the topic systems of linear equations and inequalities that were part of the focus of research in the current semester. This study involved five subjects who had criteria of self-efficacy dimensions (magnitude, strength, and generality) based on gender and six subjects social who had criteria of self-efficacy dimensions (magnitude, strength, and generality) based status (high and low).

In this study, the researchers themselves were the main instruments. In contrast, the supporting instruments were a self-efficacy questionnaire, a parents' socioeconomic status questionnaire, a mathematical representation ability test, and an interview guide. These instruments obtained data about student self-efficacy, the socioeconomic status of students' parents, and students' mathematical representation abilities. Data analysis techniques applied were data reduction, data presentation, concluding, and verification. Furthermore, the triangulation method was used to check the validity of the data.

3. RESULTS AND DISCUSSION

The data obtained were described through excerpts of the subjects' answers based on the codes of the subjects' responses in the interview transcript. The excerpt codes are a combination of three letters and five numbers. Started by the three letters, namely "SE-M," "SE-S," and "SE-G," which denote the self-efficacy dimensions of magnitude, strength, and generality (SE-G), respectively, the codes are then followed by five numbers. The first number represents the gender, namely "0" for no gender, "1" for male, and "2" for female. The second number represents the social status, namely "3" for high social status and "4" for low social status. The third number denotes the

order of questions, and the last two digits state the question or the answer order.

Data of students' mathematical representation abilities in terms of self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (gender and social status) for question number 1 obtained from written tests and interviews show that subject SE-M14, subject SE-M23, subject SE-S24, subject SE-S03, subject SE-G13, and subject SE-G24 can make a linear equation of three variables according to the information provided in the problem. In addition, in solving problems, subject SE-M14, subject SE-S24 can use the elimination method; subject SE-M23, subject SE-G13, and SE-G24 can use the substitution method; and subject SE-S03 can use both the elimination and substitution methods.

Data of students' mathematical representation abilities in terms of self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (gender and social status) for question number 2 obtained from written tests and interviews show that subject SE-M14, subject SE-M23, subject SE-S24, subject SE-S03, and subject SE-G13 can make tables and graphs from data given in the problem. In contrast, subject SE-G24 cannot make tables correctly. In addition, in solving the problem, subject SE-M14, subject SE-S24, subject SE-G13, and subject SE-G24 can use visual representation by using tables they have created; subject SE-S03 can use points on the graph he has created, but subject SE-M23 cannot use any visual representations.

The ability of mathematical representation of students in terms of self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (gender), as follows:

a. Making Mathematical Equations or Models from Other Given Representations

SE-M14 subjects can make equations or mathematical models according to the information in the story questions, and so does subject SE-M23. In addition, subject SE-M23 can explain well how to make the equations. Subject SE-S24 can also make linear equations of three-variable properly. Next, although subject SE-G13 can make equations well, the equations are not written neatly and orderly. Likewise, subject SE-G24 can make equations or mathematical models according to the information given in questions. Subject SE-G24 can provide a parable in the form of variables to make the equations. Therefore, we can say that the five subjects tend to have no difficulty determining the necessary conditions to represent equations or mathematical expressions in solving a problem, namely by making equations that match the information or data in the given questions.

b. Problem Solving by Involving Mathematical Expressions

Subject SE-M14 can use elimination and substitution methods to solve the problems. Meanwhile, subject SE-M23 can only use the substitution method to solve the problem correctly. Furthermore, subject SE-S24 can use the elimination method correctly to find the solution to the problems. Subject SE-G13 can use the substitution and elimination method to solve the problem correctly, but the way used is less neat and not orderly. Meanwhile, subject SE-G24 only uses the substitution method to solve problems in story problems. Thus, the five subjects can involve mathematical expressions to solve the problems in the given story.

c. Representing Data or Information from a Representation to a Diagram, Graph, or Table Representation

Subject SE-M14 can make tables and graphs according to the information provided in the problems. Likewise, subject SE-M23 can appropriately present data in the story questions in the form of tables and graphs, and so does subjects SE-S24. Subject SE-G13 can make tables and graphs according to the information in the questions even though there are still some incorrect points of the solution set. Likewise, subject SE-G24 can present data provided in the questions in the form of tables and graphs. However, subject SE-G24 cannot make a table correctly since the information about each element in the capsule is written in one column and the arrangement of the table was not clear. Therefore, it can be said that the five subjects can explain well how to make tables and draw graphs according to the data contained in the given problem.

d. Using Visual Representations to Solve Problems

Subject SE-M14 uses tables to solve problems in part c correctly. Meanwhile, Subject SE-M23 does not use tables or graphs to solve problems in part c because the subject solves part c of the questions before parts a and b that instruct the subject to make tables and draw graphs. Subject SE-S24, subject SE-G13, and subject SE-G24 can use the table they have created from solving part a to solve part c of the question, and therefore, they can get the correct answer. However, subject SE-G24 cannot explain well the process of finding the final solution. Thus, it can be seen that subject SE-M14, subject SE-S24, subject SE-G13, and subject SE-G24 can use visual

representations in solving a problem, but subject SE-M23 cannot use visual representations in solving a problem.

The ability of mathematical representation in terms of self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (social status), as follows:

a. Making Mathematical Equations or Models from Other Given Representations

Subject SE-M14 can make equations or mathematical models according to the information contained in the story questions. Subject SE-M23 can provide equations and explain how to find these equations well. Furthermore, subject SE-S24 and subject SE-S03 also give the equation well and correctly. Subject SE-G13 also made equations well but did not write them down neatly and orderly. Likewise, subject SE-G24 can make an equation or mathematical model according to the given information and even provides an example in the form of a variable to make the equations. Therefore, it can be seen that the six subjects tended to have no difficulty in determining the necessary conditions to use the representation of equations or mathematical expressions in solving a problem, namely by making equations that matched the information or data in the questions.

b. Problem Solving By Involving Mathematical Expressions

Subject SE-M14 can apply the elimination and substitution methods to solve problems correctly, and so does subject SE-S03, while subject SE-M23 can only use the substitution method. Furthermore, subject SE-S24 can use the elimination method clearly to obtain the solution to the problem. ALTHOUGH subject SE-G13 can use the substitution and elimination method to solve the problem correctly, the way the object presents the answer is not neat and well ordered. Meanwhile, subject SE-G24 only uses the substitution method to solve the problems. Thus, it can be seen that the six subjects can involve mathematical expressions to solve the given problems.

c. Representing Data or Information from a Representation to a Diagram, Graph, or Table Representation

Subject SE-M14 can make tables and graphs according to the information contained in the problems. Likewise, subject SE-M23 can present tables and graphs based on the data given in the problems appropriately, and so do subject SE-S24 and subject SE-S03. Subject SE-G13, although can make tables and graphs according to the information, there are still some mistakes about the points in the solution set. Likewise, subject SE-G24 can present data given in the problems in the form of tables and graphs. Subject SE-G24 cannot make the table of the data correctly, which can be seen that they put the information about each element in the capsule in one column which arranges the table unclearly. Therefore, it can be seen that the six subjects were able to explain well how to make tables and draw graphs according to the data contained in the story questions given.

d. Using Visual Representations to Solve Problems

Subject SE-M14 can use tables to solve problems in part c correctly, while the subject SE-M23 cannot since subject SE-M23 directly solves part c of questions before parts a and b, which have instructions to make tables and draw graphs. Meanwhile, subject SE-S24, subject SE-G13, and subject SE-G24 can use the table they create from part a to solve problems in part c to get the correct answer. However, subject SE-G24 cannot explain well the process of obtaining the final solution. Next, subject SE-S03 can use the points on the graph to answer the questions in part c. Thus, we can see that all subjects but subject SE-M23 can use visual representations to solve problems.

Mathematical representation ability in terms of non-cognitive variables (gender) based on self-efficacy (self-efficacy dimensions), as follows:

a. Making Mathematical Equations or Models from Other Given Representations

For male subjects: subject SE-M14 can make equations or mathematical models according to the information contained in the problem; subject SE-G13 can also make the same equations but cannot write them down in good order. For female subjects: subject SE-M23 can explain well how to make the equation correctly and adequately according to the information in the problems, and so do subject SE-S24 and SE-G24. Therefore, it can be seen that the five subjects have no difficulty in determining the necessary conditions to use a representation of an equation or mathematical expression in solving a problem or making an equation based on the information given in the problems.

b. Problem Solving By Involving Mathematical Expressions

For the male subjects, subject SE-M14 can use the elimination and substitution methods to solve story problems. Subject SE-G13 can use the substitution and elimination method to solve the problem correctly, but the way the subject present the answer is

not neat and well orderly. Meanwhile, for the female subjects, subject SE-M23 and subject SE-G24 can only use the substitution method to solve problems correctly, while subject SE-S24 can only use the elimination method to obtain the solution. Thus, the five subjects can involve mathematical expressions to solve problems.

c. Representing Data or Information from a Representation to a Diagram, Graph, or Table

For the male subjects, subject SE-M14 can make tables and graphs according to the information contained in the problem; subject SE-G13 can also create tables and graphs, although the object gives some incorrect points of the solution set. For the female subjects, subject SE-M23 can make tables and graphs correctly to represent the information provided in the problems, and so do subject SE-S24 and subject SE-G24; subject SE-G24 cannot make the table correctly because the subject put the data of each element in the capsule in one column which makes the table unclear. Thus, we can see that the five subjects can provide tables and graphs according to the information in the problems.

d. Using Visual Representations to Solve Problems

For the male genders, subjects SE-M14 and SE-G13 can use tables to solve part c correctly. For the female subjects, subject SE-M23 cannot use tables or graphs to solve problems in part c since the subject directly solve part c of the question before the part a and b, which ask the subject to make tables and graphs; subject SE-S24 and subject SE-G24 can use the table that they have created form the part a to solve the part c of the question so that they get the correct answer even though subject SE-G24 cannot explain how the process of finding the final solution. Thus, male subjects can use visual representations to solve a problem, and one female subject cannot use visual representations to solve the problems.

Mathematical Representation Ability in terms of Non-Cognitive Variables (Social Status) based on Self-Efficacy (Dimension of Self-Efficacy), as follows:

a. Making Mathematical Equations or Models from Other Representations given

For subjects with high social status: subject SE-M23 can make equations correctly according to the information in the questions; subject SE-S03 can also make equations correctly and even explain how to make them; subject SE-G13 can make equations of the three variables correctly, but they are not well ordered. For subjects with low social status: subject SE-M14 can make equations or mathematical models according to the information in the story questions, and subjects SE-S24 and SE-G24 do too; subject SE-G24 can provide an example in the form of a variable to make the equations. Hence, subjects with both high and low social status have no difficulty determining the necessary conditions to use equations or mathematical expressions to solve a problem.

b. Problem Solving By Involving Mathematical Expressions

For subjects with high social status: subject SE-M23 can only use the substitution method to solve problems correctly; subject SE-S03 and subject SE-G13 can use both the substitution and the elimination method to find the correct answer, although subject SE-G13 cannot provide the process of finding the solution in good order. For subjects with low social status, in solving problems: subject SE-M14 can use both the elimination and the substitution methods, subject SE-S24 can only use the elimination method, and subject SE-G24 can only use the substitution method. Thus, in the subject of high social status, one can only use the substitution method. The other two can use both the elimination and substitution methods in solving a problem. In contrast, in the subject of low social status, one can only use the elimination method, one can only use the substitution method, and one can use both the elimination and substitution method.

c. Representing Data or Information from a Representation to a Diagram, Graph, or Table

For subjects with high social status: subject SE-M23 and subject SE-S03 can present tables and graphs appropriately from the information contained in the problem; subject SE-G13 can make tables and graphs, but some incorrect points are provided in the set of solutions. For subjects with low social status: subject SE-M14 and subject SE-S24 can make tables and graphs according to the data contained in the story questions; subject SE-G24 even though present tables and graphs from the information in the problems, the table is incorrect since the object put the information about each element in the capsule in one column so that the table was unclear. Hence, the subject with both high and low social status can make tables and graphs according to the information given in the problems.

d. Using Visual Representations to Solve Problems

For subjects with high social status: subject SE-M23 cannot use tables or graphs to solve problems since the subject solves part c of the question directly before parts a and b that ask subjects to make tables

and graphs; subject SE-G13 can use the table that the subject has made from the part a to solve the part c of the problem with the correct answer; subject SE-S03 can use the points on the graph to answer the questions in part c. For subjects with low social status: subject SE-M14 can use tables to solve problems in part c correctly; subject SE-S24 and subject SE-G24 can use the table that they have made from part a to solve the problem in part c and find the correct answer; subject SE-G24 cannot explain well the process of obtaining the final solution. Thus, in solving problems, all but one of the subjects with high social status can use visual representations, and all subjects with low social status can use visual representations.

4. CONCLUSION

Based on the results and discussion above, we can derive conclusions as follow:

a. Students' mathematical representation abilities which are viewed by self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (gender) as follows: (1) Students can make equations well according to the information given in the problems even though one of the subjects cannot write them in a good ordered, (2) students can involve mathematical expressions to solve the problem where two subjects using the substitution method, one subject using the elimination method, and two subjects using both the substitution and elimination method. (3) Students can present tables and graphs correctly based on the information in the problems, (4) all but one of the subjects can use tables to solve problems correctly, and there is a subject who cannot explain the steps to find the final answer.

b. The ability of students' mathematical representation in terms of self-efficacy (dimensions of self-efficacy) based on non-cognitive variables (social status) is as follows: (1) students can make equations correctly according to the data or information given in the problem, (2) students can use mathematical expressions to solve problems where one subject can use the substitution method and one subject can use the substitution and elimination method, (3) Students can present tables and graphs based on the information given in the problem correctly, (4) all but of the subjects can use a visual representation that is the table that they have made to solve problems.

c. Students' mathematical representation abilities in terms of non-cognitive variables (gender) based on self-efficacy (self-efficacy dimensions) are as follow: (1) Students can make mathematical equations or models correctly according to the information given in the problems, (2) students can use mathematical expressions to solve problems by using substitution and elimination methods, (3) students can present the information in the problems in the form of tables and graphs correctly, (4) All male subjects can use visual representations in solving a problem, but one of the female subjects cannot use visual representations to solve the problems.

d. The mathematical representation of students in terms of non-cognitive variables (social status) based on self-efficacy (dimensions of self-efficacy) is as follow: (1) students can make mathematical equations or models according to the information given in the problems, (2) students can use mathematical expressions to solve problems, (3) students can explain well how to make tables and draw graphs according to the information provided in the problems, (4) in solving problems, from all subjects with high social status, there is one subject who cannot use visual representations, while all subjects with low social status can use visual representations.

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