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The Realistic Mathematics Learning Approach Improving the Ability of the Mathematical Connection of Junior High School Students at Al-Islamiyah Putat-Tanggulangin Sidoarjo

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Abstract

The aims of this study were to determine effectiveness of the mathematics learning approach in improving students' mathematical connection. This research used two Group Pretest-Posttest designs. The sample selected of this study was from random sampling, that is two classes were selected with 58 students. This research was conducted in grade VIII-1 Junior High School Al-Islamiyah Putat-Tanggulangin, Sidoarjo. The instruments of this research used essay test and observation. The results showed that the practicality of the realistic mathematic learning approach effectively used, was characterised by the ability of the teachers to manage learning to meet the criteria of good; student activities, positive student responses, and completeness of the classical student learning more than 80%. Furthermore, based on student learning outcomes, it can be concluded that the students' mathematical connection ability increases.

Keywords: The Realiy of the Mathematics Learning Approach, The Ability of Mathematics Connection.

Introduction

Mathematical connections are one of the abilities that must be possessed to solve problems. This is supported by the statement NCTM, (2000), "Mathematics is not a collection of separate strands or standards, even though it is partitioned and presented in this manner". The ability to recognise, use, understand the interrelationship between mathematical ideas, and form a connection between one idea and another to obtain an overall connection, and to recognise and apply mathematics to situations outside mathematics is called the ability of a mathematical connection. The ability of a mathematical connection is a mathematical skill that students need to develop. Based on the description, it can be said that the ability of a mathematical connection is a very important part of the purpose of mathematics learning.

The ability of a mathematical connection is very important to be developed in the process of learning mathematics. This is supported by the statement NCTM, (2000) "To help students build a disposition to use connection in solving mathematical problems, rather than see mathematics as a set of disconnected, isolated concepts and skills". Accordingly, Rohendi and Dulpaja (2013) stated that "The ability mathematical connections is needed by students, especially in solving problems that require a relationship between mathematical concepts to other concepts in mathematics and other scientific disciplines or in real life". This is based on several research results which say that students' mathematical connection skills are low and students still have difficulty in connecting mathematical concepts (Latif & Akib, 2016; Siregar & Surya, 2017; Warih, Dwi, Parta, & Rahardjo, 2016). This is also supported by the results of the PISA survey which show that mathematical achievements in Indonesia at the junior / senior high school level is always fixed on low numbers and Indonesia is ranked 64th out of 72 countries with a score of 386 (OECD, 2018).

TIMSS research results on students in Indonesia, especially mathematics, are ranked 45th out of 50 countries (TIMSS, 2015). Data shows that students are still weak in all aspects of content and the cognitive, one of which has not been able to associate three-dimensional concepts and two-dimensional concepts that result in low mathematical connection skills of students. From this problem a low mathematical connection indicates that students cannot make their own mathematical connections. This is consistent with the opinion of Sawyer (2008, p.434) who said that: "Making connections is the basis for mathematics education which is influenced by their teaching practices in a number of important ways. Who demonstrates the ability to make connections between mathematical knowledge and other forms of disciplinary knowledge, and between mathematical and real life knowledge".

Based on the above description of the learning approach that can be applied to improve students' mathematical connection skills namely Realistic Mathematics Learning. Realistic mathematics learning is appropriate for students because it uses contextual problems as the starting point of learning. Based on Freudenthal's assumption "mathematics is a human activity" which means mathematics is a human activity (Wijaya, 2012). According to Freudenthal, mathematics should not be conveyed to students as a tool that is ready to be used, but a form of activity constructing mathematical concepts (Wijaya, 2012). By this statement, mathematics learning in the classroom emphasises a link between mathematical concepts of student experience in their daily lives and it is very necessary to re-apply the knowledge of students to mathematical concepts in real life. The approach to learning mathematics that directs the mathematical knowledge of everyday students and applies mathematics to their daily lives is realistic mathematics learning. So, it can be said that mathematics learning basically trains students 'logical reasoning by increasing students' ability of mathematical connection. Therefore, the realistic mathematics learning approach is appropriate for improving students' mathematical connection skills.

The Realistic Mathematics Learning Approach

Realistic Mathematics Education, translated as Realistic Mathematics Education (PMR), is an approach to learning mathematics developed by a group of mathematicians from Utrecht University in the Netherlands (Freudenthal, 1991; Treffers, 2012; Van den Heuvel-Panhuizen & Drijvers, 2014). This approach is based on Freudenthal's assumption that "mathematics is a human activity" (Van den Heuvel-Panhuizen & Drijvers, 2014). This approach characterises mathematical activity as an activity of solving problems, finding problems and organising the subject matter. This approach emphasises student activity and not passivity. The mathematical activity in question is the activity of rediscovering mathematical ideas and concepts by exploring the real world under the guidance of the teacher as a facilitator.

The basic principle of RME refers to guided discovery, didactic phenomenology, and mediating the principle of the model. All these characteristics are inspired by (Freudenthal, 1973, 1983, 1991) where the basic principle of this RME is 'mathematics as a human activity'. This idea places a heavy emphasis on students who build their own knowledge with the guidance of teachers in the learning process of mathematics in the classroom. Two types of mathematical formulations by Treffers (2012), are stated, namely horizontal and vertical mathematics. Examples of horizontal mathematicians are identifying, formulating, and visualising problems in different ways, and transforming real-world problems into mathematical problems. Examples of vertical mathematics are representation of relationships in formulas, enhancement and adjustment of mathematical models, use of different models, and generalisations. Both types of mathematicians get balanced attention, because these two mathematicians have the same value.

The real world here is used as a starting point for learning mathematics, such as other subjects, the environment, and everyday life. This approach emphasises processes more important than results. PMR uses mathematical terms which are interpreted as "mathematically" which consists of two processes namely horizontal mathematics and vertical mathematics. Both processes are interpreted as a guided reinventing activity (Hadi, 2005). Horizontal mathematics is a process of solving contextual problems from the real world into mathematical symbols. In horizontal mathematics, students solve problems using their own rules, languages, and symbols. Whereas, vertical mathematics is a process of formalisation from informal mathematical forms to formal mathematical forms. In vertical mathematics, students will make a general procedure that can be applied in solving similar problems directly without the need for context. By Freudenthal, "horizontal mathematical means moving from the real world into the world of symbols to produce mathematical concepts, principles, or models of everyday contextual problems, while vertical mathematical means moving in the world of symbols themselves to produce concepts, principles, or mathematical models of mathematics "(Van den Heuvel-panhuizen & Drijvers, 2014). In this PMR approach, students are considered to have prior knowledge and experience to develop their own knowledge of mathematics by exploring various mathematical problems and problems in daily life, so students can rebuild findings in the field of mathematics.

The following are realistic mathematical learning principles which are guided reinvention and progressive mathematisation, didactic phenomenology (didactical phenomenology), and self-developed models (Gravemeijer, 1994).

Following are the characteristics of realistic mathematical learning approaches that are using context, using models, using student contributions, interactivity, and interrelationships between topics (Bakker, 2004; Treffers, 2012). The steps of realistic mathematics learning that are in accordance with the principles and characteristics of PMR are stated by (Mulbar, 2009) as follows: First step: Understand contextual problems,;Second Step: Resolve contextual problems, Third step: Compare and discuss; Fourth Step: Conclude.

Mathematical Connection

One of the abilities that must be mastered by students in mathematics is mathematical connection skills, as recommended by NCTM, (2000), the Standard Process of Problem Solving, Reasoning and Evidence, Communication, Connection, and Representation, highlighting how to acquire and use content knowledge. However, in reality students have not yet realised the importance of mathematical connections so they still consider that every concept in mathematics is independent and not related to other mathematical concepts. NCTM, (2000) explains that "Thinking mathematically involves finding connections, and making connections building mathematical understanding. Without connection, you have to learn and remember too many isolated concepts and skills. With connections, they can build new understanding of previous knowledge".

Mathematical connections were popularised by NCTM (1989) and used as one of the standards in the process of learning mathematics. Under NCTM (1989), mathematical connections are an important part that must be emphasised at every level of education. By NCTM (1989), mathematical connections are the relationship between mathematical topics, the relationship between mathematics and other disciplines, and the relevance of mathematics to the real world or in everyday life. Goos et al., (2007) suggest the importance of this mathematical connection. According to Goos et al., (2007) mathematical connections are connections of mathematics to mathematics itself, mathematical connections to other subjects, mathematical connections to their applications, and mathematical connections to real problems around students through mathematical modeling.

In connection with understanding this mathematical connection, we need to note that in mathematics between one concept and the other there is a close relationship, not only in terms of sides, but also in terms of the formulas used. One material may be a prerequisite for another material, or a certain concept is needed to explain another concept. This is in accordance with

Bruner's association proposition (Ruseffendi, 1991), which states that in mathematics each concept is related to one another. Like theorems with theorems, between theory and theory, between topics with topics, and between branches of mathematics. Connection in mathematics as an implication of mathematics is a unified whole. Therefore, for students to succeed in learning mathematics, they must be given more opportunities to see this link, both links between arguments, between theories, between topics, and between branches of mathematics (e.g. algebra and geometry).

Furthermore, (Reston, 2000) explains that there are three aspects that must be mastered by students in mathematical connections, namely "recognising and using connections between mathematical ideas, understanding how mathematical ideas interconnect and building a coherent whole, recognising and applying mathematics in contexts outside mathematics. Karnasih and Sinaga (2014) say that mathematical connections are the ability of students to: (1) recognise the same representation with the same topic, (2) associate procedures in one representation with procedures in the same representation, and (3) use and value relationships between mathematics and other scientific disciplines. (Coxford, 1995) says that "When students and teachers continue to" think connections "mathematics will grow and become dominant". When that happens, all will wonder why no-one has ever thought of mathematics in other ways. It can be interpreted that students and teachers continue to "think connections" and the relationship between mathematics will grow and become more dominant. When that happens, everyone will ask why no-one has ever thought of mathematics in other ways.

NCTM, (2000) describes the standard process of mathematical connection skills in teaching is an instructional program from the prekindergarten, even though class 12 must allow all students: 1) to recognise and use connections between mathematical ideas, 2) Understand how ideas are mathematically interconnected and build a coherent whole, 3) Identify and apply mathematics in contexts outside mathematics. In general, (Coxford, 1995) suggests that mathematical connection capabilities include:

1. Link conceptual and procedural knowledge.
2. Use mathematics in other curriculum fields.
3. Use maths in daily life activities.
4. Look at mathematics as an integrated whole.
5. Applying mathematical thinking and modeling to solve problems that arise in other disciplines, such as art, music, psychology, science, and business.
6. Use and value connections between mathematical topic.
7. Recognise equal representation from the same concept.

The purpose of this study was to determine the effectiveness of a realistic mathematical learning approach to improve students' mathematical connection in 8th grade.

Methods

This study used experimental research with the design of two groups of pretest-posttest. The study population was all eighth-grade students of Al-Islamiyah Putat Middle School Tanggulangin, Sidoarjo. The sample in this study was taken by random sampling, namely as many as 2 classes with a total of 58 students. The experimental class taught with the Realistic Mathematics Education Approach was class VIII-1 which consisted of 17 female students and 12 male students, while the control class taught with conventional learning consisted of 16 female students and 13 male students.

The instruments in this study used the mathematics connection description ability test sheet (TKKM) and observation sheet. The essay test instrument consisted of 4 questions about the topic of a prism. The observation sheet consists of observing teacher activities and student activities to see student activities during the lesson. Before conducting research, essay tests and observation sheets were validated by 2 lecturers and 1 mathematics teacher. After the research, repairs were made based on suggestions from the validator for the TKKM test sheet instrument and observation sheet.

Furthermore, the TKKM description test items were tested on students to get the level of validity and the level of reliability of the instruments to be used, and the TKKM items were tested outside the research subject. To measure the validity of an item, you can use the product moment correlation formula (Arikunto, 2012) below.

$$r_{xy} = \frac{\frac{\sum xy - (\sum x)(\sum y)}{N}}{\sqrt{\left(\frac{\sum x^2 - (\sum x)^2}{N}\right)\left(\frac{\sum y^2 - (\sum y)^2}{N}\right)}}$$

Then, to calculate the reliability coefficient, the Alpha-Cronbach test item (Arikunto, 2012) was used as follows:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

Whereas, the analysis technique was used in this study with the t-test. Before the t-test was carried out, the normality and homogeneity tests were carried out first.

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{S_2^1}{n_1} + \frac{S_2^1}{n_2}}}$$

Hypothesis criteria: hypothesis (H_0) was accepted if: $T_{count} > T_{table}$ and hypothesis (H_1) was rejected. The research hypothesis was as follows: H_0: The mathematical connection ability of students using the Realistic Mathematics Education (RME) approach was no better than conventional learning.

H_1: The mathematical connection ability of students using the Realistic Mathematics Education (RME) approach was increasing and getting better.

Findings

The process of conducting research begins with giving tests to both classes to see the level of students' initial connection skills. After applying a realistic mathematical approach, a test is given to see the improvement of students' mathematical connection skills. The control class and the experimental class are given different learning treatments. The results of the pre-test and post-test from the experimental class and the control class can be seen in Table 1. The scores of the post-test and experimental class controls can be seen as follows:

Table 1. Description data of Pre-Test and Post-Test

Test	Class	Number of Subject	Highest Score	Lowest Score	Mean
Pre-Test	Experiment	29	70	35	52.55
	Control	29	55	30	45.35
Post-Test	Experiment	29	95	65	82.75
	Control	29	75	50	65.15

Based on Table 1 above, it was found that the mathematical connection ability of students using Realistic Mathematics Education (RME) showed better results by looking at the average obtained by students in the class experimental and the class control.

Then, the initial analysis was carried out with a normality and homogeneity test with the aim to find out data from two groups, with normal distribution and homogeneous data obtained. Next, the hypothesis test was performed to show the T_{value} calculated from the pre-test and post-test data. Based on statistical results, T_{count} = 15,623 and T_{table} = 2,003, the $T_{count} > T_{table}$ was obtained. Based on this hypothesis (H1) was accepted and (H0) rejected, so it can be concluded that the mathematical connection ability of students using Realistic Mathematics Education (RME) in class experiments increased and was better than students who got a treatment with conventional learning in the class control. As well as seen from the posttest value of students that fulfilled the number they got a value above the Classical Completion Criteria. Learning completeness achieved by students in classical was more than 80%.

Furthermore, based on the results of observations during learning, the results showed that teacher activity showed that the criteria were well applied at each stage in the steps of Realistic Mathematics Education (RME). Then, student activities showed active criteria in learning that were characterised by being more enthusiastic and giving a positive response to mathematics learning in the classroom. That happened because students were given contextual problems at the beginning of the learning, so students would understand and solve their own problems with teacher guidance, and students can find their own mathematical ideas. Thus, students could build their own knowledge by connecting previous knowledge with their current knowledge to produce conclusions from the material that had been taught. Contextual problems were facilitated by the teacher in the learning process, so students were enthusiastic because they could solve problems related to students' daily lives, and students could apply their mathematical abilities to live in their daily lives. In addition, contextual problems could also be used as bridges with other disciplines into mathematics itself, so students would quickly recognise, understand, and apply mathematics, and recognise that mathematics is closely related to problems in everyday life.

In the mathematics learning that takes place, students' responses were positive about mathematical connection skills, because students were given contextual problems to connect the relationship between mathematics and mathematics itself, mathematics with other subjects and mathematics as associated with everyday life. So, students were motivated to build, train and develop their own knowledge skills with the guidance of better teachers, so that their knowledge and learning experience would be more meaningful and survive in the long term.

In learning activities, observers observed teacher activities and student activities in learning using the Realistic Mathematics Education (RME) approach. Based on observations made by observers, the following is a description of the learning process obtained. The stage of treatment or implementation of learning is carried out with several meetings. Each meeting lasts 90 minutes with an estimated learning time from the initial activity to closing. The material discussed in each meeting in this study was prism material. For each meeting, students were given contextual problems related to the prism material, in this case the surface area and volume of prisms that would be discussed with student group friends. In the initial activity of learning, the teacher arranged classes for learning activities and conveyed the purpose of the material to be studied. Next, the teacher formed a group based on gender and the level of ability of students with the aim that students would hold group discussions and solve problems that had been delivered by the teacher.

The initial process of learning showed that students seemed to have little difficulty understanding and resolving the contextual problems presented because the problem presented was a non-routine problem. That happened because students were not used to learning with contextual problems. At first students still had difficulty finding mathematical ideas on the problems presented, but at the next meeting students had begun to recognise mathematical ideas and had been able to represent them in symbolic form. Then students made models or procedures, so they could find and draw conclusions from the material that had been taught.

When the material discussion took place, several students in each group asked the teacher questions about the contextual issues they had discussed. In the learning process the teacher did not directly answer questions from students, but the teacher simply repeated the material and provided reasonable guidance, so students could find their own answers. In addition, the teacher also motivated the students to explore and build mathematical skills, so students who were involved in learning activities understood mathematics in general. After the group discussion was complete, the teacher asked one of the representatives from each group to present the results of their discussion and write them on the board. After the group presented the results of the discussion, the teacher checked whether the results were in accordance with what was expected in the learning objectives. Then the teacher explained further, to confirm the results of the discussion from each group. At the end of the lesson, the teacher and students summarised or drew conclusions about the material that had been taught with the guidance of the teacher.

Discussion

This research has been carried out by several researchers before using the Realistic Mathematics Education (RME) approach. In general, the results of this study can improve students' mathematical connection skills. In this study, it shows that the average mathematical connection ability of students who use the Realistic Approach Mathematics Education (RME) increases and is better than the class with conventional learning. These results occur because the learning process using the Realistic Mathematics Education Approach (RME) encourages and motivates students to find their own answers to the problems given. By using the Realistic Mathematics Education Approach (RME), which is connected with the mathematical concepts themselves, other scientific concepts and other daily life, learning will be more meaningful and students' mathematical connection abilities increase and become better.

Learning theory is a guideline for teachers to help students develop their cognitive, social, and spiritual aspects. The development so far with Realistic learning Mathematics Education Approach (RME) has always been based on 4 theories namely Piaget's theory, Vygotsky's theory, Bruner's theory and Ausubel's theory (Slavin, 2009). In accordance with the theory of learning, learning and thinking basically changes and develops cognitive structures. In his theory Piaget suggested that a person's cognitive structure occurs because of the process of adaptation. Adaptation is the process of adjusting schemes in responding to the environment through two processes of assimilation and accommodation. In fact, according to Slavin (2009), assimilation is an interpretation of new experiences in relation to existing schemes.

The learning process with RME is very closely related to theory; it is based on Piaget's theory, because realistic mathematics learning focuses on how students think, not focusing on the results of student completion. Furthermore, students who are given contextual problems will be given the opportunity to find their ideas to solve problems and represent mathematical symbols. One important theory in the developmental psychology of students is Vygotsky's theory. This theory emphasises the nature of sociocultural learning. In accordance with Vygotsky's opinion that learning occurs when children work or study in completing tasks that have not been studied before, these tasks are still in the zone of proximal development. Universally, higher mental functions appear in conversations or cooperation between individuals, before higher mental functions are absorbed into individuals, according to Vygotsky (Slavin, 2009).

This contains two main effects based on Vygotsky's theory of science learning. First, conditions in class are designed with cooperative learning, so that with these groups students will be able to interact with group friends to solve problems that are classified as difficult and produce effective problem solving strategies in each zone of their proximal development. Second, this theory also applies to those who teach by emphasising and providing assistance or guidance so that students become increasingly responsible for their own learning (Slavin, 2009). This theory is in accordance with the Realistic Mathematics Education Approach (RME), which is a contextual problem that is presented to students in understanding and completing it, designed in the form of groups, and in this group there are interactions between students and students and teachers in understanding and resolving the contextual problems presented earlier. With this approach each student will feel confident and responsible for their own knowledge obtained from the results of the discussion.

Learning mathematics is learning about the concepts and structures of mathematics found in the material studied and for discovering the relationship between the concepts and mathematical structures of Bruner (Hudojo, 1988). Through these concepts and structures, a material will be comprehensively understood. In addition, student knowledge is easier to remember and last longer if the material being studied has a structured pattern. Furthermore, in this theory students' cognitive development is developed through three stages, namely the active stage in which students learn to use concrete objects directly so that they can manipulate concrete objects, iconic stages that do not use concrete objects but other objects, symbolic stages, where students learn by manipulating direct symbols that are not related to the object. So, it can be concluded that Bruner's theory is in accordance with RME, the suitability of first guided rediscovery and progressive mathematics, conformity with the second principle, didactic phenomenology, and conformity with the characteristics of the first RME to use context, and third is student contributions and fourth is interactivity.

Learning must be meaningful when the information learned by students is governed by cognitive students (Hudojo, 1988). In Ausubel's theory, students can associate their new knowledge with the cognitive aspect. In this way, students will have strong and easy memories to transfer their knowledge. If students try to link new information into their knowledge then learning will be meaningful to them. Based on some of the descriptions above, this shows that RME is appropriate and relevant to Ausubel's theory, because RME emphasises understanding more than just memorising. In addition, the relationship between information to be learned on the cognitive structure of students in the RME approach, arises when contextual problems are given that are close to the actual student environment or students can imagine so that they can help students learn meaningfully.

Conclusion

Based on the description of the results of the data analysis above obtained from the pre-test, post-test, and observation, the conclusions in this study were carried out at the Junior High School Al-Islamiyah Putat Middle School Tanggulangin, Sidoarjo are presented below:

a) The ability of students to connect to mathematics using the Realistic Mathematics Learning Approach increases and is better than conventional learning.

b) In the results of the observations, the activities of the teachers were well done and the activities of the students showed that they were actively marked by students who were more enthusiastic in learning mathematics using the Realistic Mathematics Education Approach (RME).

Based on the conclusions above, learning mathematics using the Realistic Mathematics Learning Approach can improve mathematical connection skills of students, and teachers must master the learning approach such as the Realistic Mathematics Learning Approach so that the learning process in the classroom becomes more active, diverse, and learning will be meaningful, so that students' knowledge will last and will improve student learning outcomes for the better.

Suggestions

Until now, teaching with a realistic mathematical approach has been published in the 2013 curriculum that facilitates this country. The importance of realistic mathematics learning has been published so that students can learn mathematics in the context of everyday life. The application of this approach has been started in the last 10 years in elementary and junior high schools and provides excellent references on realistic mathematics learning. This program is a program to improve the quality of education and is inquiry-based. In general, from several research results, realistic mathematical learning approaches have a very important effect on the use of students' thinking skills and building students' knowledge. However, teaching a realistic approach to mathematics learning is very different from teaching in general, because this approach requires teachers who are professional and competent in teaching mathematics. So, the teacher must spend extra time and hard work to teach students about mathematics in a real-world context. This approach has a slight disadvantage because in the learning process students are accustomed to being informed first, so students are still having trouble finding their own answers, and it takes a long time for students who have low abilities.

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