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Mathematical connection ability on Knisley Mathematics Learning Model with an open-ended approach based on self regulated learning

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Abstract

The purpose of this study was to explore the mathematical connection ability of 8th graders in the setting of the Knisley mathematics learning model with an open-ended approach. This type of research is mixed methods while the population is 8th graders in one JHS in Semarang, and the sample is a class selected by random cluster sampling. For the qualitative study, six subjects were selected by purposive sampling technique. Data analysis was performed by analyzing quantitative data and analyzing qualitative data. The results showed that (1) The mathematical connection ability of 8th graders in the Knisley mathematics learning model with open-ended approach achieved classical completeness; (2) the average mathematical connection ability of 8th graders in the Knisley mathematics learning model with an open-ended approach is better than conventional learning model; (3) the proportion of 8th graders who completed the learning subject in the Knisley mathematics learning model with an open ended approach is more than the conventional learning model; and (4) several subjects were able to fulfill all indicators of mathematical connection ability while other subjects were able to master some indicators of mathematical connection ability.

1. Introduction

Mathematics is one of the knowledge learned at every level of education and is required to develop students' thinking abilities (Muhsinin, 2013, p.46). According to Prihandoko, as quoted by Widiyastuti (2016, p.2), mathematics is a basic science that has become a tool for learning other sciences. In addition, mathematics has a close relationship with everyday life, so that almost all aspects of life have to do with mathematics. Suherman in Maulana (2013, p.2) explains that in mathematics between one concept and another concept there is a close relationship, not only in terms of content, but also in terms of the formulas used, the relationship between topics in mathematics, mathematics and others science, and mathematics with everyday life is called mathematical connection.

The National Council of Teachers of Mathematics, as quoted by Ningrum (2016, p.2), states that there is five basic mathematical ability that becomes standard processes in learning mathematics, namely problem-solving ability, reasoning ability, communication ability, connection ability, and representation ability. Based on the five standards, mathematical connection ability has an important role in the process of solving mathematical problems. Through this mathematical connection, the ability will facilitate students in solving mathematical problems because students will be skilled at thinking that mathematics as a whole and not stand alone. Students are not only focused on one formula or concept, but students will develop all concepts related to the problems they are working on (Prasetyo, 2017, p.3).

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Based on the results of a preliminary study test conducted at one junior high school in the Semarang City, it shows that students' mathematical connection ability is still low, an average of 38.25 out of a maximum score of 70.

The low ability of students' mathematical connections can affect student learning outcomes. According to Wahyudin, as quoted by Rahman (2010, p. 4), the cause of the low understanding of students in learning mathematics is because the learning process is not optimal. Learning models are needed that can train students to be more initiative in learning and connecting mathematical problems being faced with mathematical concepts that have been obtained previously. One model that can be used is the Knisley mathematics learning model. According to Trisnawati (2015), Knisley mathematics learning model can improve students' mathematical connection ability.

In addition to the learning model, the approach is also a factor that needs to be considered in the success of mathematics learning. Suherman, as quoted by Hardi (2017, p. 5), states that the learning approach is one of the important factors for improving students' mathematical connection ability. One learning approach that is expected to improve students' mathematical connection skills is to use the open-ended approach.

Learning using the open-ended approach is learning that gives students open problems. Through this open-ended approach, students not only rely on good memories, but students can also link or connect them with other topics in mathematics itself, with other subjects, and with real-life that they have experienced or thought of (Gordah, 2012, p. 278).

In addition to cognitive aspects, students' affective aspects also need attention. The 2013 curriculum emphasizes the competencies students must have in learning mathematics, including the areas of attitude, cognitive skills, psychomotor skills, and knowledge (Septiyana & Indriani, 2018, p. 156). Happy (2014) states that learning is more effective if the teacher can develop not only cognitive aspects but also effective aspects. One of the affective aspects is independence or self-regulated learning.

Self-regulated learning can be interpreted as the self-regulation of students in the learning process to achieve learning objectives. According to Marchis (2011, p. 9), a person who has self-regulated learning will analyze the task (understanding the problem, identifying the known data, unknown data, and the relationship between the data), solving the problem, and evaluating the results. So, to improve the ability of understanding and mathematical connections, we need to know how to learn students, so as to increase student learning activities and improve the ability of students who have a relationship with self-regulated learning.

Based on the description that has been elaborated, the formulation of the problems that will be discussed in this study are (1) whether the mathematical connection ability of 8th graders in Knisley mathematics learning model with an open-ended approach can achieve classical completeness; (2) whether the average mathematical connection ability of 8th graders in Knisley mathematics learning model with the open-ended approach is better than conventional learning model; (3) whether the proportion of 8th graders who completed in the Knisley mathematics learning model with the open-ended approach is more than the conventional learning model; (4) how is the description of the mathematical connection ability of 8th graders in terms of self-regulated learning in the Knisley mathematics learning model with the open-ended approach.

The purposes of this study are (1) to know the mathematical connection ability of 8th graders in the Knisley mathematics learning model with the open-ended approach to achieving classical completeness; (2) to know the average mathematical connection ability of 8th graders in Knisley mathematics learning model with open-ended approach better than conventional learning model; (3) to know the proportion of 8th graders who completed in the Knisley mathematics learning model with an open-ended approach more than the conventional learning model; (4) to describe mathematical connection ability of 8th graders in terms of self-regulated learning in Knisley mathematics learning model with the open-ended approach.

The hypothesis in this study are (1) the mathematical connection ability of 8th graders in Knisley mathematics learning model with the open-ended approach to achieving classical completeness; (2) the average mathematical connection ability of 8th graders in Knisley mathematics learning model with the open-ended approach is better than conventional learning model; (3) the proportion of students who completed in the Knisley mathematics learning model with the open-ended approach is more than the conventional learning model.

2. Method

This type of research is a mixed-method with a sequential explanatory design that is a research design that combines quantitative method and the qualitative method by collecting and analyzing quantitative data first then proceed with collecting and analyzing qualitative data (Lestari & Yudhanegara, 2017).

The population in this study were all students of grade 8 in one junior high school in the Semarang City in the academic year 2019/2020. This study uses two sample grades, namely the experimental grade and the control grade selected using random grade techniques. The experimental grade in this study was grade 8 A who obtained the Knisley mathematics learning model with the open-ended approach, while the control grade in this study was grade 8 E, who obtained conventional learning. The subject of this study was chosen from the grade with the Knisley mathematics learning model with an open-ended approach based on a self-regulated learning questionnaire and a final test of mathematical connection ability. Self-regulated learning is divided into three, namely students with the regulation of cognition (RC), regulation of motivation (RM), and regulation of behavior (RB). After students are grouped based on their self-regulation, then two students from each category were chosen to analyze their mathematical connection ability in two-variable linear equation system material. The technique of taking the subject of this research was purposive sampling (certain considerations). In this study, considerations were made based on researchers' observations about student self-regulation and student work processes on a mathematical connection ability test. Data collection techniques in this study include mathematical connection ability tests, self-regulated learning questionnaires, interviews, and field notes.

After the data is obtained, it is analyzed quantitatively and qualitatively. Quantitative data analysis was performed to know the mathematical connection ability of 8th graders on Knisley mathematics learning model with an open-ended approach achieving classical completeness, to know the average mathematical connection ability of 8th graders on Knisley mathematics learning model with open-ended approach better than conventional learning model, to know the proportion of 8th graders completed in Knisley mathematics learning model with the open-ended approach is more than conventional learning model. Qualitative data analysis is used to describe the mathematical connection ability of 8th graders in terms of self-regulated learning in the Knisley mathematics learning model with the open-ended approach.

3. Results & Discussions

3.1. Preliminary Data Analysis

Preliminary data used are the results of preliminary study test grades 8 A and 8 E. Initial data analysis includes normality test, homogeneity test, and average similarity test. The normality test uses the Kolmogorov-Smirnov test with a significant value of 5%, which shows the results that the initial data came from a normally distributed population. The homogeneity test uses the F test, which shows the results that the initial data of these two grades are homogeneous or have the same variance, whereas the average similarity test uses the t-test, which shows the results that both classes have the same average.

3.2. Learning Implementation

Learning in the experimental grade uses the Knisley mathematics learning model with an open-ended approach, and learning in the control grade uses conventional learning. Learning in each grade was held in 4 meetings. The first meeting discussed the sub-material concept of a two-variable linear equation system and a mathematical model. The second meeting discusses the sub material solving two-variable linear equation system with graphs. The third meeting discusses the sub material solving two-variable linear equation system with substitution or elimination. The fourth meeting discusses the sub material solving two-variable linear equation system with a mixed method.

Learning was held in accordance with the syntax of each learning model that is the Knisley mathematics learning model with the open-ended approach in the experimental grade and conventional learning in the control grade. Learning uses Student Worksheets (Lembar Kerja Siswa: LKS), Student Task Sheets (Lembar Tugas Siswa: LTS), and quizzes. LTS and quizzes given to the class using the Knisley mathematics learning model with the open-ended approach are a matter of mathematical connection with the type of open-ended problem.

After learning, students in the experimental grade and the control grade are given a final test of mathematical connection ability consisting of 4 questions. Furthermore, students with the Knisley mathematics learning model with an open-ended approach were given a self-regulated learning questionnaire consisting of 35 statements. After obtaining the self-regulated learning questionnaire score, the researcher determined the research subject be interviewed later on their mathematical connection ability.

3.3. Quantitative Data Analysis

The final data used is data of the mathematical connection ability test of class 8A who obtained the Knisley mathematics learning model with an open-ended approach and 8E, who obtained conventional learning. Before testing the hypothesis, this final data is tested for normality and homogeneity test. As a result, the final data fulfill the requirements for normality and homogeneity.

In the hypothesis 1 test, the learning completeness test was conducted. Students are said to be complete in learning if students who get a mathematical connection ability test score ≥72 or reach at least 75% of the total number of students in the class. The data used are the results of class 8 A's mathematical connection ability test. This classical completeness test is performed using a party proportion test. The test criteria are rejected H_0 if $z_{count} \geq z_{table}$ with a significance level of 5%. Based on the calculation results obtained z_{count} = 1,81 and z_{table} = 1,64. Because $z_{count} > z_{table}$, then H_0 is rejected. So the mathematical connection ability of 8th graders with the Knisley mathematics learning model with an open-ended approach reached classical completeness.

In the hypothesis 2 test, the data used are the results of the mathematical connection ability test for students of grade 8 A and 8 E. Hypothesis 2 test uses the similarity test of two average one right party. The test criteria are reject H_0 if $t_{count} \geq t_{table}$ with dk = n_1+n_2-2, the significance level is 5% and t_{table} = 1,67. From the results obtained t_{count} = 3,94. Because $t_{count} > t_{table}$, H_0 is rejected. So, the average results of students' mathematical connection ability tests on the Knisley mathematics learning model with the open-ended approach are more than the average results of the mathematical connection ability test on conventional learning.

In the hypothesis 3 test, the data used are the results of the mathematical connection ability test of students of class 8 A and 8 E. Hypothesis 3 test uses the similarity test of two proportions. The criteria used are rejected H_0 if $z_{count} \geq z_{table}$ with a significance level of 5% and z_{table} = 1,64. Based on the calculation results obtained z_{count} = 2,36. Because $z_{count} > z_{table,}$ then H_0 is rejected. So, the proportion of students who completed in the Knisley mathematics learning model with the open-ended approach is more than students who completed in conventional learning.

Based on the analysis of the final test of mathematical connection ability, it is obtained that (1) the mathematical connection ability of 8th graders in Knisley mathematics learning model with an open-ended approach achieves classical completeness; (2) the average mathematical connection ability of 8th graders in Knisley mathematics learning model with the open-ended approach is better than conventional learning model; (3) the proportion of students who completed in the Knisley mathematics learning model with the open-ended approach is more than the conventional learning model.

3.4. Qualitative Data Analysis

The material in this study is a two-variable linear equations system. This study uses four indicators of mathematical connection ability, which are interpreted into four mathematical connection ability test items in the two-variable linear equation system material. The first indicator is the connection between concepts in mathematical material, interpreted in the first problem of the mathematical connection capability test, namely the connection between the concepts of solving a two-variable linear equation system with elimination and substitution. The second indicator of mathematical connection ability is the connection between topics in mathematics, interpreted in the second problem of the mathematical connection ability test, namely the connection between the topic of two-variable linear equation system and the topic of number. The third indicator of mathematical connection ability is the connection between concepts in mathematics and other science, interpreted in the third problem of the mathematical connection ability test, namely connection between two-variable linear equation systems with the concept of speed in physics. The fourth indicator of mathematical connection ability is the connection between mathematics and everyday life, interpreted in the fourth problem of the mathematical connection ability test, namely connection between two-variable linear equation system with the purchase price of goods.

The self-regulated learning questionnaire was given to the grade using the Knisley mathematics learning model with an open-ended approach to determine their self-regulated learning categories. Based on the results of a self-regulated learning questionnaire filled out by 35 students, there were ten students with the regulation of cognition, 12 students with the regulation of motivation, and 13 students with the regulation of behavior. From these results, each of the two research subjects representing each category of self-regulated learning was taken.

After selecting the research subject, then the interview process is carried out on the subject. The interview process will then be carried out triangulation techniques that compare work results analysis and interview results analysis. Based on the results of triangulation, then a table of mathematical connection ability results of the research subjects is made on each indicator presented in Table 1 as follows.

Table 1. Results of Analysis of Research Subjects' Mathematical Connection Ability

Self-Regulated Learning Category	**Subject Code**	**Mathematical Connection Ability Indicator**			
		1	**2**	**3**	**4**
RC	S-1	Able	Able	Able	Able
	S-2	Able	Able	Able	Able
RM	S-3	Able	Able	Able	Less Able
	S-4	Able	Able	Able	Less Able
RB	S-5	Able	Able	Less Able	Able
	S-6	Able	Able	Less Able	Less Able

Information:
Indicator 1: the connection between elimination concept and substitution concept (mixed) in the same material, namely the two-variable linear equation system.
Indicator 2: the connection between topics in mathematics, namely two-variable linear equation system topics, and number topics.
Indicator 3: connections between the two-variable linear equation system and other science, namely physics.
Indicator 4: the connection between mathematics and everyday life.

Mathematical connection ability is the ability that includes the connection between concepts in mathematical material, the connection between topics in mathematics, connections between concepts in mathematics and other science, and connection between mathematics and everyday life. Students can connect between concepts in the same mathematical material if (1) using mathematical concepts to solve problems. Students can connect between topics in mathematics if (1) express a problem into a mathematical model by connecting it to other topics; (2) using mathematical concepts to solve problems.

Students can connect between mathematics and other science if (1) expresses problems in other science into the form of mathematics; (2) using mathematical concepts to solve problems in other science; (3) write the conclusions of solving mathematical problems in other science. Students can connect mathematics with everyday life if (1) expresses the problems of everyday life in the form of mathematics; (2) using mathematical concepts to solve problems in everyday life; (3) write the conclusions of solving mathematical problems in everyday life.

The mathematical connection ability of students in the Knisley mathematics learning model with an open-ended approach for each category of self-regulated learning can be described as follows.

3.4.1. Mathematical Connection Ability for Students with Regulation of Cognition

Interview subjects for mathematical connection ability with the regulation of cognition are S-1 and S-2. Based on the results of the analysis, it was concluded that the subjects S-1 and S-2 were able to fulfill four indicators of mathematical connection ability, namely, the connection between concepts in mathematical material, the connection between topics in mathematics, the connection between concepts in mathematics, and other science, and connection between mathematics and everyday life.

On the indicator of mathematical connection ability, namely connection between concepts in mathematical material, students with the regulation of cognition is able to use the mixed concepts (elimination and substitution) to solve problems. Wolters et al. (2003) state that students with the regulation of cognition use elaboration strategies so that they can determine the concepts or ideas that will be used to solve problems.

In the second indicator of mathematical connection ability, namely connection between topics in mathematics, students with the regulation of cognition are able to find out information that is known and asked about the problem and are able to explain the purpose of the problem using their own sentences and language. Wolters et al. (2003) state that students with the regulation of cognition use elaboration strategies where students learn by turning material into their own words. This means that students with the regulation of cognition are accustomed to understanding a problem by changing it into their own sentence or language so as to enable students to know the meaning and purpose of the problem. In addition, students with the regulation of cognition use the concepts of addition and subtraction of numbers as steps to create a mathematical model and use the mathematical model to solve problems. This is as stated by Wolters et al. (2003) that students with the regulation of cognition use an elaboration strategy where students try to connect the material with what students already know.

The third indicator of mathematical connection ability is the connection between concepts in mathematics and other science. Students with the regulation of cognition are able to connect mathematical material with the concept of speed in physics. It is as said by Wolters et al. (2003) that students with the regulation of cognition use elaboration strategy where students try to link ideas in a lesson with other lessons whenever possible. In addition, students with the regulation of cognition, namely S-1 and S-2, are able to choose the right formula, which is the speed formula, as a step to make a mathematical model and use the mathematical model to solve the problem. Wolters et al. (2003) state that students with the regulation of cognition use better learning strategies, such as making a material summary. This shows that students who manage their logic use a strategy to make a summary, such as a summary of formulas in learning so that students understand and remember the formulas that can later be used in solving problems.

Then for the fourth indicator of mathematical connection ability, that is the connection between mathematics with everyday life. Students with the regulation of cognition can associate mathematics with everyday life. It is as said by Wolters et al. (2003) that students with the regulation of cognition use elaboration strategies by exploring relevant information from problems so that they can help them in solving problems.

3.4.2. Mathematical Connection Ability for Students with Regulation of Motivation

Interview subjects for mathematical connection ability with the regulation of motivation are S-3 and S-4. Based on the results of the analysis, it was concluded that subjects S-3 and S-4 were able to fulfill three indicators of mathematical connection ability, namely, the connection between concepts in mathematical material, the connection between topics in mathematics, and connection between concepts in mathematics and other science.

In the indicator of mathematical connections ability, namely connection between concepts in mathematical material, students with the regulation of motivation are able to use the mixed concepts (elimination and substitution) to solve problems.

In the indicators of mathematical connection ability, namely connection between topics in mathematics, students with the regulation of motivation are able to use the concepts of addition and subtraction of numbers as steps to create the mathematical model and use a mathematical model to solve problems.

The third indicator of mathematical connection ability is the connection between concepts in mathematics and other science. Students with the regulation of motivation can connect mathematics with physics material. It is as said by Wolters et al. (2003) that students with the regulation of motivation use relevance enhancement strategies in which students increase the meaningfulness of an assignment by connecting to their personal interests. In this case, the student's personal interest in physics.

Then for the fourth indicator of mathematical connection ability, that is the connection between mathematics with everyday life. Students with the regulation of motivation are less able to fulfill these indicators because S-4 is less able to express everyday life problems in the form of mathematics, and S-3 is less thorough in using concepts to solve mathematical problems.

3.4.3. Mathematical Connection Ability for Students with Regulation of Behavior

Interview subjects for mathematical connection ability with the regulation of behavior are S-5 and S-6. Based on the results of the analysis, it was concluded that the subject of S-5 is able to fulfill three indicators of mathematical connection ability, namely connection between concepts in mathematical material, the connection between topics in mathematics, and connection between mathematics and everyday life, while S-6 is able to fulfill two indicators of mathematical connection ability namely connection between concepts in a mathematical material and connection between topics in mathematics.

In the indicator of mathematical connection ability, namely connection between concepts in mathematical material, students with the regulation of behavior is able to use the mixed concepts (elimination and substitution) to solve problems.

On the indicator of mathematical connection ability, namely connections between topics in mathematics, students with the regulation of behavior are able to use the concepts of addition and subtraction of numbers as steps to create the mathematical model and use a mathematical model to solve problems.

The third indicator of mathematical connection ability is the connection between concepts in mathematics and other science. Students with the regulation of behavior are less able to fulfill these indicators because the conclusion of solving the problem is not right. Then for the fourth indicator of mathematical connection ability, namely the connection between mathematics and everyday life. Students with the regulation of behavior, namely S-6, are less able to fulfill these indicators because the conclusion of solving the problem is not right. This shows that students with the regulation of behavior must be accompanied in working on math problems that are related to other science and everyday life. During the interview, students with the regulation of behavior also had difficulty in explaining problem-solving, so the researcher had to ask repeatedly. This is, as said by Wolters et al. (2003) that students with the regulation of behavior need help such as friends and teachers in learning, so guidance from teachers and friends is needed.

Based on the results of the discussion, it was found that students with the regulation of cognition tend to have better mathematical connection ability than students with the regulation of motivation and students with the regulation of behavior. Therefore in learning, teachers must pay attention to students' self-regulated learning. Especially for students' mathematical connection ability even with different self-regulated learning.

4. Conclusion

Based on the results of research and discussion of mathematical connection ability in the Knisley mathematics learning model with the open-ended approach in terms of students' self-regulated learning, the following conclusions are obtained.

1. The mathematical connection ability of students in grade 8 in the Knisley mathematics learning model with an open-ended approach achieves classical completeness; namely, there are 86% of students in grade 8 in the Knisley mathematics learning model with an open-ended approach that gets a minimum score of 72.
2. The average mathematical connection ability of 8th graders in the Knisley mathematics learning model with the open-ended approach is better than the conventional learning model.
3. The proportion of 8th graders who completed in the Knisley mathematics learning model with an open-ended approach is more than the conventional learning model.
4. Grade 8 mathematical connection ability in Knisley mathematics learning model with the open-ended approach in terms of students' self-regulated learning, namely (i) Two subjects in the category of regulation of cognition are able to fulfill all four indicators of mathematical connection ability, namely connections between concepts in mathematical material, the connection between topics in mathematics, the connection between concepts in mathematics and other science, and connection between mathematics and everyday life; (ii) Two subjects in the category of regulation of motivation

are able to fulfill three indicators of mathematical connection ability, namely the connection between concepts in a mathematical material, connection between topics in mathematics, and connection between concepts in mathematics and other science; (iii) Two subjects in the category of regulation of behavior, one subject is able to fulfill the indicator of the connection between mathematics and everyday life. Both subjects are able to fulfill the indicators of connection between concepts in a mathematical material and connection between topics in mathematics.

It was concluded that students with the regulation of cognition tend to have better mathematical connection ability than students with the regulation of motivation and students with the regulation of behavior.

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