The Role of Interactive e-Modules Based on Realistic Mathematics Education to Improve Mathematical Representation Ability

Dewi Annisa[1*)], Cut Khairunnisak[2], Dwi Fadhiliani[3], Tuti Zubaidah[4]
[1,2,3,4]Universitas Syiah Kuala
[*)]dewiannisa@usk.ac.id

Abstract
Excellent mathematical representation ability is needed by students to develop and deepen understanding and relationships between mathematical concepts. Therefore, the teacher has the responsibility to create learning that encourages mathematical representation ability. The existence of interactive e-modules with a realistic mathematic education approach makes it easy for students to learn interactively and adapt to different students' mathematical abilities. This study aims to determine the improvement of mathematical representation ability from the use of interactive e-modules with realistic mathematics education approach. This research is a quantitative research conducted on seventh grade students of SMPN 18 Banda Aceh which is divided into experimental and control classes. The data analysis technique used was analysis of variance (ANOVA) followed by t-test. The results showed that students' mathematical representation ability in the experimental class was better than the control class. The interaction between the use of E-modules and students' initial mathematical ability on mathematical representation ability showed that the use of E-modules and early mathematical ability together had a significant effect on improving mathematical representation ability. Students who have high early math ability have a great influence if given treatment in the form of using RME-based e-modules. Students with low early mathematical ability did not experience significant improvement. Interactive e-modules with the RME approach can be used to improve mathematical representation skills by considering students' early mathematical abilities.
Keywords: early mathematical ability, interactive e-module, mathematical representation ability, realistic mathematics education.

Introduction

Mathematics is one of the subjects that has an important role in developing critical, logical and analytical thinking skills. However, the reality shows that many students have difficulty in understanding mathematical concepts, especially in terms of mathematical representation. Mathematical representation is the ability of students to interpret, express and communicate mathematical ideas in various forms such as symbolic, graphical, numerical and verbal (Mainali 2020). This ability is very important because it helps students solve problems, understand concepts and connect various mathematical concepts.

Based on the results of Jumri and Murdiana, (2022), it was found that students' mathematical representation skills were still relatively low. Many students have difficulty in visualizing abstract mathematical concepts into different forms of representation. One of the causes is the learning approach that still focuses on explaining theory and practicing problems without providing sufficient space for students to develop their representation skills.

According to Putra et al, (2023) representation skills can be improved through various approaches, strategies, technological media innovations, strategies, instruments and learning activities. One approach that is believed to be effective in improving students' mathematical representation skills is Realistic Mathematics Education (RME). The RME approach emphasizes the use of real contexts or everyday situations as the starting point in learning mathematics. Through this context, students are invited to discover and develop mathematical concepts independently. In today's digital era, the RME approach combined with technological media such as interactive e-modules is expected to be a solution so that students are more actively involved in the learning process and more easily understand and represent mathematical concepts (Yilmaz 2019).

Interactive e-modules are electronic-based teaching materials that are interactively designed, attractive and easy to use so as to increase student motivation and interest in learning (Delita, Berutu, and Nofrion 2022). The use of interactive e-modules is an alternative in improving the quality of learning. Interactive e-modules have the advantage of providing more dynamic and interactive visualizations so that they can help students build better mathematical representations. E-modules can be designed with interesting software-assisted features such as canva, liveworksheet, quizizz, googleform and heyzine, so that they can attract students to study material with e-modules. Interactive e-modules allow active student involvement in the learning process such as trying out and exploring to understand mathematical concepts more deeply. In addition, e-modules can also provide various types of mathematical representations such as images, graphs, symbols or tables.

In the e-module, there are learning tools such as LKPD and learning trajectories based on the RME approach, where the combination of the RME approach and digitization of learning tools is expected to motivate students to learn because there is a connection in everyday life and the RME approach encourages students' ability to improve their ability to represent problems in a real context in order to understand concepts thoroughly.

The e-module used in this study is specifically designed to improve mathematical representation ability on visual, verbal and symbolic indicators which are the main focus of this study. This research completes the gap in previous research that has not examined mathematical representation skills in the context of digital-based RME. As in the research of Sriyanti et al. (2024) and Sholihah & Isnarto (2023) who used learning videos to improve mathematical representation skills, but did not use the RME context. The technology media used also did not specifically direct to each representation indicator.

This research is expected to show that the use of interactive e-modules with the RME approach is significantly more effective in improving students' mathematical representation skills compared to conventional learning. In addition, the results of the research are also expected to contribute to the development of technology-based teaching materials that are more interactive and contextual in learning mathematics.

Method

The research design used was Pretest-Post-Test Control Group Design which is included in the quantitative research type of True Experimental Designs. Sample was taken by cluster random sampling so that two experimental classes and two control classes were selected. The experimental and control groups were given a pretest to measure students' initial abilities, then the experimental group was given treatment in the form of learning using interactive e-modules based on RME while the control group used conventional learning. After the treatment was completed, both groups were given a posttest to measure the improvement of mathematical representation ability. Data collection used the test method, while the instrument used, namely the mathematical representation ability test sheet in the form of description questions prepared based on indicators of mathematical representation ability. The data analysis technique used in this research is a two-way analysis of variance (ANOVA) to see the difference in mathematical representation ability between students who are given learning with interactive e-modules based on realistic mathematics education and students who are given conventional learning models. The use of ANOVA can also be used to determine whether there is an interaction between interactive e-modules based on Realistic Mathematics Education and students' initial abilities on mathematical representation skills. Further test used independent sample t test to see the difference of each group of students with high and low initial math ability in experimental and control groups.

Results and Discussion

The data used for analysis were pretest and posttest data of mathematical representation ability as well as data on students' initial mathematics ability in the experimental and control groups. Data were obtained from four classes, namely two classes for the experimental group and two classes for the control group. The following is the data on the average value of mathematical representation ability in each group.

Table 1. Average Score of Mathematical Representation Ability in Each Group

Early Mathematical Ability (B)	**Learning Model (A)**	
	E-Modul Based on RME (A_1)	**Konvensional (A_2)**
High (B_1)	80	68
Low (B_2)	70	61

Table 1, shows the average score of mathematical representation ability in groups of students with high and low initial mathematical ability in experimental and control classes. From the results obtained, normality and homogeneity were tested in each group as a prerequisite for hypothesis testing with two-way Anava and further testing with an independent sample t-test. After the prerequisite test is obtained, the data is normally distributed and homogeneous, then the two-way Anava test is carried out and the results are obtained below. The following are the results of normality and homogeneity tests in each group.

1. Normality Test of Pretest and Posttest in Experimental and Control Classes

Table 2. Normality Test of Pretest and Posttest in Experimental and Control Classes

One-Sample Kolmogorov-Smirnov Test

	pre_experiment	pre_control	post_experiment	post_control
N	56	56	56	56
Test Statistic	.103	.104	.111	.106
Asymp. Sig. (2-tailed)	.200[c]	.200[c]	.082[c]	.181[c]

The calculation results obtained Sig value =.200, .200, .082 and .181. Its means that Sig.>α =0.05, it can be concluded that H_0 is accepted. This indicates that the data values of each group come from a normally distributed population.

2. Normality Test of Pretest and Posttest of Each Group Based on Treatment and Students' Initial Mathematics Ability

Table 3. Normality Test of Pretest and Posttest in Each Group

One-Sample Kolmogorov-Smirnov Test

	Pre_ A_1 B_1	pre_ A_1 B_2	pre_ A_2 B_1	pre_ A_2B_2	post_ A_1 B_1	post_ A_1 B_2	post_ A_2 B_1	post_ A_2B_2
N	30	26	32	24	30	26	32	24
Test Statistic	.156	.123	.121	.125	.121	.154	.150	.158
Asymp. Sig. (2-tailed)	.060[c]	.200[c,d]	.200[c,d]	.200[c,d]	.200[c,d]	.113[c]	.065[c]	.127[c]

Based on the calculation results, each student group has Sig.>α =0.05, then H_0 is accepted. This indicates that the data comes from a normally distributed population.

3. Homogeneity Test of Pretest and Posttest in Experimental and Control Classes

Table 4. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
3.583	1	110	.061
2.879	1	110	.088

The results of the calculation of the two groups can be seen in the table above. Based on the calculation results obtained Sig> α =0.05, then H_0 is accepted. This indicates that the two groups are homogeneous.

4. Homogeneity Test of Pretest and Posttest in Each Group

Table 5. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
3.952	1	30	.056
4.067	1	30	.053

Based on the results of the calculation of students' mathematical representation ability scores in each group, namely groups A_1 B_1, A_1 B_2, A_2 B_1 and A_2 B_2 obtained Sig> α = 0.05 then H_0 is accepted. This indicates that the four groups are homogeneous.

Based on the prerequisite analysis test, namely the normality test and homogeneity test that has been carried out. It can be concluded that the research data is normally distributed and homogeneous, after obtaining that the data is normally distributed and homogeneous, the prerequisite test has been met and henceforth hypothesis testing can be carried out using a two-way analysis of variance (ANOVA) test followed by a further test using the t-test if there is an interaction between the learning model and initial mathematics ability.

Table 6 shows the results of the two-way anova test of the effect of the use of e-modules on mathematical representation skills and the interaction of the use of e-modules with initial math skills.

1. Differences in Mathematical Representation Ability Scores in Experimental and Control Groups

Table 6. The Table of Two-Way ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.947[a]	3	5.649	3.580	.016
Intercept	.415	1	.415	.263	.609
Metode	6.970	1	6.970	4.417	.038
KAM	1.233	1	1.233	.781	.379
Metode * KAM	6.879	1	6.879	4.359	.039

Based on the results of two-way ANOVA, it shows that the use of RME-based E-modules obtained a Sig value = 0.038 <0.05, so the conclusion is that H_0 is rejected, which means that there is a significant difference in improving students' mathematical representation skills in the experimental and control groups. The results showed that overall there was an average difference in mathematical representation ability between students in the experimental and control classes.

2. Interaction between the Use of E-Module and Students' Initial Mathematics Ability on Mathematical Representation Ability

Based on the table 6, the significance value of the interaction between the Use of E-Modules and Initial Ability is 0.039 <0.05, then H_0 is rejected. This means that there is a significant interaction between the use of E-modules and students' initial mathematics ability on mathematical representation ability.

The use of E-modules and initial math skills together have a significant effect on improving mathematical representation ability. This shows that mathematical representation ability is influenced by students' initial mathematical ability and the treatment given. The interaction between the use of E-modules and initial math ability on mathematical representation ability is presented in the figure 1.

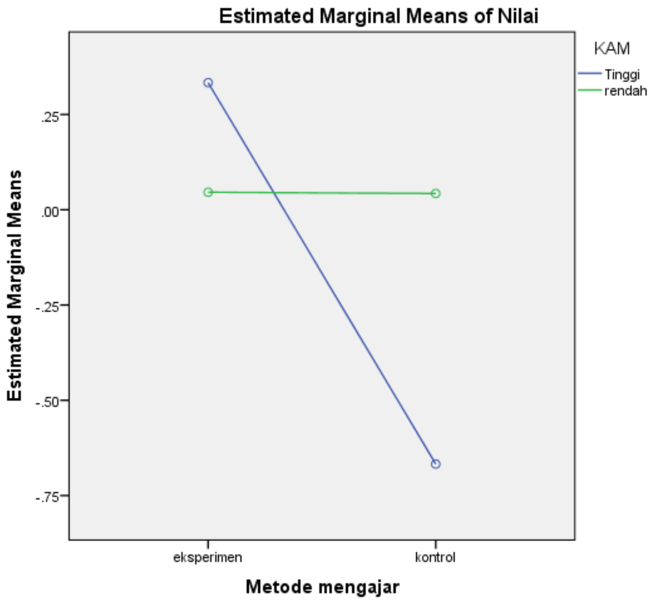

Figure 1. Interaction between the Use of E-Module and Initial Mathematical Ability on Mathematical Representation Ability

Based on Figure 1, it shows that the use of RME-based e-modules is appropriate for students with high initial mathematical ability. This condition can be seen from the average score of students' mathematical representation ability in the experimental class is higher than the control class for students with high initial mathematical ability. Students with low initial mathematical ability have an average score of mathematical representation ability that is not much different, both in the experimental and control classes. It can be concluded that students who come from high initial mathematical ability groups have a great influence if given treatment in the form of using RME-based e-modules. Students with high initial mathematical ability get optimal benefits from RME-based e-modules. Students with high initial ability are able to understand concepts more deeply and utilize the interactive features of e-modules to strengthen mathematical representation. Students with low initial mathematical ability did not experience significant improvement. The use of e-modules helps students to better understand the concepts, but students with low initial ability need additional support such as more intensive guidance.

3. Mathematical Representation Ability in the group of Students with High Initial Mathematical Ability

Table 7 shows the results of the t-test of differences in mathematical representation ability of students with high initial mathematical ability.

Table 7. T-test Results of Differences in Mathematical Representation Ability for Students with High Early Mathematical Ability

Independent Samples Test										
		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
High group score	Equal variances assumed	4.197	.195	2.421	60	.019	1.00102	.41343	.17403	1.82801
	Equal variances not assumed			2.491	35.623	.018	1.00102	.40183	.18577	1.81626

Based on the calculation results, it can be seen that the significant value between the improvement of mathematical representation ability of students who have high initial mathematical ability is 0.019 <0.05 at the 5% significance level, then H_0 is rejected. This means that the mathematical representation ability of students in the experimental class is higher than students in the control class for students who have high initial mathematical ability.

4. Mathematical Representation Ability in the group of Students with Low Initial Mathematical Ability

Table 8 shows the results of the t-test of differences in mathematical representation ability of students with low initial mathematical ability.

Table 8. T-test Results of Differences in Mathematical Representation Ability for Students with Low Early Mathematical Ability

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Low group score	Equal variances assumed	.749	.391	.024	48	.981	.00327	.13932	-.27684	.28339
	Equal variances not assumed			.024	46.263	.981	.00327	.13777	-.27401	.28056

Based on the calculation results, it can be seen that the significant value between the increase in mathematical representation ability of students who have low initial mathematical ability is Sig. 0.981> 0.05 at a significance level of 5%, so H_0 is accepted. This means that in students with low initial mathematical ability, there is no difference in mathematical representation ability between students in the experimental class and students in the control class.

Discussion of Research Results

1. Differences in Mathematical Representation Ability Scores in the Experimental and Control Groups

The results of data analysis based on statistical hypothesis testing have shown that there are significant differences between the mathematical representation abilities of students in the experimental and control classes. The mathematical representation abilities in the experimental class whose learning uses interactive e-modules with the RME approach are better than those in the control class using conventional learning. The use of RME-based e-modules has a significant influence on students' mathematical representation abilities because these e-modules are designed to emphasize the relationship between mathematical concepts and real situations that are relevant to students. RME-based e-modules facilitate students to visualize and represent problems in various forms such as visual, symbolic and mathematical expressions. The features in the e-module facilitate students to be able to access materials and repeat learning as needed. Through exploration and visualization activities, students can understand concepts more deeply so that they are able to represent mathematical ideas. A study conducted by (Lady, Utomo, and Chikita 2018) showed that the RME approach was effective in improving students' mathematical representation skills, as evidenced by increased performance in contextual problem solving. Another study conducted by (Astuti, Armanto, and Hasratuddin 2024) showed that RME-based interactive learning media significantly improved students' mathematical representation abilities. The utilization of RME-based e-modules can have a significant impact on the understanding of mathematical concepts, especially the ability to interpret various forms of mathematical representations. RME-based e-modules can create contextual and interactive learning experiences for students and are technology-based learning that is appropriate for 21st century learning needs.

2. Interaction between the Use of E-Modules and Students' Initial Mathematical Ability towards Mathematical Representation Ability

Based on the results of data analysis, it shows that there is an interaction between the use of e-modules and initial mathematical abilities towards mathematical representation abilities. This means that the use of e-modules and initial mathematical abilities together have a significant influence on mathematical representation abilities. The interaction proves that each learning has a different influence on mathematical representation abilities when applied to groups of students with high and low initial mathematical abilities.

This finding shows that the use of RME-based e-modules is appropriate to be applied as an alternative to mathematics learning in improving the mathematical representation abilities of students who have high initial mathematical abilities, while students with low initial mathematical abilities are more appropriate to use conventional learning models or when using e-modules, students with low initial mathematical abilities need additional support such as more intensive guidance. Adjustments according to the level of initial ability of each student are important to ensure that students get maximum benefit from using the e-module. By knowing each student's initial mathematical ability, it can be an important basis for designing appropriate and effective learning strategies to improve students' mathematical representation skills.

This happens because RME-based e-modules are more suitable for students with high initial abilities because the use of e-modules requires independent exploration skills, while students with low initial mathematical abilities require a learning approach that has intensive guidance (Fachrunisa, Kuncoro, and Arigiyati 2022). In addition, students who have high initial mathematical abilities have better conceptual understanding abilities so that they are able to connect new material in the e-module with concepts that have been mastered, making it easier for students to produce meaningful representations. Students with low initial mathematical abilities find it more difficult to connect new material with previous concepts, which hinders students in building mathematical representation skills (Warsito, Darhim, and Herman 2018).

3. Mathematical Representation Ability in the Group of Students with High Initial Mathematical Ability

Based on the results of data analysis, it shows that there is a significant difference for students with high initial mathematical ability whose learning uses RME-based e-modules. The results of data analysis also show that students with high initial mathematical ability whose learning uses RME-based e-modules have higher mathematical representation abilities compared to students in the control class. This can be interpreted that students with high initial mathematical ability get greater benefits in improving their mathematical representation abilities if their learning uses RME-based interactive e-modules. The use of e-modules is more suitable for students with high initial mathematical ability because the use of e-modules requires independent learning, exploration abilities in understanding contextual problems and formulating them in the form of mathematical representations (Novitasari 2016). In addition, interactive features in e-modules such as representing visual, symbolic and mathematical expressions are more optimally used by students who are accustomed to thinking independently because these students are better able to utilize interactive e-modules to understand concepts and improve their representation skills (Kurniawan, Sukestiyarno, and Hidayah 2023). Teachers' understanding of students' initial mathematical abilities, both those with high and low abilities, can be a reference for teachers in determining appropriate methods and media so that learning is maximized in helping students develop mathematical representation ability.

4. Mathematical Representation Ability in the Group of Students with Low Initial Mathematical Ability

Based on the results of the analysis, there was no significant difference in mathematical representation ability between students with low initial mathematical abilities whose learning used RME-based or conventional e-modules. The calculation results did not show any difference between groups of students with low initial mathematical abilities in the experimental and control classes. RME-based e-modules are designed for students to explore independently and can be difficult for students who have low initial mathematical abilities and have not mastered the basic concepts needed to understand the material (Husniah and Azka 2022). In addition, students with low initial mathematical abilities tend to have more difficulty in connecting various forms of mathematical representation. As a result, students need conventional learning and intensive guidance from teachers rather than independent exploration through e-modules. With these findings, it becomes a reference for teachers to be able to adjust the material or media used according to the potential and abilities of students.

Conclusion and Suggestion

Based on the results and discussion of the research that has been described, the following conclusions can be obtained. This conclusion was obtained based on the research objectives which wanted to see the difference in mathematical representation ability between the experimental and control groups in terms of high and low initial mathematical abilities. In addition, it also wants to see if there is an interaction between interactive e-module based on Realistic Mathematics Education and students' initial ability on mathematical representation ability:

1. The mathematical representation ability of students who are given learning with interactive e-modules based on realistic mathematics education is higher than students who are given conventional learning.
2. There is an interaction between interactive e-modules based on Realistic Mathematics Education and students' initial abilities towards mathematical representation abilities.
3. In students with high initial abilities, the mathematical representation ability of students who are given learning with interactive e-modules based on realistic mathematics education is higher than students who are given conventional learning.

4. In students with low initial abilities, there is no significant difference in mathematical representation abilities between students who are given learning with interactive e-modules based on realistic mathematics education and conventional.

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