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The Influence of RMT-Based Learning on Concept Understanding Ability, Spatial Reasoning and Self Regulated Learning of Junior High School Students

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Abstract

This study aims to describe the influence of the RMT-based learning on students' concept understanding ability, spatial reasoning, and self-regulated learning, as well as to describe the superiority of the RMT-based learning over the scientific learning in terms of the average ability of concept understanding, spatial reasoning, and self-regulated learning. This is a quasi-experimental study with the subjects of students in class VII.3 as the experimental class and VII.4 as the control class in one of the State Junior High Schools in Moro, Karimun Regency, Riau Islands in the 2023/2024 school year. The instruments used were tests and non-tests. The validity evidence was based on expert judgment while the reliability estimation was calculated using Cronbach's alpha coefficient. To see the influence of RMT-based learning on students' concept understanding ability, spatial reasoning, and self-regulated learning, Hotelling T^2 test was used. Meanwhile, to see which learning is superior in terms of the average of each variable, the Independent Sampe T-test was used. The results of the study at the 5% significance level showed that there is an influence of RMT-based learning on the ability of concept understanding, spatial reasoning, and self-regulated learning of students and RMT-based learning is superior to the scientific learning in terms of the average ability of understanding the concept of spatial reasoning, and self-regulated learning of students.

Keywords: *RMT-based Learning; Concept Understanding; Spatial Reasoning; Self Regulated Learning*

Introduction

Mathematics is a subject that must be taught both at the elementary and secondary school levels up to college. This is the basis that mathematics is a very important subject (Rahmadani et al., 2023). Therefore, in the learning process, a good interaction between teachers and students, students and students with learning materials is needes (Supyati et al., 2023). In order to establish good interaction between teachers and students in the process of delivering material, good communication is needed by the teacher to students, so that students understand the material conveyed by the teacher and no concept errors occur. The communication in question is language. The language used by a teacher in the process of delivering material must be adjusted to the level of intelligence and cognitive level of students, but not forgetting the role of the teacher as a facilitator. But in fact in the field, there has not been much good interaction between teachers and students, students and students, and students with learning materials. It is said that not much interaction occurs because teachers tend to still apply teacher-centered learning and most of the lesson time is used by students to hear and record explanations from the teacher (Anggraini et al., 2023). This happens because this teacher-centered learning is commonly used by teachers in daily learning. It is also considered easy to apply to all learning materials.

The National Council of Teachers of Mathematics said there are two standards for school mathematics, namely content standards and process standards (Council of Teachers of Mathematics, 2000). The content standards contain materials taught in schools, one of which is geometry. Geometry is one of the areas in mathematics that is considered the most difficult to understand due to the weak absorption of students in geometry material (Nur'aini et al., 2017). Furthermore, the difficulties faced by students in geometry materials are usually in terms of a lack of understanding of the concept so that students do not understand the meaning of the problems given (Hasan, 2020). The geometry discusses spatial objects from the abstract process of concrete objects in real life (Novita et al., 2018). Learning geometry in order to have a good understanding also requires a high level of thinking. Students must be able to visualize images well because geometry has complex elements (Ratna Yunita et al., 2019). This states that the process of reasoning students in the spatial is very important. From the above explanation, it can be seen that concept understanding and spatial reasoning skills are needed in learning geometry.

Concept understanding is the ability that students have in explaining, translating, interpreting or concluding a mathematical concept based on their own understanding not just memorizing (Mutohar, 2016). Concept understanding ability is very important for students to have, without having this ability students cannot apply the steps, concepts or processes of the material they get (Arifah & Saefudin, 2017). If students understand the concept, it will be easier for them to understand the next concept (Makur et al., 2019; Samo, 2017). Although the ability to understand concepts is said to be important in learning mathematics, it is still found that many students' concept understanding skills are low. Students' concept understanding in solving mathematical problems is categorized as low as 73% of students (Mayasari & Habeahan, 2021). Students said that they understood the material and example problems given by the teacher, but when given problems that were slightly different from the example problems given, students began to be confused to work on these problems. The factor for this happening is because there are still many students who only memorize and remember something given by their teacher (Brinus et al., 2019). Another factor that affects this is learning that is still teacher-centered during classroom learning.

In order to understand the concept, the ability that students must have in learning geometry is spatial reasoning (Nurjanah et al., 2020). Spatial reasoning is the ability that students have in correctly perceiving the visual-spatial world to change their perceptions (Pujawan et al., 2020). This ability is very important, because a large part of what underlies thinking about spatial geometry is spatial reasoning, which is the ability to see, observe, and reflect on spatial objects, images, relationships, and transformations (Arifni et al., 2019). But in reality, students still have low spatial reasoning skills. Students are completely unable to obtain visual images in their minds and do not know how to solve the given problems (Leni et al., 2021). Students have difficulty constructing three-dimensional shapes in solving geometry problems (Xie et al., 2020). The factor for this is because this geometry material contains several kinds of image abstractions that are not easy to understand and understand for students without guidance, direction and mediation from teachers or adults (Darmawan et al., 2020). Therefore, students need guidance to develop spatial reasoning skills.

Understanding the concept is very important because by understanding the concept, the student will more easily understand the next concept. Likewise, spatial reasoning is effective for training students' imagination skills. However, to understand the two abilities it is also necessary internal factors that need to be instilled to students in learning geometry, one of which is self-regulated learning (Seufert, 2018). Self-regulated learning or SRL is an active process where students set their own goals, use learning strategies to plan, monitor, regulate, and assess in various aspects including metacognitive, motivation, and behavior to achieve their goals (Lim & Yeo, 2021). Learning should train students to act independently and actively in their learning activities (Tur et al., 2022). It aims to create student-centered learning activities so as to encourage students to achieve their goals and students are accustomed to sharing knowledge and communicating their learning difficulties (Winarti et al., 2022). But the facts in the field, there are still many students who have low SRL. Students' SRL is still low due to lack of understanding of pre-requisite material (Gustiani et al., 2021). Students do not understand the previous material, students do not understand the relationship between one material and another so that when they change to another material, the old material is forgotten.

Based on the problems above, basically a good learning process is needed to develop students' SRL and can support students' concept understanding and spatial reasoning abilities. The best learning can be done by students when students can actively construct their own opinions. For so-called learning to occur, students must activate their prior knowledge structures or schemas and check the new knowledge they acquire by recalling their prior knowledge or beliefs. A learning that mediates students to understand the culture and encourages students to develop psychological tools so that good schema formation occurs is learning with the Rigorous Mathematical Thinking (RMT)-based learning. RMT-based learning is a mathematical thinking activity that involves the use of several cognitive functions and mental operations that are owned so that it can be used as a basis for knowing the extent of cognitive owned by students (Kinard, 2007). There are two theories supporting RMT, namely Feuerstein's Mediated Learning Experience (MLE) theory and Vygotsky's Socio-cultural theory. MLE is the mediation process done by teachers to students during learning (D. Hidayat et al., 2017). The principle of mediation is categorized into three, namely: intentionality and reciprocity, transcendence and meaning. The Socio-cultural theory of Vygotsky which reveals that the use of psychological tools in learning can help students in organizing and integrating cognitive functions with basic concepts that can support students' mathematical generalization and abstraction. Psychological tools can be symbolic artifacts (signs, symbols, scripts, formulas, graphs, etc).

The results of previous research show that students who learn with the RMT learning have good conceptual understanding (Asria & Wahyudin, 2019). Relevant to the results of previous research, students taught with the RMT learning have better conceptual understanding than students taught with conventional methods (Nugraheni et al., 2018). Furthermore, based on the results of previous research that the application of the RMT learning can improve students' spatial thinking ability (M. Hidayat, 2022). Similarly, the results of previous studies mention the ability of conceptual understanding and self-regulated learning of students who get RMT learning better than students who get conventional learning (Purnawan, 2017). So the solution offered in this study by using the RMT-based learning in the learning process is expected to be more meaningful and guided and can support students' concept understanding and spatial reasoning abilities and self-regulated learning.

Method

This is a quasi-experimental study. The study used two groups, namely the experimental class and the control class. The experimental class is a class that is given math learning with the RMT-based learning. While the control class is a class that is not given special treatment. In its learning, the control class uses scientific learning. The design used in this study is pretest-posttest nonequivalent control group design used to obtain data on concept understanding, spatial reasoning and students' self-regulated learning score data. Researchers applied pretest and posttest to the experimental class group and control class group. The pretest was conducted before treatment was given to the experimental and control classes. Posttests were conducted in both classes after being given different learning between experimental and control classes. The population in this study were seventh grade students of one of the public junior high schools in Moro, Karimun Regency, Riau Islands in the 2023/2024 school year. The sample in this study used cluster random sampling technique. The results obtained in class VII.3 as the experimental class, namely the treatment of mathematics learning with the RMT-based learning and class VII.4 as the control class, namely mathematics learning with a scientific learning.

Data Collection Techniques and Instruments

Data collection techniques in this study used test and non-test instruments. This study aims to determine the influence of the RMT-based learning on the ability to understand concepts, spatial reasoning and self-regulated learning of students so that the test instrument in this study consists of a test in the form of 3 pretest and posttest description questions of concept understanding and spatial reasoning. And non-test instruments in the form of self-regulated learning questionnaires (before and after treatment) consisting of 25 positive and negative statements. The indicators to measure concept understanding ability, namely: restating concepts based on whether or not the requirements in stating the concept are met, applying concepts to solve mathematical problems, and determining examples and non-examples of a concept. Furthermore, indicators of spatial reasoning ability, namely: mental rotation, spatial orientation, and spatial visualization. As for the aspects of self-regulated learning, namely: metacognition, motivation, and behavior.

Validity and Realiability

Providing evidence of the validity of the instrument used includes content validity. Content validity is obtained through rational analysis of the content of the instrument and the analysis is based on expert judgment. In this study consisted of two expert lecturers in Mathematics Education from Yogyakarta State University. Based on the results of expert 1 and expert 2 assessments, the concept understanding and spatial reasoning test instruments and self-regulated learning questionnaires are valid and suitable for use with revisions and ready to be tested on students. Furthermore, researchers conducted a reading test on 6 students who had different abilities, namely high, medium, and low. This reading test aims to test whether the instrument made can be read, clear, easy to understand and does not cause double meaning for every student who reads it. Based on the results of the reading test on these students, it was found that according to the students the instruments given were clear and legible to them and could be understood the meaning of each sentence. The estimated time given for students to work on questions and questionnaires is not enough, so it is necessary to increase the time. Overall, it can be concluded that the concept understanding and spatial reasoning test instruments and the self-regulated learning questionnaire can be used. Reliability estimation of concept understanding ability test, spatial reasoning test and self-regulated learning questionnaire is calculated using Cronbach's Alpha Coefficient. The results of the calculation of the estimated reliability of the instruments in the study are in Table 1 below.

Table 1. Reliability Estimation

Instruments		**Realiability Estimation**	**Decision**
Pretest	Concept Understanding	0.681	Reliable
	Spatial Reasoning	0.720	Reliable
Posttest	Concept Understanding	0.796	Reliable
	Spatial Reasoning	0.667	Reliable
Self-regulated Learning		0.727	Reliable

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Data Analysis Techniques

The data obtained in the study were analyzed using descriptive statistics and inferential statistics. The descriptive analysis presented consists of the average, standard deviation, minimum score, maximum score, lowest value and highest value of the pretest, postest, and questionnaire results before and after being given treatment in the experimental class and control class. In inferential analysis before conducting hypothesis testing, the initial step is first carried out an assumption test consisting of a multivariate normality test and a univariate normality test, then a covariance matrix homogeneity test and a variance homogeneity test. Hypothesis testing to see the influence of RMT-based learning on students' concept understanding ability, spatial reasoning, and self-regulated learning used Hotelling T^2 test. Meanwhile, to see which learning is superior to each variable of concept understanding, spatial reasoning, and self-regulated learning using independent sample t test.

Results and Discussion

Descriptive Analysis Results

1. Concept Understanding Ability Test

Data on concept understanding ability was obtained from the pretest and posttest results of concept understanding ability in the experimental class given learning with the RMT-based learning and the control class given learning with the scientific learning. In summary, the data of the test results of concept understanding ability obtained from both classes can be seen in Table 2 below.

Table 2. Concept Understanding Test Results

	RMT-Based Learning		**Scientific Learning**	
	Pretest	Posttest	Pretest	Posttest
Average	19.6	73.08	16.19	62.50
Standard Deviation	15.94	16.44	12.84	18.60
Mininum Score	0	0	0	0
Maximum Score	100	100	100	100
Lowest Score	0	50	0	50
Highest Score	60	100	40	100

In Table 2 above, it can be seen that the application of both learning can improve students' concept understanding ability on flat-sided space building material. In the experimental class (RMT-based learning) the increase can be seen from the average value of 19.6 to 73.08 while the control class (scientific learning) the average value is 16.19 to 62.50. Concept understanding ability in experimental class students given the RMT-based learning is better than control class students given the scientific learning. This can be seen from the average which shows that the final results or after treatment of the class with the RMT-based learning to concept understanding ability are higher than the class with the scientific learning.

2. Spatial Reasoning Ability Test

Spatial reasoning ability data obtained from the pretest and posttest results of spatial reasoning ability in the experimental class given learning with the RMT-based learning and the control class given learning with the scientific learning. In summary, the data of spatial reasoning ability test results obtained from both classes can be seen in Table 3 below.

Table 3. Spatial Reasoning Test Results

	RMT-Based Learning		**Scientific Learning**	
	Pretest	Posttest	Pretest	Posttest
Average	36.4	74.62	37.14	66.00
Standard Deviation	20.59	13.63	20.28	13.53
Mininum Score	0	0	0	0
Maximum Score	100	100	100	100
Lowest Score	0	50	0	50
Highest Score	80	100	70	80

In Table 3 above, it can be seen that the application of the two learning can improve students' spatial reasoning ability on flat-sided space building material. In the experimental class (RMT-based learning) the increase can be seen from the average value of 36.4 to 74.62 while the control class (scientific learning) the average value is 37.14 to 66.00. Spatial reasoning ability in experimental class students given the RMT-based learning is better than control class students given the scientific learning. This can be seen from the average which shows that the final results or after treatment of the class with the RMT-based learning to spatial reasoning ability are higher than the class with the scientific learning.

3. Self Regulated Learning Questionnaire

Self-regulated learning questionnaire data were obtained from the results of pre-treatment and post-treatment in classes with RMT-based learning and classes with scientific learning. In summary, the results of self-regulated learning questionnaire in both classes can be seen in Table 4.

Table 4. Self Regulated Learning Questionnaire Results

	RMT-Based Learning		**Scientific Learning**	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Average	76.88	85.54	70.38	77.20
Standard Deviation	9.96	10.06	11.67	9.92
Mininum Score	25	25	25	25
Maximum Score	125	125	125	125
Lowest Score	61	68	57	62
Highest Score	107	116	98	98

In Table 4 above, it can be seen that the two learning that have been implemented are able to improve students' self-regulated learning. This is supported by an increase in the average of each aspect and the overall average of self-regulated learning. In the experimental class (RMT-based learning) the increase can be seen from the average value of 76.88 to 85.54 while the control class (scientific learning) the average value is 70.38 to 77.20. It is also seen that the self-regulated learning of students who are given learning geometry with RMT-based learning is better than students who are given learning geometry with a scientific learning.

Assumption Test

1. Multivariate Normality Test

The hypothesis in the multivariate normality test is a follows:

$\boldsymbol{H_0}$: Data comes from a normally distributed population

$\boldsymbol{H_1}$: Data comes from a population that is not normally distributed

The normality test was conducted multivariately on the data of concept understanding ability scores, spatial reasoning and self-regulated learning before and after treatment in experimental and control classes by making a scatter plot between the squared distance (mahalanobis distance) and chi-square. If the chi-square tends to form a straight line and about 50% of the mahalanobis distance value is less than or equal to the chi square, then it is $\boldsymbol{H_0}$ accepted and it can be concluded that the data on the value of concept understanding ability, spatial reasoning, and self-regulated learning are normally distributed. Furthermore, it will be seen from the correlation coefficient on the data. If the correlation coefficient > r table or significance value < 0.05 then there is a significant correlation. The results of the multivariate normality test (Mahalanobis distance) of the two classes before and after treatment are presented in Table 5 below.

Table 5. Multivariate Normality Test Results

	Class	Correlation Coefficient	Sig	Decision
Pre-treatment	Experiment	0.953	0.000	Normal
	Control	0.987	0.000	Normal
Post-treatment	Experiment	0.968	0.000	Normal
	Control	0.983	0.000	Normal

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

From Table 5, it can be seen that in the experimental class before being given the treatment, the scatter plot results show that the graph tends to form a straight line and the correlation coefficient is 0.953 and the significance value is 0.000 < 0.05, so there is a significant correlation. It can be concluded that the pretest data on concept understanding ability, spatial reasoning, and self-regulated learning in the experimental class are normally distributed. In the control class before being given the treatment, the scatter plot results show that the graph tends to form a straight line and the correlation coefficient is 0.987 and the significance value is 0.000 < 0.05, so there is a significant correlation. It can be concluded that the pretest data of concept understanding ability, spatial reasoning, and self-regulated learning in the control class are normally distributed.

Meanwhile, in Table 5 it can be seen that in the experimental class after being given the treatment, the scatter plot results show that the graph tends to form a straight line and the correlation coefficient is 0.968 and the significance value is 0.000 < 0.05, so there is a significant correlation. It can be concluded that the posttest data on concept understanding ability, spatial reasoning, and self-regulated learning in the experimental class are normally distributed. In the control class after being given the treatment, the scatter plot results show that the graph tends to form a straight line and the correlation coefficient is 0.983 and the significance value is 0.000 < 0.05, so there is a significant correlation. It can be concluded that the posttest data on concept understanding ability, spatial reasoning, and self-regulated learning in the control class are normally distributed.

2. Univariate Normality Test

The hypothesis in the univariate normality test is as follows:

H_0 : Data comes from a normally distributed population

H_1 : Data comes from a population that is not normally distributed

Univariate normality test was conducted on the data of concept understanding, spatial reasoning and self-regulated learning scores before and after treatment in experimental and control classes. The univariate normality test was conducted to determine whether the data values on each variable before and after were normally distributed. In this test using Shapiro Wilk by looking at the significance value obtained greater than 0.05, it can be concluded that the data values of concept understanding, spatial reasoning and self-regulated learning are normally distributed. The results of the univariate normality test (Shapiro Wilk) of the two classes before and after treatment are presented in Table 6 below.

Table 6. Univariate Normality Test Results

	Class	Variables	Sig	Decision
Pre-treatment	Experiment	Concept Understanding	0.308	Normal
		Spatial Reasoning	0.239	Normal
		Self-regulated Learning	0.740	Normal
	Control	Concept Understanding	0.183	Normal

		Spatial Reasoning	0.155	Normal
		Self-regulated Learning	0.617	Normal
		Concept Understanding	0.711	Normal
Post-treatment	Experiment	Spatial Reasoning	0.606	Normal
		Self-regulated Learning	0.118	Normal
		Concept Understanding	0.971	Normal
	Control	Spatial Reasoning	0.455	Normal
		Self-regulated Learning	0.433	Normal

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Based on Table 6 above, it is obtained that the significance value of Shapiro Wilk on the pre-treatment value data of each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes (experimental and control) before being given treatment is more than 0.05 so it can be concluded that the pre-treatment value data of concept understanding, spatial reasoning and self-regulated learning are normally distributed. Meanwhile, the post-treatment value data for each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes (experimental and control) after treatment is more than 0.05 so it can be concluded that the post-treatment value data of concept understanding, spatial reasoning and self-regulated learning are normally distributed.

Homogenity Test

1. Homogenity Test of Covariance Matrix

The hypothesis for the covariance matrix homogenity test is as follows:

$H_0 : \Sigma_1 = \Sigma_2 = \ldots = \Sigma_k$

$\boldsymbol{H_1}$: At least one $\Sigma_i \neq \Sigma_j$ for $\boldsymbol{i \neq j}$

Multivariate homogenity test on data values of concept understanding, spatial reasoning, and self-regulated learning before and after treatment in experimental and control classes. This multivariate homogenity test was conducted to determine whether the data on the values of concept understanding, spatial reasoning, and self-regulated learning before and after treatment in both classes were homogeneous or not. In this test using Box's M test by looking if the significance value is more than 0.05, it can be concluded that the covariance matrix of the two classes is homogeneous. The results of the multivariate homogenity test (Box's M) of the two classes before and after treatment are presented in Table 7 below.

Table 7. Covariance Matrix Homogenity Test Results

	Box's M	**Sig**	**Decision**
Pre-treatment	7.527	0.325	Homogeneous
Post-treatment	3.616	0.765	Homogeneous

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Table 7 shows that the significance value for the homogenity test of the covariance matrix pre-treatment is 0.325 > 0.05, so it can be concluded that the covariance matrix of the two classes is homogeneous. While in the data post-treatment the significance value is 0.765 > 0.05, it can be concluded that the covariance matrix of the two classes is homogeneous.

2. Variance Homogenity Test

The hypothesis in the variance homogenity test is as follows:

$$H_0 : \sigma^2_{1\_pk} = \sigma^2_{2\_pk}$$

$$H_1 : \sigma^2_{1\_pk} \neq \sigma^2_{2\_pk}$$

Univariate homogenity test was conducted on pre-treatment and post-treatment data of concept understanding and spatial reasoning as well as questionnaires before and after self-regulated learning of experimental and control classes. The univariate homogenity test was conducted to determine whether the value data on each variable before and after the two classes were homogeneous or not. In this test using the Levene test with the criteria if the significance value is more than 0.05, it can be concluded that the variance in the data value of concept understanding ability, spatial reasoning and self-regulated learning of students in both classes is homogeneous. The results of the variance homogenity test (Levene test) of the two classes before and after treatment are presented in Table 8 below.

Table 8. Variance Homogenity Test Results

	Variables	Levene Statistic	Sig	Decision
	Concept Understanding	0.118	0.733	Homogeneous
Pre-treatment	Spatial Reasoning	1.358	0.250	Homogeneous
	Self-regulated Learning	0.043	0.837	Homogeneous
	Concept Understanding	0.297	0.589	Homogeneous
Post-treatment	Spatial Reasoning	1.115	0.297	Homogeneous
	Self-regulated Learning	0.009	0.925	Homogeneous

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Based on Table 8 above, it is obtained that the results of the variance homogenity test on the pre-treatment value data of each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes (experimental and control) before being given treatment with a significance value of more than 0.05 so it can be concluded that the pre-treatment value data of each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes are homogeneous. While in the post-treatment value data for each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes (experimental and control) after being given treatment with a significance value of more than 0.05 so it can be concluded that the post-treatment value data for each variable of concept understanding ability, spatial reasoning and self-regulated learning in both classes are homogeneous.

Inferential Analysis Results

1. Hotteling's T^2 Test

The hypothesis pre-treatment in this study is as follows:

$$H_0 : \mu_1 = \mu_2 \text{ or } \begin{pmatrix} \mu_{11} \\ \mu_{12} \\ \mu_{13} \end{pmatrix} = \begin{pmatrix} \mu_{21} \\ \mu_{22} \\ \mu_{23} \end{pmatrix}$$

$$H_1 : \mu_1 = \mu_2 \text{ or } \begin{pmatrix} \mu_{11} \\ \mu_{12} \\ \mu_{13} \end{pmatrix} = \begin{pmatrix} \mu_{21} \\ \mu_{22} \\ \mu_{23} \end{pmatrix}$$

Then the hypothesis after being given treatment in this study, which is as follows:

$$H_0 : \mu_1{}' = \mu_2{}' \text{ or } \begin{pmatrix} \mu_{11}{}' \\ \mu_{12}{}' \\ \mu_{13}{}' \end{pmatrix} = \begin{pmatrix} \mu_{21}{}' \\ \mu_{22}{}' \\ \mu_{23}{}' \end{pmatrix}$$

$$H_1 : \mu_1{}' \neq \mu_2{}' \text{ or } \begin{pmatrix} \mu_{11}{}' \\ \mu_{12}{}' \\ \mu_{13}{}' \end{pmatrix} \neq \begin{pmatrix} \mu_{21}{}' \\ \mu_{22}{}' \\ \mu_{23}{}' \end{pmatrix}$$

The score data pre-treatment on concept understanding ability, spatial reasoning, and self-regulated learning is to determine whether the experimental class and control class have the same initial ability. Furthermore, the purpose of the multivariate test of score data post-treatment on the ability to understand concepts, spatial reasoning, and self-regulated learning is to determine whether there is an influence of the RMT-based learning on the ability to understand concepts, spatial reasoning, and self-regulated learning of students. The calculation of the multivariate test of pre-treatment and post-treatment data was carried out with the help of IBM SPSS Statistics 26 by looking at Hotelling's T^2 test statistics. Hotelling's T^2 test results can be seen in Table 9 below.

Table 9. Hotelling T^2 Test Results

	T^2	**F**	**p-value**
Pre-treatment	0.133	1.865	0.150
Post-treatment	0.207	2.893	0.046

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Based on Table 9, it can be seen that the p-value on the pre-treatment value data is 0.150 more than 0.05. This means that there is no difference in the average pre-treatment scores of the experimental and control classes, so it can be concluded that the students' abilities in both classes are relatively the same. Then it can also be seen that the p-value on the post-treatment value data is 0.046 less than 0.05. This shows that there is a difference in the average post-treatment value data of the experimental and control classes, so that H_0 rejected, then there is an influence of the RMT-based learning on the ability to understand concepts, spatial reasoning and self-regulated learning of students.

2. Independent Sample T-test

The hypothesis of the concept understanding ability test in this study is as follows:

$$H_0 : \mu_{PA} \leq \mu_{PB}$$

$$H_1 : \mu_{PA} > \mu_{PB}$$

The hypothesis of the spatial reasoning ability test in this study is as follows:

$$H_0 : \mu_{PX} \leq \mu_{PY}$$

$$H_1 : \mu_{PX} > \mu_{PY}$$

The hypothesis of the self-regulated learning questionnaire in this study is as follows:

$$H_0 : \mu_{PM} \leq \mu_{PN}$$

$$H_1 : \mu_{PM} > \mu_{PN}$$

The data used for univariate hypothesis testing are post-treatment scores of concept understanding ability, spatial reasoning, and self-regulated learning. The results of the independent sample t-test on the post-treatment scores of concept understanding ability, spatial reasoning, and self-regulated learning can be seen in Table 10 below.

Table 10. Independent Sample T-test Results

	t	**df**	**p-value**
Concept Understanding	2.043	44	0.047
Spatial Reasoning	2.131	44	0.039
Self-regulated Learning	2.802	44	0.008

Source: IBM SPSS Statistics 26 Output Data (processed by researchers)

Based on Table 10 on the data of concept understanding ability scores, it can be seen that the p-value is 0.047 less than 0.05, so it is concluded that the RMT-based learning is superior to the scientific learning in terms of students' average concept understanding ability. $\boldsymbol{H_0}$ rejected so it can be concluded that the RMT-based learning is superior to the scientific learning in terms of the average students' concept understanding ability. In the data on the value of spatial reasoning ability, it can be seen that the p-value is 0.039 less than 0.05 so it is $\boldsymbol{H_0}$ rejected so it can be concluded that the RMT-based learning is superior to the scientific learning in terms of the average spatial reasoning ability of students. Then on the self-regulated learning data, it can be seen that the p-value is 0.008 less than 0.05, so it is $\boldsymbol{H_0}$ rejected so it can be concluded that the RMT-based learning is superior to the scientific learning in terms of the average self-regulated learning.

Conclusion

Based on the results and discussion, the conclusions in this study are as follows:

1. RMT-based learning influence the ability of concept understanding, spatial reasoning, and self-regulated learning of students.

2. RMT-based learning is superior to the scientific learning in terms of the average ability of concept understanding, spatial reasoning, and self-regulated learning of students.

Teachers can apply the RMT-based learning as an alternative learning that can develop the ability to understand concepts, spatial reasoning, and self-regulated learning, especially geometry material, namely flat-side spaces. Suggestions for future researchers who will examine similar learning with the RMT-based learning can be combined with the use of media or interesting learning technology to make students more motivated in learning.

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