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Multi-Representation Discourse Model and Math Problem Solving Skills of High School Students

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Abstract
This research is a pseudo-experimental study that aims to determine the influence of multi-representation discourse learning model on the mathematical problem solving skills of grade X students of SMA Negeri 3 Singaraja. The design of this research is post-test only control group design. The sampling of the research was conducted by cluster random sampling technique. Sampling is done by drawing against 3 classes. In this study, class X MIPA 1 and class X MIPA 2 were selected. The draw was re-drawn to determine the experimental class and control class, the result of the drawing was selected class X MIPA 2 as the experimental class and class X MIPA 1 as the control class. Data on solving students' math problems were collected through essay tests and analyzed using one-tail t-tests at a rate of 5% significance, the results of which showed that thitung = 1,79 and ttabel = 1,67. The results showed that with the application of multi-representation discourse learning model is better than the math solving skills of students who are taught with conventional learning.

Keywords: multi-representation discourse model; math problem solving

Introduction

Troubleshooting is the process of accepting the problem as a challenge to solve the problem (Hudojo 2005). Problem solving skills are basic math skills that students must have. Students with good problem solving skills will be easier in solving non-routine problems and will help students to achieve the objectives of math learning. However, it is undeniable that some of the research results show that students' math problem solving skills are still low (Amperawan, Pujawan, and Suarsana 2018; Apsari, Suarsana, and Sudiarta 2012; Budarsini, Suarsana, and Suparta 2018; Dewi, Suarsana, and Suryawan 2018; Dewi et al. 2018; Juliantari, Suharta, and Suarsana 2018; Loka, Suarsana, and Sugiarta 2018; Partini, Suweken, and Suarsana 2017; Suarsana 2013). The low ability to solve math problems of students, especially in the province of Bali can also be seen from the results of the Gema High School Mathematics Competition test in Bali province. The results showed that the average score of students who answered correctly decreased throughout 2016-2018. In 2016 the average was 5.01, then decreased in 2017 to 4.92. The decline again occurred in 2018, the average being 4.02 (PGM, 2016-2018). Glm's math problems measure more reasoning, problem solving and written communication. One of the factors causing the low average math score of students in the GLM test is thought to be because students have not been able to solve GLM problems dominated by non-routine problems that demand a high level of thinking ability, one of which is problem solving ability, by having good problem solving skills will help students to solve these types of non-routine problems. The difficulty of students in working on these types of non-routine problems can also be caused because many students are not used to working on problem solving problems (Amperawan et al. 2018).

In learning there are still many teachers who have not made problem solving activities as the main activity in learning (Suherman 2003). Teachers still emphasize the learning process that tends to cause students to memorize materials and work on routine questions. Students who tend to memorize material will encounter obstacles or failures when faced with slightly changed mathematical problems (Cahyani, Suarsana, and Mahayukti 2021; Suarsana, Lestari, and Mertasari 2019). In solving math problems students tend to use formulas without identifying information in the problem, students are accustomed to

directly applying formulas in solving math problems, so that students can solve math problems by paying attention to the information on the problem, efforts or problem solving strategies are required (Suarsana et al. 2021). As for problem solving strategies according to (Herman 2000; Wahyudi and Anugraheni 2017) as follows: 1) Act It Out Strategy, 2) Creating Images or Diagrams, 3) Finding Patterns, 4) Creating Tables, 5) Systematically Paying Attention to All Possibilities, 6) Guess and Check, 7) Reverse Work Strategies, 8) Determining what is known, what to ask, and the information needed, 9) Using Open Sentences, 10) Solving Similar Problems or Easier Problems, 11) Changing Angles of View. Therefore, one of the efforts or strategies to improve students' math problem solving skills is to use representation in learning.

According to Steffe (Budarsini et al. 2018)states that representation is a process of mental development that a person already has, which is revealed and visualized in various mathematical models namely verbal, concrete objects, tables, manipulative models or a combination of all of them. Representation is a component of processes related to students' cognitive development. Vigotsky (Budarsini et al. 2018) reveals that representations built by students at a simple early level can develop more perfectly through cognitive activity during the learning period. Bruner (Suarsana and Pujawan 2019) thinks that any knowledge can be conveyed when presented as simply as possible. Bruner distinguishes the mental model of representation which is palatable, iconic, and symbolic. A good representation, with regard to teaching that emphasizes action or motion. Iconic representations are produced through images and spoken language, and symbolic representations are generated through mathematical models and symbols (Rangkuti 2013). The representation model used in learning is one that covers all representation models according to Bruner's theory of learning.

Representations can basically be expressed as internal and external representations. Thinking about mathematical ideas that are then communicated requires external representations that exist, among others: verbal, images and concrete objects. Thinking about a mathematical idea that allows one's mind to work on the basis of that idea is an internal representation. Representation used to improve the ability of mathematical problem solving is an external representation because in solving problems, to think about mathematical ideas that allow one's mind to work on the idea (internal representation) can not be observed due to activity in the mental (Sabirin 2014).Therefore students need external representation to communicate the idea so that others can know the steps of the student's problem solving solution.

Each student has different abilities. In a class, there are students who have high, medium and low math skills. (Sabirin 2014; Suarsana and Pujawan 2019) stated that representation plays a role in developing and optimizing students' math skills. That shows that representation skills relate to students' math skills. The use of more than one representation in solving a problem is called multi representation. According to (Ainsworth 1999) there are three main functions of multi representation, namely: 1) As a complement in cognitive processes, 2) Helps limit the possibility of other misinterpretations, 3) Build a deeper understanding of concepts. This representation learning will be better if using cooperative settings because by using cooperative settings there will be an active learning atmosphere, and there will be interaction between students and students and between students and teachers. In the process of intercation must be communication (discourse).

Discourseis a discipline that investigates the relationship between the form and function of verbal communication (Renkema 2004). Verbal communication is a form of communication used to convey something to other parties both verbally and in writing, verbal communication includes words spoken or written. One form of verbal communication is discussion presentation. In the process of learning mathematics required the activities of students in communicating learning materials to know how far the understanding of concepts that have been owned by students (Purwasih and Bernad 2018), if students have a good understanding of concepts then directly students will have excellent problem solving skills as well, because the ability to solve mathematical problems is inseparable from the ability to understand concepts. In the learning of discourse activities built not only communicate something in the form of words or languages but also used nonlinguistic symbol systems simultaneously namely technology, objects and tools ((Gee 2004)). According to Kieran, et. al (2001) states that "special mathematical discourses are created due to two main factors, the first due to dependence on the symbolic as a means of communication mediator and the second due to certain rule changes in communicating mathematics". Mathematics learning mostly uses certain symbols and rules so, to know the student's understanding of the symbols and rules of mathematics learned by communicating verbally and in writing through various representations.

DMR or Multi Representation Discourse is one of the student-oriented mathematics learning (Purwasih and Bernad 2018) while (Ardiansyah 2021) suggests DMR is a learning model oriented towards the formation, use and utilization of various representations with class settings and group work. So it can be concluded DMR is a learning model in which consists of a process that affects the learning activities of mathematics where by criticizing mathematical ideas presented in the form of multi representation. In this model, the representation of students is trained by teachers through worksheets or through discussions in

the form of group work. Learning with DMR model is designed with small heterogeneous groups. It is expected that with the formation of small heterogeneous groups there will be interactions in an atmosphere of mutual respect for each other's opinions and sharing with each other and the occurrence of a discourse, and the result of the discourse in the form of various representations as a result of different backgrounds. The mathematical representation model used in learning, in addition to acting as an understanding tool, is also related to one's abilities and readiness. At a higher level, students' ability and readiness to learn mathematics has been at a certain level, students no longer need the help of concrete model presentation, but it can be in the form of other mathematical representations, such as: graphs, symbols, tables or verbal descriptions with their modeling, while the ability of one's mathematical representation, in addition to showing a level of understanding, is also closely related to problem solving skills in mathematics.

A problem that is considered complex and complex, usually becomes simpler, if the strategy and utilization of mathematical representations used according to the problem, so that through this DMR model will help students to perform every step necessary to solve a problem that requires the ability to solve math problems and in accordance with the steps of problem solving, so that it will result in improved ability of student math problems. One of the research studies that supports the application of this model is MujiSusianto in his research entitled "Student Activity Sheet in Multi Representation-Based Fractional Number Material and Its Influence on The Mathematical Reasoning and Communication Skills of Junior High School Students" concluded that there is an improvement in students' mathematical reasoning and communication skills, this is seen from the individual test results of each student. Therefore, with the increasing ability of reasoning and communication students can more easily understand and solve problems, so that the ability to solve math problems students will also improve. It is also expected that the math problem solving skills of students who follow the DMR model are better than those who follow the learning process with conventional learning models.

Based on the description that has been presented above, the researchers are interested to propose further research that can improve students' math problem solving skills entitled "Influence of Multi-Representation Discourse Learning Model (DMR) on Mathematics Problem Solving Skills of Grade X STUDENTS of SMA Negeri 3 Singaraja".

Method

Participants

This type of research is experimental research, in the category of quasi-experimental research, because not all of its variables or symptoms appear strictly regulated and controlled. This research was conducted from March 05, 2018 to April 17, 2018 and was held at SMA Negeri 3 Singaraja. The target or target of this study is the ability to solve math problems in grade X MIPA SMA Negeri 3 Singaraja. The population of this study is students of grade X MIPA SMA Negeri 3 Singaraja consisting of 3 classes, namely X MIPA 1, X MIPA 2 and X MIPA 3.The research sample is determined by random sampling cluster technique.Two classes were randomly taken to be samples i.e. experimental classes and control classes.

Measurement

These research instruments are LKS, RPP, student math problem solving skills tests and other instruments that support learning activities. Data on mathematical problem solving skills are collected math problem solving skills teststhat have been expertly validated and fieldtested with a validity coefficient of 0.84 and a test reliability coefficient of 0.75 which means it falls into the category of high validity and reliability. The material of the post-test question used is trigonometry consisting of 5 questions. The scoring guidelines used in this study are referring to sudiarta (2010) which was modified.

Table 1. Scoring Rubric for Problem Solving Capabilities

Troubleshooting Stages	Score	Scoring Indicators
Understand the problem	3	Write what is known and asked from the question correctly or do not write what is known and asked of the question but write in the sketch of the solution of the question
	2	Write down what is known and asked of the question but one of them is one of them
	1	Write down one of the known or asked questions
Create a troubleshooting plan	3	Write down the problem solving steps correctly and correctly
	2	Write down the steps to solve the problem but there is still something not right
	1	Write down the troubleshooting steps but still be wrong
Resolve issues	4	Write down the problem solving problem systematically and correctly
	2	Write down the problem solving of the problem systematically but still not precisely
	1	Write down problem solving problems unsystematicly and still wrong
Check back	-	Not discord, but measured using a re-examination questionnaire

Data Analysis

The data needed in this study is data on students' math problem solving skills, to determine the influence of the Multi Representation Discourse (DMR) model on students' math problem solving skills, data analysis is conducted using normality test (Kolmogorov Smirnov), homogeneity test (F test). If both assumptions are fulfilled then a hypothesis test is carried out using a t-test of one tail.

Results and Discussion

Results

Based on the results of post-test experimental class students and control classes, obtained average results and percentages per aspect of indicators of students' math problem solving skills are as follows.

Table 02. Results of Aspect Analysis Of Student Post-Test Indicators Problem Solving Ability

Math Troubleshooting Indicators	Experiment Class		Control Class	
	Average	(%)	Average	(%)
Understand the problem.	2, 87	95, 69	2, 82	94, 10
Create a Troubleshooting Plan.	2, 54	84, 51	2, 34	78, 10
Implement a problem solving plan.	2, 47	61, 76	2, 17	54, 14
Check back	Not measured			

It appears that the average analyzed per indicator between the experiment class and the control class indicates that the experiment class has a higher number than the control class. This indicates that the math problem solving skills of experimental classes are better compared to the math problem solving skills of control class students.

Student math problem solving data was obtained through post-tests with the same tests for the experiment group and control group. The post-test results in the experimental group obtained an average score of 39.24

and the average for the control class was 36.80. It appears that the average score achieved by the experiment class is higher than the average score achieved by the control class. The following is a summary of the analysis of student math problem solving scores for the experiment group and the comparison group listed in Table 3 below.

Table 03. Summary of Analysis on Solving Math Problems

variable	Post-Test	
	Experiment Group	Control Group
N	34	35
$\overline{X}$	39, 24	36, 80
S2	24, 18	16, 87
s	4, 92	4, 10

Based on table 3 obtained the average score of math problem solving skills among students who were taught using the DMR model higher than students who were taught using conventional learning, this means that problem solving skills in experimental classes are better than control classes.

The results of the normality test analysis using Kolmogorov Smirnov test obtained the results of the calculation of normality data of mathematical problem solving skills of students in the experimental group valuesDhitung = 0, 111 and Dtabel = 0.233 with a significant level of 5% and n = 34, this means the distribution of data on mathematical problem solving skills of students of the normal distribution experiment group. In the control group obtained Dhitung = 0, 164 and and Dtabel = 0,230 with a significant level of 5% and n = 35, this means the distribution of data on the mathematical problem solving skills of normally distributed control group students.

The results of homogeneity test analysis using F-test obtained Fcalculate = 1, 43 and Ftabel = 1.99 at a level of significance of 5% with dk numerator = 33 and dk denominator = 34. This means there is no variance between the experiment group and the control group (homogeneous data variants).

Based on the results of the normality test and variance homogeneity obtained that the data score the math problem solving ability of students for the experimental group and control group is normally distributed and has a homogeneous variance. Therefore, hypothetical tests can be conducted with a t-test of one tail, obtained thitung = 1, 79 and ttabel = 1.67 at a significant level of 5% with dk = 67. This means that students' math problem solving skills are taught under the Multi Representation Discourse (DMR) model better than students' math problem solving skills taught by conventional learning models.

Discussion

Based on data obtained from the study, the average score of students' math problem solving skills in the experimental class was 39, 24 and the average score of the students' math problem solving skills in the experimental class was 36.80. Testing the research hypothesis using t test obtained thitung = 1, 79 and ttabel = 1, 67 with a significant level of 5% and free derjat (db) = 67 this shows that the math problem solving skills of students who are taught with the multi-representation discourse (DMR) learning model is better than students who are taught conventional learning. The difference in math problem solving skills between the experimental and control classes can be seen from table 2. It appears that the average and percentage of answers between the two classes have a significant difference that the experimental class has an average and a higher percentage on each indicator compared to the control class. This means students' math problem solving skills in experimental grades are better compared to control classes.

This is due to differences in treatment between the experimental class and the control class. Experimental classes during the learning process use the Multi-Representation Discourse (DMR) model, where this model uses various representations in the learning process with group work. This is in line with the statement (Ardiansyah 2021) that DMR is a learning model oriented towards the formation, use and utilization of various representations with class settings and group work. LKS used in this DMR model is a multi-representation LKS such as figure 1. Various representations are poured in the LKS so that students in completing the LKS are required to construct their own knowledge so that it will have an impact on understanding the student's concept, because the student's activities in the DMR learning process instruct their knowledge so that the learning becomes more meaningful, this will have an impact on the memory of the student to be longer, this is in line with the opinion (Hudiono 2005) that meaningful learning is needed so that the knowledge gained by students from the learning process can be attached longer in the

student's memory. From the completion of the LKS, the understanding of the mathematical concepts of experimental grade students will be better, it will have an impact on the ability to solve students' math problems. This is in line with the opinion (Faoziyah and Rohyati 2019) that students who master the concept of mathematics well, will find a way to solve math problems. It is also affirmed by (Budarsini et al. 2018) that the higher the ability to understand concepts possessed by a student, the higher the success rate of solving math problems.

In the learning process that students go through experimental classes in addition to the completion of more constructivist LKS, students are used to working on problems using representations such as image representation to make it easier for students to model the problem and find solutions to the problem, students are also trained to get used to solving non-routine problems that are not usually done by students, students are also accustomed to solving problems by using representation, this is in accordance with the opinion (Ardiansyah 2021) that mathematical representation is indispensable in solving mathematical problems. The purpose of using representation in solving mathematical problems so that there is no misinterpretation in understanding a problem, therefore in the learning process students are accustomed to solving problems given by representing into mathematical models, drawings and mathematical equations used to solve a problem. This is also in line with the opinion (Hudiono 2005) that a problem that is considered complex and complex, can be simpler if the strategy and utilization of mathematical representations used in accordance with the problem.

Another thing that is different is the learning process or the stage of implementation of learning carried out in the experimental classroom. Adapuan stage of implementation of the multi-representation discourse model according to (Ardiansyah 2021) namely In the first stage of preparation, students and teachers open learning by praying together. Teachers arrange seats for students in groups, as well as students sit based on groups that teachers have specified. Each group consists of 3-4 students. After the students sit in their respective places, the students remove the writing equipment.

at phase second that is Introduction, student repeat return knowledge previously and Experience deep life everyday student in order to get become Introduction to student deep receive knowledge new. thing aforementioned get Done with the existence of ask answer between student and teachers, ask answer that Done not only to underlie Knowledge just but student get more Motivated at deep process learning. besides ask answer student also automatically Structured Deliver ideas that owned by him, Arranged each student get Issued the idea ownednyya so that student get more Trained at deep Develop power representation that Owned student deep finish questions Solving problem mathematics that Form question story.

In the third stage of development, students have discussions with groups that have been created before, students are given problem solving questions in the form of story problems by teachers. Here students write down the information contained in the questions provided, or write down the context that has been known and asked based on the question. Students design a plan or steps in answering the question, then the student creates a mathematical model. Each member of the group is expected to participate in determining a plan to resolve the issue. This is necessary for the role of the teacher. Teachers need to monitor the course of discussions so that the discussion can run well. If each group has found a suitable plan to solve the problem, then the student then executes the plan so that the problem solving questions provided by the teacher can be solved the problem. Not to forget the students also re-examined the answer, by re-proving the answer. In solving the problem, students are directed so that the representation power can appear well. Students need to use the power of representation in solving problems, because in order for students to more easily understand and solve problems. Students at the high school level are easier to understand a learning material, if the student uses representation well or at an iconic stage. At the iconic stage students use the images to better understand the concept or material presented by the teacher.

In the fourth stage of application, students make group reports based on discussions that have been conducted in solving math problems provided by the teacher. The report will be presented to get an agreement on the available issues. During the learning process discussion activities not only occur at the implementation stage, but discussion and communicating activities occur during the learning process, this is in accordance with the opinion of Purwasih (2013) multi-representation discourse learning model is a learning centered on students by generating group discussions.

In the fifth phase of the closing, students and teachers together make conclusions on the issues discussed in the learning. After that students conduct evaluations based on the learning that has been done, and students and teachers do reflections.

By stages that Implemented seem difference that Striking with stages Learning Conventional Located at phase Introduction when Activities remember returnat class experiment process remember return not only Just ask answer together teacher but Activities discussion aforementioned Guided teacher with use representation Shiva, besides that the difference seem at phase development student class experiment finish LKS with constructing Knowledge with guidance representation that Presented teacher deep LKS and in deep process Learning student class experiment Presented Problems deep shape Simulation computer, so that mathematics that abstract more easy Understood with see immediately simulation.

In general, the implementation of learning with the Multi Representation Discourse model can run well and according to plan and contribute positively to the ability to solve student math problems. It is also affirmed by Maharani (2015) that (1) overall problem solving skills during teaching and learning activities using problem-based multirepresentation LKS obtain an average percentage of 85% with good criteria and (2) students' response to multirepresentation LKS based on problem solving from the response questionnaire data given to students is divided into six aspects, namely , students' enjoyment of learning has a percentage of 97% with excellent criteria; 90% update of learning components with excellent criteria; students' interest in the learning process by 95% with excellent criteria; ease of subject matter by 97% with excellent criteria; language ease with a percentage of 92% with excellent criteria and students' enjoyment of writing and drawing on multirepresentation LKS based on problem solving by 97% with excellent criteria.

The learning process that is carried out does not escape obstacles. The obstacles faced aresiswa not used to use LKS used in this model and terbennya time on the learning process such as the time provided is still less so rarely done self-test. Despite some constraints in its application, the description above shows that the use of the Multi Representation Discourse (DMR) model in mathematics learning has a positive impact on students' math problem solving skills. It is also supported by the results of hypothetical analysis that shows students' mathematical problem solving skills are taught using the Multi Representation Discourse (DMR) model better than using conventional learning. Therefore, the Multi Representation Discourse (DMR) model can be used as an alternative in the learning process to improve the quality of education mainly in the field of mathematics.

Conclusion

Based on the results of the research and the results of data analysis that has been discussed before, solving the math problems of students who are taught with the multi-representation discourse learning model is better than the problem solving of mathematics students who are taught with conventional learning. Therefore, it can be concluded that the average math problem solving ability of students who are taught with the Multi Representation Discourse learning model is better than the math solving skills of students who are taught with conventional learning. Other interested researchers are advised to test the influence of this model on different aspects of learning, for example on mathematical communication, measuring students' mathematical ability is done by scoring students' ability to provide answers to questions by drawing, making mathematical expressions and writing answers in their own language (written texts). This can be achieved by implementing the Multi Representation Discourse (DMR) model.

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