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Development of Learning Paths on Opportunities Based on Realistic Mathematical Education in Class VIII SMP

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ABSTRACT

The purpose of this research is to design a learning flow for the topic of statistics for class VIII SMP based on Realistic Mathematics Education (RME), implemented through HLT, valid and practical Teacher's Books and Student's Books that can improve students' problem-solving abilities. The method used in this study is to combine the Plomp, research design model with the Gravemeijer & Cobb model, which consists of 3 phases, namely the preliminary research phase (preparing for the experiment), the development phase (development or prototyping phase/design experiment) and the development phase (development or prototyping phase/design experiment). Assessment (retrospective assessment/analysis stage). From this research, the flow of learning statistics topics for class VIII SMP is generated. The resulting learning design also meets practical criteria with the characteristics of helping students understand material concepts and making it easier to develop mathematical problem-solving skills.

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1. INTRODUCTION

An ability that must be possessed and developed in students is the potential to solve mathematical problems. Students' mathematical problem-solving abilities have not met expectations (Surya & Putri, 2017) In addition, Ulandari, Amry, & Saragih, (2019)also said that many mathematical problem-solving abilities are still not as expected. The importance of having mathematical solving skills, when viewed from the achievement results obtained from Indonesia's participation in one of the international assessments, namely PISA (Program for International Student Assessment), can be categorized as low because, from the results of the International Survey Program for International Student Assessment (PISA) in 2012, Indonesia was ranked 64 of the 65 PISA participating countries (OECD, 2012). In 2015, Indonesia was still ranked 63 out of 70 PISA participating countries in the ability to count, read, and science (OECD, 2015).

Ariawan & Nufus, (2017) stated that the potential in solving mathematical problems is the potential for students to think in a directed manner to generate ideas to solve problems. There are potential indicators in solving problems, namely understanding problems, classifying and sorting information, identifying problems, presenting problem formulations in various forms, choosing appropriate approaches and strategies, implementing and developing strategies in solving problems, interpreting the results obtained in solving problems (Widjajanti, 2009).

From the results of interviews with several mathematicians in learning statistics for class VIII, the teacher said that the lesson began by explaining and calculating and distributing data with formulas based on the examples given and then students solved problems based on the examples that had been given. Educators use books provided in the library without doing any design. From observations on textbooks at school, the statistics presented have not helped students construct their knowledge. Statistics are presented based on concepts and exercises that have been given at the meeting. In addition, the exercises provided aim to improve numeracy skills and the use of formulas. This is contrary to the expectation of learning mathematics that students are expected to be able to construct their understanding in their own language, thus making students bored in understanding mathematics learning. Students are not given guidance to construct their knowledge by starting contextual questions or can be imagined by students and making conclusions according to the concept. The way of presentation makes students think less when solving problems.

SMP N 34 Kerinci		SMP N 5 Kerinci	
Class	Students who Pass	Class	Students who Do not Pass
VIII A	54,5 %	VIII A	35,7 %
VIII B	42,4 %	VIII B	41,3 %
VIII C	40,6 %	VIII C	34,5 %
VIII D	51,6 %	VIII D	41,4 %
VIII E	45,1 %	VIII E	44,4 %
VIII F	29,1 %	VIII F	31,1 %
VIII G	30,3 %	VIII G	46,9 %
VIII H	33,3 %	VIII H	50 %

Some of the effects on students' potential to solve mathematical problems above, namely the use of learning resources, is not optimal. Learning resources can be in the form of subject matter. The subject matter is material that contains learning material that is systematically arranged based on its potential, which aims to increase students' knowledge and insight when participating in lesson activities aimed at planning and studying the application of the teaching and learning process (Anggraini, 2022).

In the stages of learning mathematics activities, teachers are required to be able to direct students to understand concepts well, which will affect students' learning achievements to be good. This means that, in learning mathematics, the teacher does not only transfer the mathematics they have to students or is limited to explaining teaching materials based on the curriculum, but must direct and guide students in expressing mathematical ideas based on the exploration of everyday problems. Students who study mathematics should be allowed to express mathematical concepts and ideas (Prananda, 2021). Therefore, students are not passive recipients of learning but need to be allowed to express and construct mathematical ideas under the direction of the educator. Stages of discovery developed based on the exploration of real-world problems.

In response, it is necessary to design a learning design that provides opportunities and guides students to reinvent (reinvent) the ideas learned using students' mathematical problem-solving techniques. Teaching and learning design is a stage that is carried out in analyzing a need or lesson goal that can develop techniques in delivering teaching materials that are useful in achieving the

goals that have been set (Purnomo, 2015). Teaching and learning design is a stage in planning instruments and teaching materials to transfer knowledge between educators and students. The teaching and learning designs components are students and lesson objectives, learning methods, and learning evaluation (Cindy, 2019). Learning design explains the connection between ideas and experiences (Oktafianto et al., 2019). The need to design learning designs that trigger curiosity and critical and creative thinking can build knowledge and solve a problem in the proper stages. In other words, teaching and learning designs are implemented by educators with real applications when teaching practice in the classroom. Learning design is based on Learning Trajectory (Learning Trajectory) with the term Hypothetical Learning Trajectory (HLT). HLT is a series of activities carried out by students based on contextual problems to find learning goals (Wijaya, 2015). The learning stages of the lesson objectives and the learning process, as well as the hypothesis of learning stages that predict students' thoughts and understanding (Fuadiah, 2017). The learning stages provide direction to educators in determining and monitoring learning objectives to be achieved. Research that has been done explains that Hypothetical Learning Trajectory (HLT) can develop students' reasoning (Rezky, 2019).

The learning process design is related to students' potential in thinking and understanding of students that can develop with the stages of learning, which is under a realistic approach to mathematics education. RME is an approach based on human activities, and learning mathematics means working with mathematics (*doing mathematics*) (Sopyan et al., 2019). Based on the observations made, learning in schools uses learning materials that have not been able to support the improvement of students' problem-solving abilities, which can be seen in students who have not been able to solve mathematical problems under the indicators of mathematical problem-solving abilities. With the RME approach, human and mathematical activities can relate to students' real lives and apply applications based on mathematical stages both horizontally and vertically (Armania, 2018). With the RME-based teaching materials, students' mathematical problem-solving abilities are expected to be improved. The design of mathematics lessons based on RME is a lesson design that can increase the contribution to the development of students' problem-solving abilities (Anggraini, 2021). Therefore, the authors argue that the Realistic Mathematics Education (RME) approach has the potential to overcome these problems. According to Sembiring, R.K., Hoogland, K. & Dolk, (2010)by using the RME approach, learning mathematics will be fun and meaningful for students. Then Laurens, (2016)argues that increasing student knowledge by being given lessons using RME is more supportive than using ordinary learning.

2. METHODS

The method applied in his research is combining the Plomp design with the Gravemeijer, K. & Cobb, (2013) divides into 3 phases, 1) preliminary research(*preparing for the experiment)*,2) development (*prototyping phase/design experiment)*, and 3)assessment phase *(retrospective analysis).*The research subjects were eighth-grade students of SMP Negeri 34 Kerinci. In the prototype development phase, a formative evaluation was carried out to investigate the validity and practicality, including self-evaluation, expert review, one-to-one and small group. The analysis method is the collection of quantitative data obtained based on questionnaires and qualitative data obtained based on observations, interviews, and field notes.

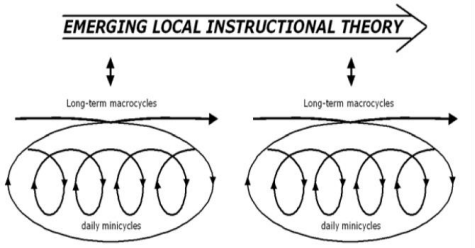

Figure 1. Learning Experiment of Gravemeijer & Cobb.

The preparation stage (preparing for the experiment) explains the field of literature regarding the ideas applied in HLT planning. This flow has a purpose in collecting data and resources needed in designing HLT. The next activity is the preparation of the HLT. HLT is arranged according to dynamic properties to make improvements in the experimental stage.

At the experimental stage (experimenting), the HLT plan was piloted on three students with high, medium, and low abilities. If the HLT is being tested, there will be no revision, and further improvements were tested on 6 students grouped into several groups. It consists of students with high, medium, and low potential. In this stage, the author is a researcher and educator in data collection. 6 students were appointed to experiment in groups. The potential of students varies from high to low. Mathematics education assists with student selection. In addition to focusing on the development of HLT, researchers also observed and analyzed the impact of HLT on potential development in solving student problems during tests.

In the retrospective analysis stage, an evaluation of the HLT developed was carried out so that it could be implemented based on what had been previously planned. The lesson plan planning in the analysis is a reference to the formulation of the existing problems. This process aims to provide support for the development of HLT to support students in studying Statistics lessons. Moreover, the author has a role as a handler in determining the focus of the analysis of his research.

This study aims to describe the characteristics of Realistic Mathematics Education-based learning designs on the topic of valid and practical Statistics and describe the characteristics of Realistic Mathematics Education-based learning designs on the topic of Effective Opportunities in improving students' problem-solving abilities.

3. FINDINGS AND DISCUSSION

The aim of this research is to produce a valid and practical lesson design on Statistics based on Realistic Mathematics Education (RME). This research was conducted through 2 phases: the initial investigation phase (preliminary research/preparing for the experiment) and the development or prototyping phase/design experiment phase.

The learning flow developed is a statistical topic learning flow using the RME principle. The resulting learning flow has a learning sequence that begins with introducing the concepts of mean, mode, median and five series statistics. For students, shipping activities are placed in a concrete and familiar context, namely introducing the mean concept; the problems used as starting points are problems related to the distribution of marbles as the starting point because the mean is a fair distribution. This learning flow can maximize the student's learning process and education because the learning flow is optimally structured. The concept of the mode through the context of students' favourite candy flavours is used as a context when learning mathematics in order to be able to have a positive impact on quality and fun lessons and support students' potential on the topic of mode.

Furthermore, the contextual problem of determining the parent company and the birth order of children are used as the starting point to find the median concept, and this is effective in stimulating students to find the concept of mean as the data that is in the middle after the data is sorted (Abele). The learning flow that was developed fulfils the principles of the RME approach under the validation results from experts. This learning flow refers to the main principles of RME, namely guided reinvention and progressive mathematizing, didactical phenomenology, and self-developed models (Fahrudin, 2018).

The learning flow developed is based on HLT tested for validity. Acquisition in this study illustrates that the learning stages meet very reasonable standards. Based on the validity experiment, it was found that the prototype was in accordance with the validity criteria, although several parts had to be revised. Things that must be revised are writing errors, changes in designed activities, alleged students' thought processes, and anticipation of answers on HLT. The activities designed have not led to the discovery of formal mathematical ideas. In addition, the estimation of the stages of thinking and anticipating students' answers also needs to be described in more detail.For this reason,

a revision is carried out, namely looking at the activities that have been designed in learning activities. This affects the stages of development of the flow and the media applied. This revision cannot be done immediately because it takes time to find and analyze the relevant supporting theory. The results of the product validity experiment illustrate that the research product is valid so that it can be applied and then tested in the following research stage. However, several parts must be revised, such as writing errors, understanding test questions that have not led to mathematical problem-solving abilities and unattractive covers.

The learning flow that experts have validated has been tested in two cycles: cycle 1 in the one-to-one stage and cycle 2 in the small group stage. Based on the trial of the learning flow in the one-to-one stage, in meeting 1, students solve contextual problems in their way but with the help of anticipation from the researcher. Activities at the first meeting of students were directed to understand the concept of the mean through solving the problem of distributing marbles and selling fried bananas fairly. Students are given a problem with the data of marbles then asked to determine the total number of each acquisition. After completing the context, the teacher and students conclude that the mean is the number of data values divided by the data. At meeting 2, students discussed the concept of the mean if the data were added, subtracted, multiplied and divided. This problem stimulates students to find out the change in the mean if each data is added, subtracted and divided.

At meeting 3, students were given a problem regarding the taste of their favourite candy as a starting point to find the concept of the mode, then given the context of the shoe size that students used the most in the class, and students can conclude that the mode is the data that has the highest frequency, the highest bar from the bar chart, the highest peak from the line chart and the largest angle from the pie chart. At meeting 4, students discussed presenting data in the form of diagrams and determining the mode of the pie chart where the percentage value was still empty. This problem directs students to solve problems regarding the mode of data presentation. At meeting 5, students discussed finding the median concept based on the problems given, namely the determination of the parent company's office, then students were given problems related to the birth order of children. The purpose of these two activities on the median concept is to stimulate students to find the median concept by sorting the data first. Furthermore, at meeting 6, students found the concept of five sets of statistics from the problems of students who will participate in competitions in scouting activities. This problem stimulates students to find the concept of five sets of statistics by sorting the data.

In learning that prioritizes RME as the basic foundation, each student is free to use their strategy (utilization of student contributions) in solving problems in each Student Book. This study clearly illustrates how students have various views about their friends' opinions when discussing.

In each HLT unit that will be achieved, students are given an understanding test to understand problems in solving problems accurately. There is an increase in understanding of solving problems accurately for each HLT that will be achieved, although in HLT understanding the median concept has decreased slightly, in HLT there are five statistical concepts series again has increased.

In the small group stage at meeting 1, students complete the context regarding the mean by adding up each data and then dividing it by as many data as possible, and students choose that method because they think it is the easiest way to get an equal share. The second meeting presented ideas in a revised set of information. Overall, students can use the concepts they found in the previous meeting to find a standard formula to calculate the new average of the problem. However, initially, students only tried to do calculations without paying attention to their findings of the formula for the new average if it was replaced, added, subtracted, multiplied and divided. However, through class discussions, students finally found agreement on the standard formula for determining the average of the new data.

The study results at meeting 1 in this small class showed that students were not used to conducting group discussions. At the beginning of the discussion, group members did not participate in the discussion but were busy doing activities that were not related to learning, so the researcher had to reprimand students and ask them to participate in group discussions. In addition, at meeting

1, it was also found that students were still not used to writing down what they knew and asked questions about the problem. When students present the results of their research at meeting 1 in a small class, group 1 completes the incomplete distribution of marbles and is then repaired and completed by group 2. The learning process that occurs at meeting 1 always uses the principles contained in the RME approach in accordance with the teacher's book that has been made.

At meeting 2, the researchers initially wanted to prepare actual candy in learning to help students understand the problems given, but because based on the advice of the mathematics teacher in that way it would be difficult and make a fuss so that the statistical material will be carried out in the month of Ramadan, the researchers only asked students to remember 10 names friends in class and determine the taste of his friend's favourite candy. The teacher gives candy questions to each student so that the problems given feel natural to them. The results of the study at meeting 3 in the class showed that students already understood the concept of mode. They also already know the data in their lives. At the end of the meeting, the educators and students conclude the meaning of the candy-flavoured data and other types of data and tell students that the concept to determine the mode of a student's data must first know the frequency. At meeting 4, both groups presented data into a diagram; both groups used a bar chart, and students could conclude that the mode was the value with the highest bar position on the diagram.

At meeting 5 and 6, the students understood the concept of the median and statistics of the triad. Based on the results of research obtained in class, students have started to write down what is known and ask about the problem. Students seem to have no difficulty solving the problems given in the student book because the problems are presented from the things around the students. When writing conclusions, students agree that the median number is the data that is in the middle after the data is sorted and has a minimum total distance deviation. Next, students use the median concept to find the statistical concept of a triad, which is constructed by students themselves through the problem of participating in a scouting competition. While finding the median concept, some students made a mistake in determining the median; that is, students did not sort the office distance data first. By challenging students with considerations of time, distance and the profits earned by a company, finally, students can find the properties of the median, namely the median has the slightest total deviation.

At the assessment stage, students are given mathematical problem solving questions that aim to determine the level of mathematical problem solving ability, the results of the assessment can be seen in the following table.

No	Nama Peserta Didik	Jumlah Skor				Skor Total	Nilai
		Soal 1	Soal 2	Soal 3	Soal 4		
1	PD 1	10	9	8	9	36	90
2	PD 2	9	6	7	7	29	72.5
3	PD 3	9	8	7	6	30	75
4	PD 4	8	9	9	9	35	87.5
5	PD 5	10	9	8	10	37	92.5
	PD 6	10	9	8	7	34	85

It can be seen that there are 2 students whose scores are below the KKM, namely 72.5 and 75. These students are students with low abilities. The average value of the six students was 84.80. It can be seen that 4 students are above the KKM. According to the effectiveness criteria, the RME-based

mathematics learning design is effective if the number of students reaches 65% of KKM. The number of students who reach the KKM exceeds 65%, namely 4 people.

Thus, it can be concluded that the RME-based statistical learning design can be said to be effective or impact the mathematical problem-solving abilities of VIII grade junior high school students. The following table shows a general description of each indicator's mathematical problem-solving ability test results.

No	Indikator Kemampuan Pemecahan Masalah	Persentase (%)	Kriteria
1.	Memahami Masalah	86,11 %	Sangat Efektif
2.	Menyusun Rencana	91,67 %	Sangat Efektif
3.	Melaksanakan Rencana	78,12 %	Efektif
4.	Menarik Kesimpulan	83,33 %	Sangat Efektif
	Rata-Rata Persentase (%)	84,80 %	Sangat Efektif

It can be seen that the average problem-solving ability test of students after being tested is 83.54%, with a very effective category. The criteria for the problem-solving ability of students on each indicator are 86.67% for the indicator of understanding the problem, 90.00% for the indicator of planning, 74.16% for the indicator of implementing the plan, and 83.33% for concluding. It shows that the questions given can be understood by students and can illustrate that the implementation of the learning flow with the RME approach can instill or assist students in finding statistical concepts. Therefore, it can be said that the learning design developed can be categorized in the effective category.

4. CONCLUSION

Based on the description above, it can be concluded that the teaching and learning design on Statistics based on RME in class VIII SMP/MTs was developed based on the self-evaluation and validation stages with 5 validators, one-to-one evaluation/conducting experiments Cycle 1, small group evaluation/conducting experiments cycle 2 is valid, practical and effective. Valid because the learning design is developed according to scientific and logical knowledge principles. Practical because teaching and learning designs are applied based on predetermined demands and are effective because learning designs positively impact students' problem-solving abilities in class VIII SMP.

From the explanation above, it can be concluded that the design of mathematics lessons on Statistics based on RME is a lesson design that can increase the contribution when developing students' problem-solving abilities. Lessons can be quality because the lessons are carried out with contextual problems. Students who have high abilities can take part in learning activities well, while students who have low abilities cannot participate in learning activities effectively. Students can express ideas about lessons that can be done with learning activities.

From the description above, the researcher suggests improving the results of the field test by using a lesson design designed to test its effectiveness, and other researchers can improve the lesson design of the lesson material. Educators are advised to present lessons regarding contextual problems related to student activities.

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