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CORE RME learning model on improving students' mathematical problem-solving ability

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Abstract. The use of learning models is crucial to consider to facilitate students' mathematical problem-solving ability (MPSA). Therefore, this study was conducted to analyze the comparison of improving MPSA between students who learn through the model of Connecting, Organizing, Reflecting, and Extending with Realistic Mathematics Education (CORE RME), CORE model, and conventional model. Participants of this study consist of three groups of junior high school students, namely students who learned through the model of CORE RME of 50 people, students who learned through the CORE model of 49 people, and students who learned through the conventional model of 46 people. The findings in this study are that there were significant differences in the improvement of students' MPSA who learn through the model of CORE RME, CORE model, and conventional model. Multiple comparison test results show that the development in the MPSA of students who learn through the CORE RME model was better than the students learning through the CORE model. There was no significant difference in the improvement of MPSA between students who learn through the CORE RME model and the conventional model, as well as between students learning through the CORE model and the traditional model.

1. Introduction

Mathematical problem-solving means engaging in mathematical tasks for which the solution method has not been known advance, and to find solutions, students must draw on their knowledge in developing new mathematical understanding [1]. Solving mathematical problems requires problem solver skills in applying new ways, develop a deeper understanding of mathematical ideas, even a get taste experience the experience of being a mathematician [2]. The process of solving mathematical problems strongly emphasizes the activity of managing the thinking process effectively, efficiently, and flexibly [3]. These statements illustrate that solving mathematical problems is an active experience involving cognitive and meta-cognitive strategies because it requires the creation of new strategies to find solutions to those problems.

Solving mathematical problems requires a high-level thinking process, so students will have difficulty if not prepared and facilitated during the process of learning mathematics. Students' difficulties in solving mathematical problems are often revealed through research. Some of those researches revealed that solving mathematical problems is a difficult and complex cognitive activity [4]. Students aged 14-16 years experienced different levels of difficulty in solving mathematical problems and got low results, even though the problems were simple [5]. Students experienced difficulty in solving mathematical problems, which may come from certain factors such as language barrier and lack of

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information and skills in mastering concepts and facts [6]. Many students VII graders at junior high schools in West Timor are still making errors in solving given mathematical problems [7].

Such difficulties experienced by students in solving these mathematical problems should receive serious attention, require diagnosis and reflection on the learning process organized by the teachers. Teachers should create a learning environment enabling students to solve mathematical problems because students' intellectual development is strongly influenced by the social environment in which the learning process takes place, which involves interactions among students and between students and teachers [8]. The Social environment in which the learning process and social interaction among students take place can be observed from the syntax of the learning model used. Therefore, the learning model applied by the teachers should be considered in developing strategies to facilitate students' skills in solving mathematical problems. In other words, the learning model applied by the teacher should be taken into account in developing students' skills in solving math problems [9].

One important consideration in applying a learning model that can develop students' skills in solving math problems is that the learning process should be student-oriented [10]. It means that a teacher should realize that instead of being teacher-centered, a learning process should place more emphasis on students' thinking processes and their active involvement in the learning process. A learning model of connecting, organizing, reflecting, and extending (CORE) is a student-centered learning model [9]. Learning steps of the CORE model consisting of connect, i.e. connecting new and old knowledge, organize, i.e. organizing the information learned, reflect, i.e. rethinking information already obtained, and extend, i.e. expanding knowledge [11].

Connecting emphasizes the process of making connections between old and new knowledge, the relationship of ideas that students already know with new ones. When mathematical ideas or topics are connected to one another or connected to real-world phenomena, students will understand that mathematics as useful, relevant, and integrated. Contextualization and making connections to student experiences is a powerful process in developing mathematical understanding [1]. This statement explicitly explains that students will have a wider understanding of mathematics, and be able to solve mathematical problems if the learning process involving connections with students' experiences and real-world phenomena. In the school mathematics curriculum, realistic mathematics education (RME) is known as a learning process that places the real context and student experience as the learning starting point. The realistic word in RME means 1) a real context in daily life; 2) a formal mathematical context in the world of mathematics; and or (3) an imagery context that is not contained in reality but can be imagined [12].

Research on the influence of the CORE model, as well as realistic mathematics education on students' mathematical problem-solving skills, has been carried out in Indonesia, but implementation was carried out separately. Results of studies using the CORE learning model concluded that learning through the CORE model can improve students' mathematical problem-solving skills [12, 13]. While research using realistic mathematics education concludes that improvement of the mathematical problem-solving ability of students who learn through the RME approach is better than students who learn through the conventional approach [14, 15]. The difference between the above research and this study is in this study the CORE learning model combines with realistic mathematics education which called the CORE RME learning model.

The syntax of the CORE RME learning model is the same as the CORE model syntax [16]. The difference lies in the implementation of each stage, namely applying the principles and characteristics of the RME in the four stages of the CORE model. At the connecting stage, the teacher facilitates students with real contexts, contexts that are in the student environment, and relates to their experiences. Prior knowledge, real context, and interactivity are the main principles of the connecting stage. The next stage is to provide opportunities for students to reinvention and develop mathematical models of the real context provided at the connecting stage. This is an activity at the organizing stage with the main principles being reinvention, self-developed models, and interactivity. At the reflecting stage, students reflect, rethinking, and seeing the relationship of non-formal mathematical models (models of) with formal mathematical models (models for). This reflection stage applies the principles of metacognition, self-monitoring, and interactivity. The extending stage is a step where students expand their knowledge through other real contexts, which applies the principles the develop a formal mathematical model, another real context, intertwining, and interactivity. So, this CORE RME learning model applies the principles and characteristics of the RME into the CORE model, so that the design of this study uses three sample groups to compare the improvement of mathematical problem-solving ability between students who learn through the model of CORE RME, students who learn through the CORE model, as well as students who learn through the conventional model.

2. Method

This study does not re-group the classes that have been formed by the school so this quantitative research uses a quasi-experimental approach. The classes in this study consisted of two experimental groups namely 50 students who learn through the model of CORE RME, and 49 students learning through the CORE model, as well as one control group namely 46 students who learn through the conventional model. These 145 students are grade VII students in two state junior high schools in the Kefamenanu city-Indonesia, 2018/2019 academic year. Data in this study were obtained through a mathematics problem-solving ability (MPSA) test. Students' MPSA tests are arranged based on problem-solving indicators according to Polya namely 1) understand the problem, 2) devising a plan, 3) carry out the plan, and 4) look back [17]. This instrument has been validated and tested on other students to find out the level of validity and reliability before using it. Validator assessment resulted in an average of 91,67; which means these instruments are in a good category and are suitable for use. While the results of the test on other groups of students show that these instruments are reliable and valid, based on the Cronbach alpha value of 0,69; and the Pearson correlation value of 0,73; 0,75; 0,65; and 0,79. Data analysis of this study used a normalized gain test, one-way ANOVA, and post hoc Scheffe test. A normalized gain test is performed to determine the improvement in MPSA of each student. Furthermore, the normalized gain test results are used in the one-way ANOVA test to determine differences in students' MPSA improvement. The post hoc Scheffe test is a further test of the one-way ANOVA. Both the prerequisite test and the hypothesis test in this study were analyzed using IBM SPSS Statistics 22.

3. Result and Discussion

The average pre-test, post-test, and normalized gain of MPSA students who learn through the model of CORE RME, the CORE model, and the conventional model can be seen in Figure 1.

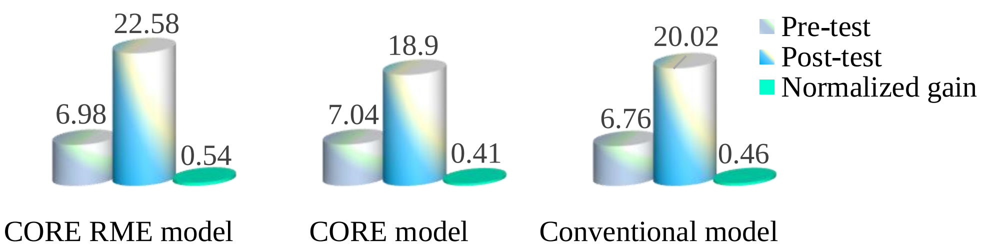

Figure 1. Average of pre-test, post-test, and normalized gain of students' MPSA

Figure 1 shows that the average of gain normalized of students' MPSA who learn through the model of CORE RME was 0.54; students who learn through the CORE model was 0.41, and of students who learn through the conventional model was 0.46. This analysis specifically compares statistically normalized gain in MPSA from three groups of students. The results of the normality test showed that the MPSA improvement data of students who learn through the model of CORE RME, the CORE model, and the conventional model were normally distributed. Homogeneity test results also showed that the data group of students' MPSA improvement is homogeneous.

Data distribution met the parametric statistical test requirements, so the difference in the improvement in MPSA between students who learned through the model of CORE RME, the CORE model, and the conventional model can be analyzed using the one-way ANOVA test, the results of which was presented in Table 1.

Table 1. Test results for differences in students' MPSA improvement

	Sum of squares	df	Mean square	F	Sig.	Ho
Between groups	0,45	2	0,23	6,42	0,00	rejected
Within groups	5,00	142	0,04			
Total	5,46	144				

The output of the one-way ANOVA test in Table 1 shows that Ho is rejected, which means there were significant differences in the improvement of MPSA between students who learn through the model of CORE RME, the CORE model, and the conventional model. Since there was a significant difference in the students' MPSA improvement, Scheffe post hoc test was conducted whose results are presented in Table 2.

Table 2. Post hoc test results for students' MPSA improvement

Learning models		Mean difference	Std. error	Sig.	Ho
(I)	(J)	(I-J)			
CORE RME	CORE	0,13*	0,04	0,00	Rejected
	Conventional	0,09	0,04	0,08	Accepted
CORE	Conventional	-0,04	0,04	0,48	Accepted

Based on the post hoc test in Table 2, it can be concluded that at $\alpha = 5\%$:

1. There was significant difference in the improvement of students' MPSA who learn through the model of CORE RME and students who learn through the CORE model. Descriptively the average normalized gain of MPSA of students who learn through the model of CORE RME is $0{,}54$ and the average normalized gain in MPSA of students who learn through the CORE model is $0{,}41$. Because inferentially there is a significant difference, and $0{,}54 > 0{,}41$ it was concluded that the improvement in MPSA of students who learn through the model of CORE RME was better than the improvement in MPSA of students who learn through the CORE model.
2. There was no significant difference in the improvement in MPSA of students who learn through the model of CORE RME and students who learn through the conventional model.
3. There was no significant difference in the improvement in MPSA of students who learn through the model of CORE and of students who learn through the conventional model.

The improvement of students' MPSA who learn through the model of CORE RME is better those of students who learn through the CORE model since the CORE RME learning model applies RME principles and characteristics. This shows that combining the principles and characteristics of RME into the CORE learning model can improve students' MPSA. The initial step in learning using the model of CORE RME is connecting which prioritizes prior knowledge, real context, and interactivity principle. Learning starts with contextual problems related to students' daily life. The problems given are closely related to students' lives so that they get used to using their experience in solving these problems. The learning process which involves problems that are closely related to students' real-life and environment helps them use prior knowledge in understanding problems and accustomed to solving mathematical problems [15]. The use of real problems in the process of learning mathematics must be cultivated so that students are accustomed to solving mathematical problems in both the school and community contexts. It will bring significant impacts on the extent to which students learn to prepare themselves in solving problems related to their daily life [18].

In the organizing step, students are given the opportunity to interact with each other, discuss and build mathematical models of real-life problems encountered. In such a discussion, students are guided to practice mathematics according to their experiences in building non-formal mathematical models. Then they are guided to develop connections between non-formal mathematical models (model of) and formal mathematical models (model for). This model can fulfill the bridging function between the informal and formal levels by shifting from the "model of" to the "model for". A model developed by these students then becomes a model for more sophisticated mathematical reasoning [19]. Then in the reflecting stage, students are given an opportunity to rethinking on their mathematical processes, identify whether the mathematical model they develop is right or wrong, and immediately correct if there are errors. This is intended to make students understand their mathematical process, to make improvements when there is any mathematical misconception so that the formal mathematical model developed is truly discovered by students, not delivered by the teacher.

Extending is the final stage, which is the stage of expanding knowledge through different and challenging real contexts. This stage also providing opportunities for students to practice mathematics principles, building mathematical models in their own way will foster a sense of responsibility in their efforts to solve the mathematical problems they face. Students themselves experience the same process when mathematics is discovered, finding ideas and concepts mathematical, so they can recognize their own capacity to think deeply as a means to solve problems [20], and each student who uses their own way to solve a problem will be able to improve their problem-solving skills [21].

A series of learning processes through the learning model of CORE RME described above can facilitate students using experience and prior knowledge to solve problems so that the improvement of the students' mathematical problem-solving ability who learn through the model of CORE RME is better than students who learn through the CORE model. Whereas the improvement in mathematical problem-solving ability between students who learn through the model of CORE RME and students who learn through the conventional model does not show significant difference statistically. Nevertheless, descriptively the average normalized gain of the students' mathematical problem-solving ability who learned through the model of CORE RME is higher than those of students who learn through the conventional model.

4. Conclusion

The main principles CORE RME learning model are prior knowledge, real context, guided reinvention, self-developed models, metacognition, self-monitoring, intertwining, and interactivity. Applying principles above in this study obtain the findings that there were significant differences in the improvement of the students' mathematical problem-solving ability who learn through the model of CORE RME, the CORE model, and the conventional model. Multiple comparison test results show that the improvement in the mathematical problem-solving ability of students who learn through the CORE RME model was better than the students learning through the CORE model, and there was no significant difference in the improvement of mathematical problem-solving ability between students who learn through the CORE RME model and students who learn through conventional models, as well as between students learning through the CORE model and students learning through the conventional model.

Solving mathematical problems requires abilities in applying new ways, developing a deeper understanding of mathematical ideas, even feeling the experience of being a mathematician. Therefore, in learning mathematics, it is necessary to consider learning models that can facilitate students to develop their mathematical problem-solving abilities. The CORE RME learning model is one of the solutions offered in the learning process to develop students' mathematical problem-solving abilities.

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