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IMPROVING STUDENTS' MATHEMATIC CONCEPT UNDERSTANDING VIEWED FROM SELF-EFFICACY WITH RME-BASED KRULIK RUDNICK HEURISTIC LEARNING MODEL

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ABSTRAK

A low understanding of mathematical concepts can affect a student's learning process. In overcoming this problem, teachers must pay attention to students' self-efficacy. This quasi-experimental study aimed to determine the effect of the RME-based Krulik-Rudnick Heuristics learning model on understanding mathematical concepts regarding students' self-efficacy. The samples were obtained using the cluster random sampling technique. The data collection technique used was a test of description questions. Hypothesis testing was performed using two-way ANOVA. The research found that Fa was F(0.05;1.45); therefore, H_{0A} was rejected. Furthermore, Fb was lower than F(0.05;2;45), so H_{0B} was accepted, and Fab was lower than F (0.05;2.45), so $H0_{AB}$ was accepted. It can be concluded that there was an effect of the learning model used on understanding mathematical concepts, there was no effect of self-efficacy (high, medium, and low) on mathematical concept understanding, and there was no interaction between learning models and self-efficacy (high, medium and low) on students' mathematical concepts understanding. It is recommended that further researchers apply RME-based Krulik-Rudnick Heuristics to other learning materials.

PENINGKATAN PEMAHAMAN KONSEP MATEMATIS SISWA DITINJAU DARI SELF-EFFICACY DENGAN MODEL PEMBELAJARAN HEURUSTIK KRULIK RUDNICK BERBASIS RME

Kata Kunci:

Pemahaman konsep matematika
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ABSTRACT

Rendahnya pemahaman konsep matematis dapat mempengaruhi proses belajar siswa. Dalam mengatasi masalah pemahaman konsep matematis, pendidik harus memperhatikan *self efficacy* siswa. Penelitian *quasy eksperimen* ini bertujuan untuk mengetahui pengaruh model pembelajaran Heuristik Krulik Rudnick berbasis RME terhadap pemahaman konsep matematis ditinjau dari *self efficacy* siswa. Sampel diperoleh menggunakan teknik *cluster random sampling*. Teknik pengumpulan data yang digunakan yaitu tes berupa soal uraian. Pengujian hipotesis menggunakan ANAVA dua jalur. Diperoleh hasil Fa > F(0,05;1,45) maka $H0_A$ ditolak, kemudian Fb < F(0,05;2;45) maka $H0_B$ diterima, dan Fab < F(0,05;2,45) maka $H0_{AB}$ diterima. Dapat disimpulkan bahwa terdapat pengaruh model pembelajaran yang digunakan terhadap pemahaman konsep matematis, tidak terdapat pengaruh *self efficacy* (tinggi, sedang dan rendah) terhadap pemahaman konsep matematis, dan tidak terdapat interaksi antara model pembelajaran dan *self efficacy* (tinggi, sedang dan rendah) terhadap pemahaman konsep matematis siswa. Disarankan kepada peneliti selanjutnya untuk dapat menerapkan model pembelajaran Heuristik Krulik Rudnick Berbasis RME pada materi pembelajaran lainnya.

1. INTRODUCTION

Education development in a country determines its success; education is important because it is an international standard of action in human life [1]. According to Edgar Dalle, education is the desire of families, communities, and governments to play a role and adapt to various environments in the future through leadership, teaching, and learning both in and out of school [2]. According to Edgar Dalle, the concept of education is consistent with the opinion of the father of Indonesian education, Ki Hajar Dewantara. He defined education as a necessity to gain experience to achieve the best safety and welfare and prepare students for guidance, coaching, or training for their future careers [3]. as a very important component, which is a teacher. The success of the teaching and learning process depends on the teacher's expertise in learning methods, techniques, and tactics. As a result, the teacher, in addition to serving as a model or role model for students and learning managers, plays a critical role in the learning process. The quality and ability of the teacher have a large impact on the success of a learning process. Mathematics as the queen or mother of science denotes that mathematics is a source of knowledge and the mother of all sciences, which is why mathematics is so important to study and further study in today's science education [4]. Mathematics is a subject taught worldwide, from elementary school to university [5]. The term mathematics is derived from the Latin word mathematics, which was derived from the Greek word mathematike, which means "study" [6]. The word derives from the Greek word mathema, which means "knowledge" or "knowledge." Mathematics is one of the scientific disciplines that has played an important role in advancing science and technology as a tool for use in other scientific fields [7].

According to Permendikbud number 58 of 2014, one of the goals of mathematics is to understand mathematical concepts [8]. Understanding mathematical concepts refer to a person's ability to explain the knowledge he has gained to others so that the person understands what is conveyed. A student's ability to understand a mathematical concept is critical in solving mathematical problems at school and in the workplace [9]. Understanding mathematical concepts is a critical aspect of learning mathematics [10].

According to the low TIMSS test study and PISA data findings, Indonesian students' conceptual understanding is still poor when it comes to solving problems involving the application of objects, explaining the relationship of a concept, and selecting specific methods or operations [11]. Meanwhile, based on the preliminary research, the researcher interviewed one of the eighth-grade mathematics teachers at Al-Huda Jati Agung Junior High School. They stated that in the learning process, they still used conventional learning, namely the expository learning model and the short duration of study hours due to the pandemic. Students lack enthusiasm and confidence in expressing their ideas and understanding for fear of being wrong. Mathematics is always regarded as a difficult subject due to the numerous calculations and formulas that must be memorized [12]. As a result, the teacher cannot determine the student's ability to comprehend the concept of the material that has been delivered. The table below shows the preliminary research findings:

Table 1. The Results of Pre-Research on the Eight-Grade Students of SMP Al-Huda Jati Agung

Class	**Criteria of Minimum Mastery**		**Number**
	0 ≤ X <72	**72 ≤ X ≤ 100**	
VIII A	25	0	25
VIII C	24	0	24
VIII D	28	0	28
VIII E	23	0	23
Total	100	0	100
Percentage	100%	0%	

The mathematics concept understanding test results at SMP Al-Huda Jati Agung revealed that 0 of 25 students in class VIII. A fulfilled the criteria of minimum mastery, 0 of 24 students in class VIII.C criteria of minimum mastery, 0 of 28 students in class VIII.D criteria of minimum mastery, and 0 of 23 students in class VIII.E criteria of minimum mastery. Many students could not answer questions based on indicators of mathematical concept understanding. This situation exemplifies students' inability to grasp mathematical concepts. Another reason for students' poor understanding of mathematical concepts was a lack of self-efficacy in dealing with problems during learning activities. The RME-based Krulik-Rudnick Heuristics learning model is one of the learning models that can be used and is predicted to improve the ability to understand mathematical concepts. Krulik and Rudnick define heuristics as a method for students to solve mathematical problems using their discoveries, which includes five stages: read and think, explore and plan, select a strategy, find an answer, search for an answer, and reflect and extend [13].

The RME-based Krulik-Rudnick Heuristics learning model emphasizes student activity to seek and find; all activities carried out by students are directed to seek and find their answers to a question to foster self-confidence, and the goal is to develop the ability to think systematically, logically, and critically as part of the mental process [14]. Learning Krulik Rudnick's Heuristics in mathematics is important because it can lead students to solve non-routine math problems and lead them to reflect and develop answers in other situations. Another advantage gained is assisting students in understanding problems, planning and designing solutions, and exploring solutions in difficult times. Students can use the Krulik-Rudnick Heuristics learning model to solve a mathematical problem individually or in groups. The Krulik-Rudnick Heuristics steps can cause interactions in the classroom, leading to a higher level of mathematical thinking [15].

In Elsa Widya Asri's research, Krulik Rudnick's Heuristic learning model is used in his learning activities because the problems presented are general. Students do not see the relationship between problems and the context of everyday life, so the researchers turn these problems into contextual problems (RME) to make it easier for students to solve the problem [16]. Several studies have been conducted on the effect of the Krulik-Rudnick Heuristic learning model on improving learning outcomes and increasing algebraic thinking skills and reflective thinking processes based on previous research. [1], [13], [16], [17]. However, no previous research has examined the effect of the Krulik-Rudnick Heuristic learning model based on RME on mathematical concept understanding. Based on previous research, the novel aspect of this study is the application of the RME-based Krulik-Rudnick Heuristics to the ability of students to understand mathematical concepts in terms of self-efficacy.

2. METHOD

This research utilizes a quantitative method. The research design was quasi-experimental with a posttest-only control group design with a 2X3 research design. An experimental method studies the effect of certain variables on other variables through trials under specially created conditions. Researchers cannot control environmental conditions that can affect research results in quasi-experimental research, so the research is not pure but rather quasi-experimental [17].

Table 2. Research Design

Learning Model \ Self Efficacy	High (B_1)	Moderate (B_2)	Low (B_3)
RME-based Krulik-Rudnick Heuristics (A_1)	A_1B_1	A_1B_2	A_1B_3
Conventional learning model (A_2)	A_2B_1	A_2B_2	A_2B_3

This study focuses on understanding mathematical concepts in terms of self-efficacy in the subject of Statistics. This study's data collection methods included tests and questionnaires. A test of understanding mathematical concepts in the form of descriptions can be used to assess understanding of mathematical concepts. The test is administered after students have received learning treatment using the RME-based Krulik-Rudnick Heuristics. A self-efficacy questionnaire can be used to assess self-efficacy.

The following are indicators of mathematical concept understanding used in this study: (1) restating a concept's definition, (2) classifying objects based on certain properties based on the concept, (3) giving examples and not examples of concepts, (4) presenting concepts in various forms of mathematical representation, (5) developing necessary or sufficient conditions of a concept, (6) using, utilizing, and selecting certain procedures or operations, and (7) applying concepts or algorithms to problem-solving [17]. In addition, the following indicators are used to assess student self-efficacy: (1) belief in one's abilities, (2) belief in one's ability to adapt and face difficult tasks, (3) belief in one's ability to face obstacles and challenges, (4) belief in one's ability to complete a specific task, and (5) belief in one's ability to complete several different tasks [18].

This study was carried out at SMP Al-Huda Jati Agung during the even semester of the 2021/2022 academic year. The research population consisted of all eight-grade students in the even semesters of SMP Al-Huda Jati Agung, consisting of five classes and 141 students. The sampling technique used in this study was a probability sampling of random cluster sampling. With this sampling method, every member of the population has an equal chance of being drawn as a sample member [19]. In this research, hypotheses were tested using analysis of variance (ANOVA) of two unequal cells as a prerequisite for normality and homogeneity tests.

To clarify self-efficacy, Arikunto suggests a formula [20].

$$SD = \sqrt{\frac{\sum_{i=1}^{n} {X_i}^2}{N} - \left(\frac{\sum_{i=1}^{n} X_i}{N}\right)^2} \quad (1)$$

Description:

SD = Standard deviation

$\sum_{i=1}^{n} {X_i}^2$ = The sum of the squared scores of each student

$(\sum_{i=1}^{n} X_i)^2$ = The number of squared scores of each student squared

N = Total number of students

The following are the self-efficacy scoring criteria:

Table 3. Self-Efficacy Scoring Criteria

Score	Description
X ≥ Mean + SD	High
Mean – SD ≤ X < Mean + SD	Moderate
X < Mean – SD	Low

A Likert scale was used to process questionnaire data. The statements were negative and positive, with the words always, often, sometimes, and never. A table of self-efficacy questionnaire scoring criteria is provided below [21].

Table 4. Questionnaire Scoring Criteria

Answer	Positive Statement	Negative Statement
Always	4	1
Often	3	2
Sometimes	2	3
Never	1	4

$$\text{Final score} = \frac{Obtained\ score}{maximum\ score}\ x\ 100 \qquad (2)$$

The following table shows how to process test result data using scoring criteria based on indicators of mathematical concept understanding [22].

Table 5. The Scoring Criteria for Mathematical Concept Understanding

No	Indicator	Description	Score
1	Restate a concept	a. No Answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4
2	Classify objects according to certain characteristics	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4
3	Give examples and non-examples of the concept	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4
4	Present concepts in various forms of mathematical representation	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4
5	Develop necessary or sufficient conditions for a concept	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4
6	Use, utilize, and choose certain procedures or operations	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4

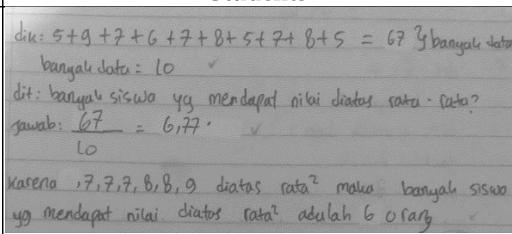
7	Apply problem-solving concepts or algorithms	a. No answer	0
		b. Answering using a method but the answer is still wrong	1
		c. Correct answer but no reason	2
		d. Answering but not all correct	3
		e. Answering with understandable and correct reasons	4

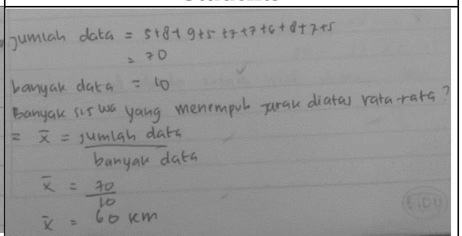
3. RESULT AND DISCUSSION

This research is divided into several stages. The first is Phase I reading and thinking (understanding contextual problems). The teacher divides group worksheets about presenting data to students in groups and directs students to identify problems. Phase II is an exploration and planning phase in which the teacher directs each group to find the necessary information, organizes information, illustrates problem models, and creates pictures or diagrams of a problem [23]. Phase III involves selecting a settlement strategy (solving contextual problems). The teacher directs students to select strategies to find answers, such as making patterns, working backward, simulations/experiments, simplification/expansion, logical deduction, or categorizing problems into simple problems. Phase IV is where the teacher directs students to find answers by predicting or using numeracy skills, algebraic abilities, or geometric abilities. The teacher selects one or two groups to present their work and asks which group is ready. Open a question and answer room for other groups to respond to the results presented in front of the class for other students to observe and compare with the results they have obtained, and students respond to the work of other groups. Phase V reflects and develops (concludes), in which the teacher helps students reflect or evaluate their thinking processes toward solving problems discovered from the beginning of the process of finding answers, directing students to develop answers in other situations based on their conclusions found [24].

Statistics were used in the research. The following is an example of a student's response to question 3, which includes indicators of classifying objects based on certain properties according to the concept.

Table 6. Students' Answer

<table>
<tr><th>Question</th><th>The Answer of the Axperimental Class's Students</th><th>The Answer of Control Class's Students</th></tr>
<tr><td>It is known that the data for the mathematics test scores of 10 students are as follows:
5 9 7 6 7
8 5 7 8 5
Count the number of students who get a score above the average!</td><td>

According to the students' answers above, they answered the questions correctly and calculated them correctly. It can be concluded that experimental class students could classify objects based on certain properties based on their concepts and received a score of 4 on the assessment rubric.</td><td>

According to the students' answers above, they did not answer the questions until the end. The calculations were incorrect. Therefore, they earned a score of 2 on the assessment rubric.</td></tr>
</table>

Based on Table 6, the experimental class's students comprehended and understood better when working on the questions. The mathematical concept understanding test and self-efficacy questionnaire results obtained the highest value (Xmax) and the lowest value (Xmin). The researchers then searched the central tendency of the data that included the mean (X), mode (Mo), and median (Me). Also, the researchers measured the group variance that includes range (J) and standard deviation (S). The results are summarized in Tables 7 and 8.

Table 7. The Data Description of Students' Mathematical Concept Understanding in the Experimental and Control Classes

Classes	X_{maks}	Central Tendency			Group Variance	
		$\bar{x}$	Mo	Me	J	S
Experimental	93	73,250	68	72	36	12,592
Control	82	65,478	54	64	28	8,743

According to Table 7, the maximum score of the experimental class was 93, which was higher than the maximum score of the control class (82). The experimental class's average score was 73.250, which was higher than the control class's average score of 65,478. The score that frequently appeared in the experimental class was 68, while the value that frequently appeared in the control class was 54. The experimental class's median value was 72, which was higher than the control class's median value of 64. The difference between the largest and smallest score in the experimental class was 36, whereas it was 28 in the control class. The experimental class's standard deviation was 12,592, greater than the control class's standard deviation of 8,743.

Table 8. Data Description of Self-Efficacy Questionnaire in the Experimental and Control Classes

Classes	$\bar{x}$	S	Criteria		
			High	Moderate	Low
Experimental	66,893	7,405	2	19	7
Control	72,217	8,686	8	11	4

Table 8 shows that the average score in the experimental class was 66,893, with a standard deviation of 7,405. Two students were in the high self-efficacy group, 19 in the moderate self-efficacy group, and 7 in the low self-efficacy group. The average value in the control group was 72.217, with a standard deviation of 8.686. Eight students were in the high self-efficacy group, 11 in the moderate self-efficacy group, and four in the low self-efficacy group.

The normality test was performed with the Liliefors formula with a significance level of 5% [25]. Table 9 displays the results of the normality test.

Table 9. The Result of the Normality Test

Class	$L_{observed}$	$L_{criticcal}$	Description
Experimental	0,162	0,167	H_o is accepted
Control	0,132	0.185	H_o is accepted
High Self-Efficacy	0,234	0,261	H_o is accepted
Moderate Self-Efficacy	0,128	0,159	H_o is accepted
Low Self-Efficacy	0,161	0,250	H_o is accepted

The normality test in the experimental class yielded $L_{observed}$ of 0,162 and $L_{critical}$ of 0,167, which indicated that $L_{observed}$ was lower than $L_{critical}$. Therefore, the sample was taken from a normally distributed population. The normality test in the control class yielded $L_{observed}$ of 0,132 and $L_{critical}$ of 0,185. Therefore, $L_{observed}$ was lower than $L_{critical}$. Therefore, the sample was taken from a normally distributed population. The normality test of the high self-efficacy yielded $L_{observed}$ of 0,234 with ten samples and L_{tabel} of 0,261. It meant that $L_{observed}$ was lower than $L_{critical}$. Therefore, the sample was taken from a normally distributed population. The normality test of the moderate self-efficacy yielded $L_{observed}$ of 0,128 with 30 samples and $L_{critical}$ of 0,159. It meant that $L_{observed}$ was lower than $L_{critical}$. Therefore, the sample was taken from a normally distributed population. The normality test of the low self-efficacy yielded $L_{observed}$ of 0,161, with 11 samples with $L_{critical}$ of 0,250. It meant that $L_{observed}$ was lower than $L_{critical}$. Therefore, the sample was taken from a normally distributed population. Overall, the whole class's $L_{observed}$ was lower than $L_{critical}$, which indicated that H_0 was accepted and normally distributed.

The homogeneity test was performed with the Barlett test with a significance level of 5% [26]. Table 10 displays the result of the homogeneity test.

Table 10. The Result of the Homogeneity Test

Classes	$\chi^2_{observed}$	$\chi^2_{critical}$	Description
Experimental and control classes	3,084	3,481	H_o is accepted
Self-Efficacy	5,410	5,591	H_o is accepted

Table 9 shows that $\chi^2_{observed}$ (3,084) was lower than $\chi^2_{critical}$ (3,481). Therefore, H_0 was accepted. The results of the calculation of the homogeneity test between self-efficacies obtained $\chi^2_{observed}$ of 5,410 dan $\chi^2_{critical}$ of 5,559. Therefore, H_0 was accepted. The acceptance of the null hypothesis in the test on each group variance demonstrated that the sample was drawn from the same population (homogeneous).

After the data had been collected and normally distributed and homogeneous, the data analysis was carried out to test the hypothesis. The following is the summary of the results of the Two-Way Anava analysis.

Table 11. The Summary of the Two-Way ANOVA Analysis

Sources	JK	dk	RK	$F_{observed}$	Description
HKR-RME (A)	588,075	1	588,075	4,057	H_o is rejected
Self Efficacy (B)	329,157	2	164,578	3,204	H_o is accepted
(AB)	230,430	2	115,215	3,204	H_o is accepted
Error	5483,157	45	121,848		
Total	6630,819	50			

Table 11 shows that the value of F_a (4,826) with a significance level of 0,05 obtained $F_{(0,05;1,45)}$ of 4,057. It means that F_a was higher than $F_{(0,05;1,45)}$. Therefore, H_{0A} was rejected, and it can be concluded that the RME-based Krulik-Rudnick Heuristics influenced students' mathematical concept understanding. Next, an F_b of 1,351 with a significance level of 0,05 obtained an $F_{(0,05;2;45)}$ of 3,204. It means that F_b was lower than $F_{(0,05;2;45)}$. Therefore, H_{0B} was accepted, and it can be concluded that self-efficacy (high, moderate, and low) was no influence on students' concept understanding. Furthermore, F_{ab} of 0,946 with a significance level of 0,05 obtained $F_{(0,05;2;45)}$ of 3,204. It means that F_b was lower than $F_{(0,05;2,45)}$. Therefore, H_{0AB} was accepted, and it can be concluded that there was no interaction between RME-based Krulik-Rudnick Heuristics and self-efficacy (high, moderate, and low) toward students' concept understanding.

Based on the data analysis results, it was discovered that Fa was greater than $F_{critical}$, implying that the RME-based Krulik-Rudnick Heuristics learning model impacts students' understanding of mathematical concepts. The RME-based Krulik-Rudnick Heuristics learning model has the potential to improve students' understanding of mathematical concepts [27]. In this learning model, students were given a problem and then required to solve it through group discussion. They were asked to develop their conceptual understanding of knowledge through real-life learning experiences. During group discussions, the students transferred knowledge and concepts understanding to one another [28]. Students gain an understanding of concepts from other students' explanations in group discussions and can solve the problems given. During the learning process, the group discussion results were presented. Because the students were directly involved when learning, each step of the RME-based Krulik-Rudnick Heuristics in the experimental class made them learn optimally, actively, and enthusiastically. In the control class, the students only received and listened to the material presented by the teacher, which made the learning monotonous and caused the students to feel bored and less active, making it difficult for students to understand the subject matter presented by the teacher. This condition caused a lack of motivation for students to understand concepts, resulting in a low understanding of mathematical concepts [29].

According to the data analysis findings, the RME-based Krulik-Rudnick Heuristics outperformed the learning model commonly used by teachers in the classroom (conventional). According to previous research by Dessy Noor Ariani and Hamdan, the RME-based Krulik-Rudnick Heuristics can improve students' understanding of mathematical concepts [30]. Students taught using the RME-based Krulik-Rudnick Heuristics understand mathematical concepts better than students taught using conventional learning models. The ANOVA test hypothesis analysis results for the experimental and control classes indicate this.

Based on the data analysis results, it was discovered that Fa was smaller than F_{table}, implying that self-efficacy (high, medium, and low) did not affect students' mathematical concepts understanding. This result is consistent with previous research by Safitri Wulandari, who found no effect of self-efficacy (high, medium, or low) on students' mathematical concepts understanding [31]. Furthermore, Masnia's research found no effect of self-efficacy (high, medium, or low) on students' mathematical concepts understanding [32]. There is also Sri Hastuti Noer's research, which shows that self-efficacy (high, medium, and low) does not affect students' mathematical concepts understanding [33].

According to the data analysis results, Fa was lower than $F_{critical}$, implying no interaction between the RME-based Krulik-Rudnick Heuristics and self-efficacy (high, medium, and low) in students' mathematical concepts understanding. The lack of interaction between RME-based Krulik-Rudnick Heuristics and self-efficacy (high, medium, and low) on students' mathematical concepts understanding indicated that the two independent variables had their effects and were unrelated. It is suggested that future researchers apply the RME-based Krulik-Rudnick Heuristics to other types of learning materials.

4. CONCLUSION

Based on the findings of data analysis and hypothesis testing on research data, it is possible to conclude that the RME-based Krulik-Rudnick Heuristics learning model affects students' mathematical concepts understanding. There is no effect of self-efficacy (high, medium, and low) on students' mathematical concepts understanding, and there is no interaction between RME-based Krulik-Rudnick Heuristics and students' mathematical concepts understanding.

Based on the study's findings and conclusions, the researchers recommend several suggestions, including that schools should pay more attention to each student's self-efficacy and that educators should use the RME-based Krulik-Rudnick Heuristics. To ensure that the learning process is carried out properly, educators must be able to manage time effectively. It is expected that future researchers will add measured abilities, such as numerical abilities, or replace self-efficacy with other driving factors, such as cognitive style.

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