Infinity Journal of Mathematics Education
Volume 14, No. 1, 2025
p-ISSN 2089-6867
e–ISSN 2460-9285
https://doi.org/10.22460/infinity.v14i1.p45-64

Realistic mathematics education: Mathematics e-modules in improving student learning outcomes

Anderson Leonardo Palinussa[1*], Pieter Zakarias Tupamahu[1], Vederico Pitsalitz Sabandar[1], Yulian Hanny Makaruku[1], Jozua Sabandar[2]

[1]Department of Mathematics Education, Universitas Pattimura, Ambon, Indonesia
[2]Department of Mathematics Education, Institut Keguruan dan Ilmu Pendidikan Siliwangi, West Java, Indonesia
[*]Correspondence: palinussaandersonl@gmail.com

Received: May 12, 2024 | **Revised**: Jul 27, 2024 | **Accepted**: Aug 2, 2024 | **Published Online**: Aug 25, 2024

Abstract

Realistic Mathematics Education (RME) has gradually influenced the development of mathematics learning worldwide, including in Indonesia. Through the implementation and development of online-based 21st-century education, RME is increasingly proving itself as an effective approach to improving the quality of mathematics teaching and student learning. Learning using the RME approach based on the e-module System aims to become a real learning experience for education and students in implementing mathematical concepts into web-based software systems. The type of research used is pseudo-experimental research with a population in this study of 3 schools, and the number of samples is 147 students. Hypothesis testing was carried out with the N-gain test on the experimental class and control class and the Linear Regression Analysis Test to determine the effect of Gender on improving the learning outcomes of the experimental class. The results of this study show that: 1) There is a difference in the improvement of learning outcomes of classes taught with the RME approach based on the e-module System with conventional learning models; 2) There is no significant difference in the improvement of learning outcomes of students taught using the RME approach based on the E-Module System based on gender characteristics; 3) Gender only contributes 0.1% to the improvement of learning outcomes while 99.9% of other factors.

Keywords:
E-module, Gender, Realistic mathematics education

How to Cite:
Palinussa, A. L., Tupamahu, P. Z., Sabandar, V. P., Makaruku, Y. H., & Sabandar, J. (2025). Realistic mathematics education: Mathematics e-modules in improving student learning outcomes. *Infinity Journal*, *14*(1), 45-64. https://doi.org/10.22460/infinity.v14i1.p45-64

1. INTRODUCTION

The development of science and information and communication technology in the era of society 5.0 (super intelligent city), which is increasingly advanced and rapid, has encouraged a paradigm shift in the way humans think to be able to adapt and develop appropriately by utilizing the available technology (Calp & Bütüner, 2022; Kamid et al., 2021). The development of technology, which is increasingly advanced and rapid, has become a reference for humans to make various kinds of equipment to assist in multiple activities (Beer & Mulder, 2020). These problems prove that the development of Information and Communication Technology in the 21st century has positively influenced multiple sectors of the world, including education (Kumar et al., 2019). In dealing with the problems and impacts of ICT advances in the field of education, it is necessary to shift the pattern of face-to-face learning toward more open education by using technology-based learning media so that the information provided will be more effective, targeted, and valuable (Stoian et al., 2022). The utilization of technology in the learning process also needs to pay attention to the national standard curriculum of education developed and determined by the government. The current curriculum refers to the learning process that is no longer educator-centered but learner-centered (Tang, 2023). The competencies possessed by educators are expected to be able to guide students to achieve learning objectives, besides educators must also utilize online content and be innovative in presenting learning activities and designing exciting and interactive learning models or approaches by using technology so that quality education can be achieved in responding to challenges in the era of society 5.0 (Lin et al., 2020; Saptono, 2022).

Realistic Mathematics Education (RME) is a learning approach that places learners' reality and authentic experiences in everyday life as the starting point of learning and makes mathematics a learner activity (Laurens et al., 2018). The Realistic Mathematical Education (RME) approach has several advantages: making mathematics learning more meaningful, less formal, not too relevant, and more interesting (Bosica et al., 2021; Fauzan et al., 2024; Sutarni et al., 2024). RME is a form of classroom learning designed based on reality and the environment around students with the aim that students can find out things or mathematical concepts in a natural context that have not previously been learned (Lady et al., 2018; Palinussa, 2020). RME places the reality and experiences of learners as the starting point of learning, with mathematical concepts or formal mathematical knowledge emerging from these realistic problems (Dewantara et al., 2023; Diponegoro et al., 2024; Van Zanten & Van den Heuvel-Panhuizen, 2021). RME can be applied to learning using cooperative learning models and mathematics learning that utilize electronics or learning media to help solve mathematical problems and motivate students to connect concepts with everyday life (Palinussa et al., 2021).

Learning using the Realistic Mathematics Education (RME) approach based on the E-Module system is designed using technology development as a web-based software system that implements mathematical concepts in everyday life (Lestari et al., 2023). The E-Module system is a digital module that can be used on computers and smartphones (Fahmi et al., 2022; Hidayat & Aripin, 2023; Pertiwi et al., 2021). Using the E-Module System in learning can facilitate student learning activities to achieve learning objectives. The E-

Module system is based on a complete and systematic learning program designed for an independent learning system (El-Sabagh, 2021). The E-Module System contains teaching modules, teaching materials, student worksheets, and evaluations. Therefore, the material covered in the module is more focused and measurable and is more concerned with learning activities. All of its presentations are conveyed through communicative and easy-to-understand language. Learning using the E-Module System can make students more active and understanding, and students can study in the E-Module System at any time or learn independently.

Figure 1 displays RME learning tools uploaded to the E-Module System by educators, which students will access during the learning process.

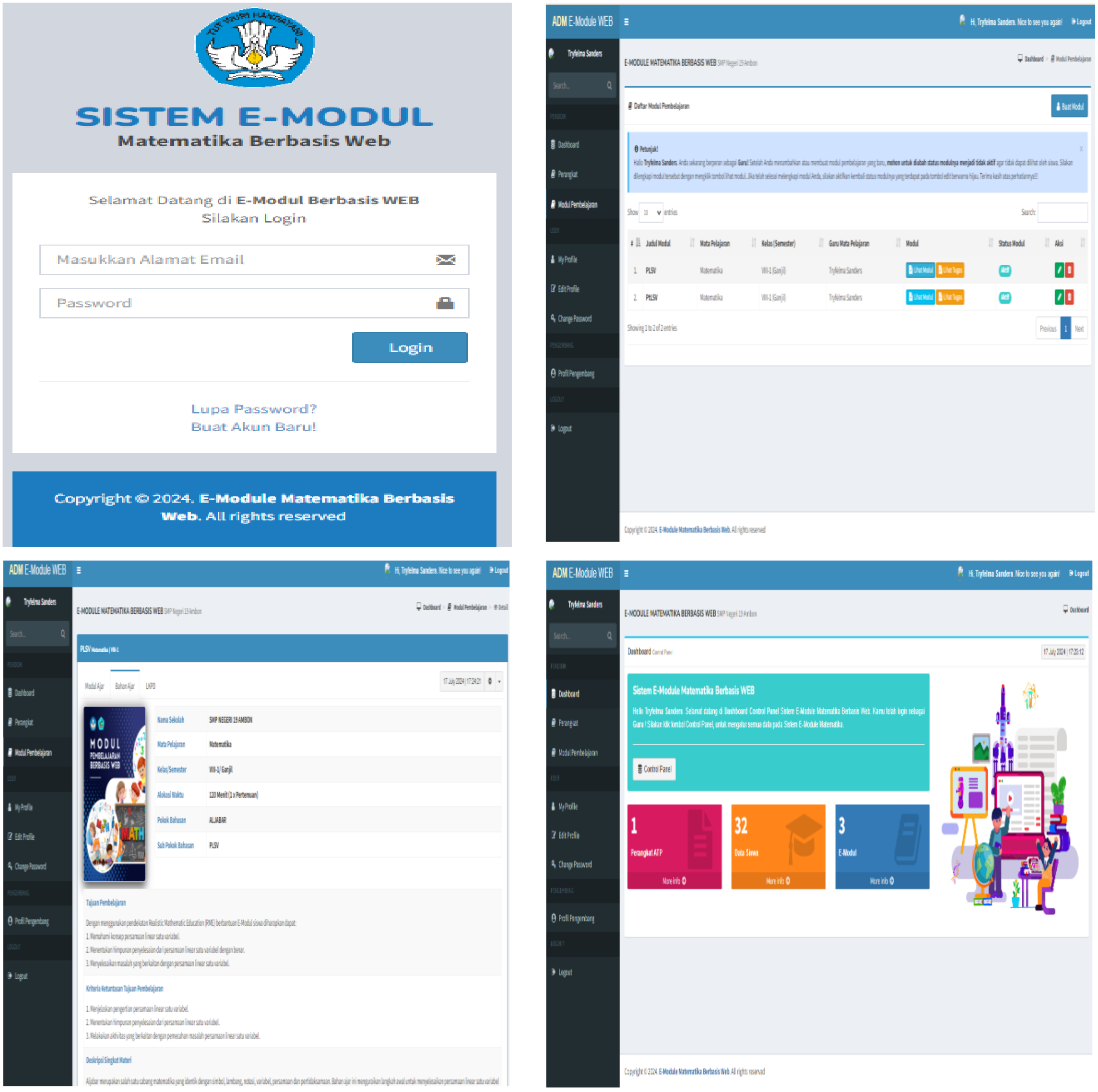

Figure 1. Display of RME learning tool on e-module system

It is essential to understand real-life problems that can be integrated into learning tools using the E-Module System or technology to train students to be skilled at accessing and not being literate about technological advances in the learning process (Logan et al., 2021). By presenting real-life problems that require technological understanding, the E-

Module System can help improve learners' digital literacy, making them more independent and confident in interacting with technological developments (Coman et al., 2020). In addition, focusing on real-life problems in the e-Module System can strengthen the foundation of learners' learning and develop technology access skills. It means that we can shape learners who are more independent, skilled, and confident in facing the challenges of modern technology, especially in learning.

In a learning domain that is increasingly linked to the application of technology, the role of gender characteristics emerges as a factor that can influence various aspects. It is essential to understand that gender differences can create dynamics in the learning context (Aditya & Permadi, 2020). In the application of technology, gender differences can be reflected in how male and female learners interact with digital platforms. Female learners are more likely to perceive the use of technology through digital platforms as more positive and beneficial than male learners (Apriani et al., 2022). By understanding gender characteristics in technology-based learning, educators and technology developers can design strategies that are more inclusive and supportive of all learners, especially in mathematics learning (Xie & Liu, 2023).

Based on the existing problems, the starting point of learning using the Realistic Mathematics Education (RME) approach has yet to utilize technology to represent RME learning and significantly improve students' learning outcomes. Some studies show that digitization-based RME has been developed in various forms and topics in mathematics; for example, animation-assisted RME strengthens students related to mathematics learning so that the learning outcomes obtained are expected to have an influence and experience better changes (Amir et al., 2021). Previous research findings state that RME is a mathematics learning approach that can facilitate students' mathematics learning. Other research findings also state that animation can attract students' interest and attention, making learning easier (Kühl, 2021). Some countries tend to emulate countries that perform well in mathematics, hoping their students will perform as well as their peers. Therefore, many teachers still struggle to determine appropriate learning methods and learning media for mathematics lessons. This results in low student learning outcomes (Revina & Leung, 2021). Therefore, RME is one of the evidence-based approaches to improving students' mathematics learning outcomes. Related to this, this research was conducted to realize students who are strong in inheriting mathematical values and mastering technology in today's era based on gender characteristics, as well as to provide junior high school mathematics literature related to contextual problems.

2. METHOD

The research was conducted using quasi-experimental research with pretest and posttest control groups. The research design is shown in Table 1.

Table 1. Pretest-posttest control group design

Experimental group	O1	X	O2
Control group	O3		O4

Where
X : Learning process (Treatment)
O1 : Pretest of RME learning based on E-Module System
O2 : Posttest of RME learning based on E-Module System
O3 : Pretest of Conventional learning
O4 : Posttest of Conventional learning

This research was conducted in three junior high schools (SMPN) in Ambon City. The research sample was 147 students from six classes, with each school consisting of 1 experimental class and one control class. Experimental classes from the three schools were VII-3 SMPN 4 Ambon, VII-3 SMPN 6 Ambon, and VII-1 SMPN 19 Ambon. The experimental class was taught using the RME approach based on the E-Module System, and the control class was taught using conventional learning modules. After both classes from each school carry out learning activities, then a posttest is given to determine the achievement of student learning outcomes. The research was carried out for several months, from the data collection stage to analyzing the data.

The research instruments developed and used are teaching modules, teaching materials, Pretest and posttest questions, and as many as three questions in the form of descriptions. Learning tools such as Teaching Modules, Teaching Materials, and Learner Worksheets are inputted by educators in the E-Module System, which later in the learning process can be accessed by students. Before the teaching module, teaching materials and learner worksheets were used in the experimental class, and three learning experts first carried out validation. Before being used in the learning class, the research instrument was tested in 5 junior high schools in Ambon City with a total sample of 300 people.

Data analysis in this study used SPSS v.26 software. Data analysis uses descriptive statistics, and data requirements tests include normality and homogeneity tests. Furthermore, hypothesis testing was carried out using the N-gain test to see the achievement of learning outcomes. Independent t-tests, One Way ANOVA tests, and Tukey HSD further test to determine differences in the improvement of learning outcomes from classes that have been given treatment. A simple Linear Regression Analysis test was conducted to see the effect of the Gender of each student on the achievement of learning outcomes using the RME approach based on the E-Module system. Simple Linear Regression Analysis Test uses dummy variables because the gender variable is nominal data while the learning outcomes variable is a scale.

Scoring is based on the student's answers for each item to obtain data on the pretest and posttest results. The scoring guideline used in this study is the Benchmark Assessment guideline with a scale of 5 based on Bloom's methods of grading in summative evaluation convention.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Students' pretest and posttest results

Table 2 shows the pretest and posttest scores for the experimental class (RME based on the E-Module System) and the control class (Conventional). The experimental classes had 78 students, while the control class had 69. In the pretest results, both classes have students who occupy medium, low, and very low qualifications, although with different proportions. Furthermore, on the posttest results, both classes have learners who are only found to have very high, high, and medium qualifications. The percentage of students on the posttest who scored very high in qualification for the experimental class was 18%, while in the control class, it was only 4%. In addition, the percentage of students on the posttest who scored high in qualifications for the experimental class was 75%, while in the control class, it was 54%.

Table 2. Number of students based on pretest and posttest mathematical ability

Qualification	Value	Experiment Class		Control Class	
		Pretest	Posttest	Pretest	Posttest
Very High	$x \geq 90$	0	14	0	3
High	$75 \leq x < 90$	0	59	0	37
Medium	$60 \leq x < 75$	18	5	9	29
Low	$40 \leq x < 60$	59	0	55	0
Very Low	$x < 40$	1	0	5	0

Furthermore, the data in Table 3 show the average pretest value of the E-Module System-based RME class (52.82) and the Conventional class (47.23), as well as the average posttest value of the E-Module System-based RME class (83.05) and the Conventional class (75.87).

Table 3. Average pretest and posttest scores

Class	Pretest	Posttest
Experiment Class	52.82	83.05
Control Class	47.23	75.87

In addition to the students' Pretest and Posttest results, gender data for the Experiment and Control Classes were also obtained. Figure 2 shows that 32 students are male in the Experiment Class of the three schools and 46 females. Meanwhile, 34 male students and 35 female students are in the control class of the three schools.

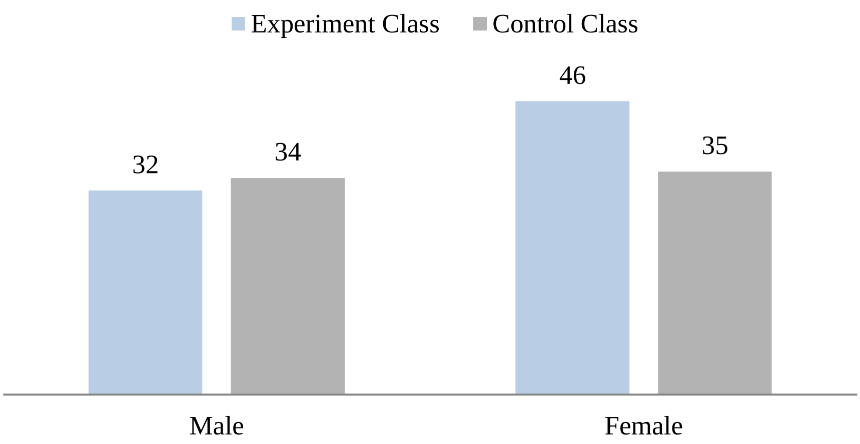

Figure 2. Learner gender data

3.1.2. Improvement in learning outcomes of experiment class and control class

Prerequisite tests for analyzing learning outcomes improvement include normality test and homogeneity test. The data normality test was calculated using Shapiro-Wilk on the Pretest and post-test scores of each class in the three schools. Data is expected if the probability value or Sig. > 0.05. Normality test data is presented in Table 4.

Table 4. Normality test

School	Class	Sig.
SMPN 4 Ambon	Experiment Class	0.200
	Control Class	0.122
SMPN 6 Ambon	Experiment Class	0.072
	Control Class	0.130
SMPN 19 Ambon	Experiment Class	0.118
	Control Class	0.200

After the data tested is normally distributed, the data is then tested for homogeneity using the Test of Homogeneity of Variance. Data is said to be homogeneous if the probability value or Sig. > 0.05. Homogeneity test data is presented in Table 5.

Table 5. Homogeneity test

School	Class	Sig.
SMPN 4 Ambon	Experiment Class	0.954
	Control Class	0.479
SMPN 6 Ambon	Experiment Class	0.106
	Control Class	0.251
SMPN 19 Ambon	Experiment Class	0.474
	Control Class	0.118

Based on prerequisite testing, it was found that the data from the pretest and posttest results from the three schools were normally distributed and homogeneous. Furthermore, the N-gain test was conducted to determine increased student learning outcomes in the Experimental class (RME Approach based on the E-Module System) and the Control class (Conventional Model). Table 6 shows the average N-gain value of the two classes.

Table 6. Mean N-gain score

Class	Average N-gain	Minimum	Maximum
Experiment	64.21	40	90
Control	54.11	22.22	80

Based on Table 6, the average N-gain value of learning outcomes for the RME class based on the E-Module System (64.21) or 64%, including in the moderately effective category with a minimum N-gain value of 40% and a maximum value of 90%. Meanwhile, the average N-gain of learning outcomes for conventional classes (54.11) or 54%, including in the less effective category, with a minimum N-gain value of 22% and a maximum value of 80%. Realistic mathematical education (RME) learning based on the E-Module System in experimental classes is quite effective. It influences student learning outcomes compared to control classes or classes taught with conventional learning, which could be more effective.

3.1.3. The difference in improving learning outcomes

After testing the improvement of learning outcomes using the N-gain test, test the difference in the improvement of learning outcomes Experiment Class (RME based on E-Module System) and Control Class (Conventional Learning) using the t-independent test. The test results are presented in Table 7.

Table 7. Independent t-test results of N-gain value of experiment and control class

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
1.509	0.221	5.032	145	0.000	10.09618	2.00634	6.13074	14.06162
		5.015	140.480	0.000	10.09618	2.01329	6.11592	14.07645

Based on Table 7, it is known that the Sig. (2-tailed) is 0.000 < 0.05; thus, there is a significant difference in improvement between using E-Module System Based RME learning with Conventional learning to improve the learning outcomes of seventh-grade students. In addition to testing the increase in learning outcomes of the entire Experiment class taught using E-Module System Based RME learning, a test was also conducted to test the difference in the increase in learning outcomes of each school. The One-way ANOVA test was used to test the difference in improving learning outcomes (see Table 8).

Table 8. One-way ANOVA test results experiment class

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	834.304	2	417.152	3.156	0.048
Within Groups	9914.270	75	132.190		
Total	10748.574	77			

Based on the data in Table 8, the Sig. Value on the learning outcomes of the three classes, namely VII-3 SMPN 4 Ambon, VII-3 SMPN 6 Ambon, and VII-1 SMPN 19 Ambon is (0.048), which means it is smaller than the α value (0.05), so it can be concluded that there is a difference in the improvement of learning outcomes of the classes taught using the E-Module System Based RME learning. Furthermore, to find out which class is better in improving learning outcomes taught using E-Module System-Based RME learning, further testing was carried out with the Tukey HSD test, as in Table 9.

Table 9. Tukey HSD Test Results

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SMPN4	SMPN6	-2.75741	3.15914	0.659	-10.3113	4.7965
	SMPN19	-7.92424*	3.19117	0.040	-15.5547	-0.2938
SMPN6	SMPN4	2.75741	3.15914	0.659	-4.7965	10.3113
	SMPN19	-5.16683	3.22054	0.250	-12.8675	2.5338
SMPN19	SMPN4	7.92424*	3.19117	0.040	0.2938	15.5547
	SMPN6	5.16683	3.22054	0.250	-2.5338	12.8675

*. The mean difference is significant at the 0.05 level.

In addition to the Tukey HSD test results, Table 10 presents data related to the improvement of learning outcomes of experimental classes taught using the RME approach based on the E-Module System for VII-3 SMPN 4 Ambon, VII-3 SMPN 6 Ambon and VII-1 SMPN 19 Ambon.

Table 10. Data on the improvement of learning outcomes of each experimental class

VII-3 SMPN 4 Ambon				VII-3 SMPN 6 Ambon				VII-1 SMPN 19 Ambon			
Xmin	**Xmax**	$\bar{x}$	**s**	**Xmin**	**Xmax**	$\bar{x}$	**s**	**Xmin**	**Xmax**	$\bar{x}$	**s**
40	85.45	60.75	14.45	45.45	87.5	63.51	9.54	54.55	90	68.67	9.61

Based on the data in Tables 9 and 10, it can be concluded that; 1) The difference in the improvement of learning outcomes of students taught with RME learning based on the E-Module System in class VII-3 SMPN 4 Ambon and VII-1 SMPN 19 Ambon; 2) Of the three classes that have differences in improving problem-solving skills, the average value of N-gain in class VII-1 SMPN 19 Ambon is higher at (68.67), while the average value of N-gain in class VII-6 SMPN 6 Ambon and VII-3 SMPN 4 Ambon is (63.51) and (60.75), respectively.

This study also tested the differences in the improvement of learning outcomes based on the Gender of students in classes taught using the Realistic Mathematic Education (RME) approach based on the E-Module System. The test also uses the t-independent test of the results of the N-Gain Test to increase the learning outcomes of female and male students.

Table 11. Independent t-test results of experiment class N-gain values based on Gender

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**
0.101	0.751	-0.252	76	0.801	-0.69066	2.73640	-6.14068	4.75936
		-0.252	66.890	0.801	-0.69006	2.73591	-6.15173	4.77040

In the data in Table 11, the sig value of the t-independent test of improving learning outcomes based on Gender (0.801), which means it is smaller than the α value (0.05), so it can be concluded that there is no difference in improving the learning outcomes of female and male students who are taught using the RME approach based on the E-Module System. Furthermore, to further emphasize that there is no difference, Table 12 presents data related to differences in the improvement of learning outcomes according to Gender.

Table 12. Data on the improvement of learning outcomes based on gender

Female				Male			
Xmin	**Xmax**	$\bar{x}$	**s**	**Xmin**	**Xmax**	$\bar{x}$	**s**
40	90	64.49	11.89	40	87.5	63.8	11.88

Based on the data in Table 12, it can be concluded that the improvement in the learning outcomes of students taught using the RME approach based on the e-Module System of female and male Gender does not have a significant difference. This is evidenced by the average result of increasing the learning outcomes of female students by (64.49), which is similar to the average result of increasing the learning outcomes of male students by (63.8).

3.1.4. The effect of Gender on improving learning outcomes taught using the RME approach based on the E-Module System

In this study, testing was also carried out to determine the effect of gender characteristics (male and female) on the improvement of learning outcomes obtained from the N-gain value of the experiment class. The Simple Linear Regression Analysis test results with dummy variables are presented in Tables 13 and 14.

Table 13. Linear regression analysis test coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	63.110	4.554		13.859	0.000
	Gender	0.691	2.736	0.029	0.252	0.801

a. Dependent Variable: Learning Outcome

From Table 13, the Sig. is 0.801 > 0.05 and the count value of 0.252 < table of 1.99085, so it can be concluded that the independent variable X (Gender) does not affect the dependent variable Y (increased learning outcomes taught using the RME approach based on the E-Module System). Furthermore, Table 14 will explain the influence of variable X on variable Y.

Table 14. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.029a	0.001	-0.012	11.88739

a. Predictors: (Constant), Gender

Based on Table 14, the R-Square value of 0.001 is obtained, meaning that the influence of gender characteristics is in the weak category on improving the learning outcomes of students who get E-Module System-Based RME learning. The R-Square value of 0.001 means that the contribution of gender influence to enhancing student learning outcomes using the E-Module System-Based RME approach is 0.1%, and other factors influence the remaining percentage.

3.2. Discussion

Innovative and practical learning in mathematics learning is needed so that students can play an active role in the learning process, and educators must have competence in utilizing developing technology by learning objectives and the current curriculum so that the application of technology makes a significant contribution to learning (Poçan et al., 2023). The learning model or approach given to students must also be based on the characteristics and development of science, giving rise to new experiences and insights for students and educators. The RME approach based on the E-Module System is a learning approach that uses problems in everyday life that are implemented and visualized in the E-Module System so that students not only gain essential knowledge and concepts based on subject matter but also get new learning experiences using existing technology. The study result of Lin et al. (2017) stated that the majority of students believe that the online learning approach helps them with their learning (89%) and consequently has a positive impact (74%) on their math learning outcomes. They also believe that web-based learning complements classroom learning (80%), and online quizzes (90%) are an effective way to receive teacher feedback. Therefore, online tests are also popular among students as learning aids and evaluation materials for students. Regular formative and summative testing with prompt feedback in online learning helps increase student engagement and promote student learning in the classroom. In addition, students actively use the math learning website as a source of information from the teacher to acquire knowledge and understand mathematical concepts. During the learning process, the teacher assists students, increases their engagement, and assists them in completing the tasks. This process enhances students' learning of mathematical concepts, develops their ability to solve related problems, and allows students to reflect on and organize mathematical problems. Interactions between teachers and students, and between students, have been neglected in traditional teaching, resulting in inefficiencies in learning. After the learning process, students stated that they were interested in the E-Module-based RME learning activity to improve their ability to learn mathematics.

This research is supported by several relevant previous studies that the RME approach applied in learning models and the application of technology can improve the ability, learning outcomes, and achievement of students in learning mathematics compared to conventional learning models (Makonye, 2014; Prahmana et al., 2020). In classes taught with RME learning based on the E-Module System, at the beginning of learning, educators provide a stimulus by introducing E-Module System tools and understanding teaching materials using contextual examples that exist in people's lives. Furthermore, by following the steps in E-Module System-based RME learning, educators guide students who initially look confused so that they can understand the learning objectives. The study is in line with Yuanita et al. (2018) that the RME approach positively influences mathematics learning, representation, and problem-solving among students. Therefore, teachers must adjust teaching methods using RME and encourage students to participate in activities and discussions. The RME approach provides opportunities for students to generate knowledge on topics taught to them. Students can convey their ideas until they form concepts for each learning step. Many students provided solutions consisting of different steps but had the same answer. Students believe in producing their own results, which is a process that they will later discover as the concept of linear equations and inequalities of one variable. In addition, the RME approach is one of the most effective approaches in fostering mathematical representation, confidence, and problem-solving skills that high-achieving students can improve.

The E-Module-based RME developed at this time has a considerable influence. The influence of technology on students' mathematics performance is still a matter of debate among scientists, but other scientists view technology as having a significant impact on students' mathematics performance. A study found that technology-based learning interventions, such as gamification and interactive software, improved student math performance (Hillmayr et al., 2020). In addition, technology can provide students with easy feedback on their work, allowing them to self-correct and adjust more quickly. However, technology is not a panacea for improving math performance (Gómez-García et al., 2020). Also, technology-based interventions may not be suitable for all students and must be tailored to individual learning styles and abilities. Furthermore, the effectiveness of technology-based interventions may depend on how the technology is used (Birgin & Acar, 2020). For example, using technology to supplement traditional classroom instruction may be more effective than using it as a substitute for face-to-face instruction (Zhang & Wang, 2020). Overall, while technology can improve students' math performance, the effectiveness of technology-based interventions depends on several factors, including the quality of the technology, the pedagogical approach used, and the needs and abilities of individual students. Other studies have shown that the use of technology in mathematics teaching and learning can positively impact students' interest in mathematics (Kelley et al., 2020). Technology can help students visualize abstract mathematical concepts, make connections between mathematical ideas, and engage actively with the material (Benning et al., 2018).

The research result of Yokoso et al. (2024) in Ghana showed that 170 students needed to be made aware of linear equations and inequalities of one variable. Consequently, this hampered their ability to solve problems and interpret their implications correctly. One recommendation is to improve teacher education by emphasizing various teacher-student interactions that thoroughly consider students' mathematical ideas. This approach aims to support teachers in effectively utilizing students' experiences in the learning process. Results of the same study by Jupri and Drijvers (2016) revealed that students need help formulating mathematical models, as evidenced by errors in formulating equations in schemes and diagrams. Some schools perceive math as abstract, difficult to understand, tedious, and viewed with limited connection or relevance to everyday life experiences. Students begin to learn the subject well but gradually start to dislike some topics or the whole subject. They feel uncomfortable and nervous during lessons and exams. This is due to students needing more confidence and motivation in solving problems. Some students are very persistent in learning advanced mathematics, and it becomes an exciting challenge for them. Indeed, the others do not recognize the importance of learning math. Students may need help relating mathematical concepts outside of the classroom and, therefore, have a negative attitude toward the subject. This can lead to their failure to transfer mathematical knowledge and skills to solve societal problems positively. This situation also impacts increasing students' engagement, interest, and motivation in mathematics. Therefore, interactive and simulation software applications are very important for students and can provide students with visually rich and interactive learning experiences that can help make math more interesting (Cai et al., 2023). Similarly, the gamification of math learning, where mathematical concepts are presented in games, can help make learning more exciting and fun for students (Sibomana et al., 2021). The study's results in Ghana revealed that the impact of technology on math performance was positive and significant, and the effect of math of interest on math performance was positive and significant. Also, the impact of technology on math interest was positive and significant (Bright et al., 2024).

Furthermore, the difference in improving student learning outcomes based on Gender through the RME approach based on the E-Module System was obtained at 0.69. This proves no significant gap exists between male and female learners' mathematics abilities or individual cognitive abilities. Although there are statistical differences in mathematics achievement between male and female learners, these differences are often due to environmental factors and educational experiences rather than fundamental biological differences (Stewart et al., 2017). Therefore, gender characteristics cannot be used as a factor that can serve as a mechanism to determine or explain gender differences in mathematical ability (Li et al., 2018). Recent studies suggest that women are still underrepresented in science, technology, engineering, and mathematics (STEM) fields. It is evident that worldwide, 35% of students enrolled in higher education are female with STEM degrees. In general, previous findings have shown that gender differences in math performance are not present in childhood (Bakker et al., 2019; Hutchison et al., 2019), but differences emerged that favored males in high school and persisted into adulthood (Else-Quest et al., 2010). This is because math ability consists of various skills, and gender differences in math performance may depend on the test used (Lindberg et al., 2010). Word problems are considered complicated math tests; these problems are often solved superficially, as one might choose a suitable way to solve a fundamental problem that is textual (Hickendorff, 2021). The teacher believes that giving story problems is part of remembering contextual things that can stimulate students' thinking skills. Still, some students think it is very dull, takes a long time, and can cause high anxiety when faced with national exams or competitive events (Rizaldi et al., 2022).

Differences in gender characteristics do not affect improving student learning outcomes in mathematics learning taught using the RME approach based on the E-Module System. Based on the results obtained, gender characteristics only contribute 0.1%, which is included in the weak category, meaning that other factors influence 99.9% of the increase in mathematics learning outcomes. Internal and external Factors affecting math learning outcomes include teaching quality, motivation, interest, intelligence, emotional, learning difficulties, and social environment (Elastika et al., 2021). Learning independence and practical support from educators are essential to improving students' mathematics skills (Jian et al., 2023). All these factors can interact complexly and influence each other in determining students' mathematics learning outcomes. Therefore, paying attention to these various aspects is essential to improve the quality of mathematics education. The study result of Radišić et al. (2024) pointed out that six countries, namely Norway, Finland, Sweden, Portugal, Estonia, and Serbia, showed that motivation can improve students' mathematics learning outcomes. Students' intrinsic value and perceived competence were positively related to students' mathematics learning outcomes across the six countries. Teachers' beliefs about the nature and learning of mathematics moderated the classroom relationships between boys and girls and motivation and mathematics learning outcomes. Math learning outcomes for boys in Portugal and Norway differed with girls who consistently perceived themselves as less competent in mastering mathematics in primary school. The class socioeconomic composition had a more pronounced influence on teacher beliefs in Sweden, Norway, and Serbia. Concerning teacher beliefs, class composition is relevant in Estonia and Sweden. In

Finland and Norway, class composition is essential for differentiating boys' and girls' motivation to learn mathematics. Learning independence is one of the determinants of students' mathematics achievement. Mulyono (2021) states the extent to which students can participate in determining the objectives, material, learning experiences, and evaluation of learning in the learning process. An independent person can make choices responsibly when he wants to learn or what he wants to learn. Self-directed learning frees students to use their learning styles, progress at their own pace, explore their interests, and develop their talents using their preferred multiple intelligences. Self-directed learning is closely related to 'self-understanding' itself. Students have a 'self-organizing' or 'self-ordered' personality type. They make their own decisions and accept responsibility. Realizing the principle of independence in learning will place the teacher as a facilitator and motivator. In addition, solving math cases or tasks involves multiple representations to positively predict student improvement in solving complex questions. The frequency of math tasks with high cognitive demands did not indicate any of the three learning outcomes. However, it positively predicts student interest in math learning, demonstrated class participation, and a dynamic view of math learning (Ni et al., 2018).

4. CONCLUSION

Based on the research analysis that has been carried out, there are differences in improving the learning outcomes of students taught using the Realistic Education Mathematics (RME) learning approach based on the E-Module System and conventional learning models. The RME learning approach based on the E-Module System is also more effective in improving student learning outcomes than traditional learning models. Furthermore, the improvement of learning outcomes of the RME class based on the E-Module System in each school is also different based on what is seen from the average value where class VII-1 SMPN 19 Ambon is higher than class VII-3 SMPN 6 Ambon, which is not much different from class VII-3 SMPN 4 Ambon. Gender characteristics on the improvement of learning outcomes of students taught using the RME approach based on the e-Module System female and male Gender do not have significant differences. In addition, Gender only contributes 0.1% to improving student learning outcomes using the E-Module System-Based RME approach, and the rest is influenced by other factors that are expected; further research can be done to discover these factors.

Acknowledgments

The authors would like to thank Universitas Pattimura for the Research Grant of the Faculty of Teacher Training and Education, Universitas Pattimura, Indonesia. This research is a 2023 budget with the chief researcher Dr. Anderson Leonardo Palinussa, M.Pd.

Declarations

Author Contribution : ALP: Conceptualization, Writing - Original Draft, Editing, Formal analysis and Visualization; PZT: Writing - Review & Editing, Formal analysis, Software, Formal analysis and Methodology; VPS: Software, Methodology, Formal analysis, Validation and Supervision; YHM: Editing and Visualization; JS: Validation and Supervision.

Funding Statement : This research was funded by the Research Grant Fund of the Faculty of Teacher Training and Education, Universitas Pattimura, Indonesia with a budget of 2023

Conflict of Interest : The authors declare no conflict of interest.

Additional Information : Additional information is available for this paper.

REFERENCES

Aditya, B. R., & Permadi, A. (2020). Gender factor in designing features of a learning management system in higher education In International Conference on Online and Blended Learning 2019 (ICOBL 2019), (pp. 28-31). https://doi.org/10.2991/assehr.k.200521.006

Amir, T. H., Syamsuddin, A., & Sulfansyah, S. (2021). Online learning based on realistic mathematic education (RME) assisted animation media in improving student learning outcomes. *Jurnal Ilmiah Sekolah Dasar*, *5*(3), 478-478. https://doi.org/10.23887/jisd.v5i3.39716

Apriani, E., Arsyad, S., Syafryadin, Supardan, D., Gusmuliana, P., & Santiana, S. (2022). ICT platforms for Indonesian EFL students viewed from gender during the COVID-19 pandemic. *Studies in English Language and Education*, *9*(1), 187-202. https://doi.org/10.24815/siele.v9i1.21089

Bakker, M., Torbeyns, J., Wijns, N., Verschaffel, L., & De Smedt, B. (2019). Gender equality in 4- to 5-year-old preschoolers' early numerical competencies. *Developmental Science*, *22*(1), 1-7. https://doi.org/10.1111/desc.12718

Beer, P., & Mulder, R. H. (2020). The effects of technological developments on work and their implications for continuous vocational education and training: A systematic review. *Frontiers in psychology*, *11*, 1-19. https://doi.org/10.3389/fpsyg.2020.00918

Benning, I., Linsell, C., & Ingram, N. (2018). *Using technology in mathematics: Professional development for teachers* The 41st annual conference of the Mathematics Education Research Group of Australasia, Auckland.

Birgin, O., & Acar, H. (2020). The effect of computer-supported collaborative learning using GeoGebra software on 11th grade students' mathematics achievement in exponential and logarithmic functions. *International Journal of Mathematical Education in Science and Technology*, *53*(4), 872-889. https://doi.org/10.1080/0020739X.2020.1788186

Bosica, J., Pyper, J. S., & MacGregor, S. (2021). Incorporating problem-based learning in a secondary school mathematics preservice teacher education course. *Teaching and Teacher Education*, *102*, 103335. https://doi.org/10.1016/j.tate.2021.103335

Bright, A., Welcome, N. B., & Arthur, Y. D. (2024). The effect of using technology in teaching and learning mathematics on student's mathematics performance: The mediation effect of students' mathematics interest. *Journal of Mathematics and Science Teacher*, *4*(2), em059. https://doi.org/10.29333/mathsciteacher/14309

Cai, S., Niu, X., Wen, Y., & Li, J. (2023). Interaction analysis of teachers and students in inquiry class learning based on augmented reality by iFIAS and LSA. *Interactive*

Learning Environments, *31*(9), 5551-5567. https://doi.org/10.1080/10494820.2021.2012808

Calp, M. H., & Bütüner, R. (2022). Chapter 7 - Society 5.0: Effective technology for a smart society. In A. E. Hassanien, J. M. Chatterjee, & V. Jain (Eds.), *Artificial Intelligence and Industry 4.0* (pp. 175-194). Academic Press. https://doi.org/10.1016/B978-0-323-88468-6.00006-1

Coman, C., Țîru, L. G., Meseșan-Schmitz, L., Stanciu, C., & Bularca, M. C. (2020). Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective. *Sustainability*, *12*(24), 1-22. https://doi.org/10.3390/su122410367

Dewantara, A. H., Setiawati, F. A., & Saraswati, S. (2023). Towards numeracy literacy development: A single-case study on the use of the living book homeschooling model. *Infinity Journal*, *12*(2), 225-242. https://doi.org/10.22460/infinity.v12i2.p225-242

Diponegoro, A. M., Khalil, I. A., & Prahmana, R. C. I. (2024). When religion meets mathematics: From mathematical anxiety to mathematical well-being for minority group student. *Infinity Journal*, *13*(2), 413-440. https://doi.org/10.22460/infinity.v13i2.p413-440

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, *18*(1), 53. https://doi.org/10.1186/s41239-021-00289-4

Elastika, R. W., Sukono, S., & Dewanto, S. P. (2021). Analysis of factors affecting students' mathematics learning difficulties using sem as information for teaching improvement. *International Journal of Instruction*, *14*(4), 281-300. https://doi.org/10.29333/iji.2021.14417a

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological bulletin*, *136*(1), 103-127. https://doi.org/10.1037/a0018053

Fahmi, S., Rahmawati, R. Y., & Priwantoro, S. W. (2022). Two-variables linear system: A smartphone-based-e-module with a realistic mathematic education approach. *Kreano: Jurnal Matematika Kreatif-Inovatif*, *13*(1), 55-66. https://doi.org/10.15294/kreano.v13i1.31661

Fauzan, A., Harisman, Y., Yerizon, Y., Suherman, S., Tasman, F., Nisa, S., Sumarwati, S., Hafizatunnisa, H., & Syaputra, H. (2024). Realistic mathematics education (RME) to improve literacy and numeracy skills of elementary school students based on teachers' experience. *Infinity Journal*, *13*(2), 301-316. https://doi.org/10.22460/infinity.v13i2.p301-316

Gómez-García, M., Hossein-Mohand, H., Trujillo-Torres, J. M., Hossein-Mohand, H., & Aznar-Díaz, I. (2020). Technological factors that influence the mathematics performance of secondary school students. *Mathematics*, *8*(11), 1935. https://doi.org/10.3390/math8111935

Hickendorff, M. (2021). The demands of simple and complex arithmetic word problems on language and cognitive resources. *Frontiers in psychology*, *12*, 727761. https://doi.org/10.3389/fpsyg.2021.727761

Hidayat, W., & Aripin, U. (2023). How to develop an e-LKPD with a scientific approach to achieving students' mathematical communication abilities? *Infinity Journal*, *12*(1), 85-100.

Hillmayr, D., Ziernwald, L., Reinhold, F., Hofer, S. I., & Reiss, K. M. (2020). The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis. *Computers and Education*, *153*, 103897. https://doi.org/10.1016/j.compedu.2020.103897

Hutchison, J. E., Lyons, I. M., & Ansari, D. (2019). More similar than different: Gender differences in children's basic numerical skills are the exception not the rule. *Child development*, *90*(1), e66-e79. https://doi.org/10.1111/cdev.13044

Jian, X., Wijaya, T. T., & Yu, Q. (2023). Key factors affecting mathematics teachers' well-being and stress levels: An extended engagement theory. *International Journal of Environmental Research and Public Health*, *20*(1), 548. https://doi.org/10.3390/ijerph20010548

Jupri, A., & Drijvers, P. (2016). Student difficulties in mathematizing word problems in Algebra. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(9), 2481-2502. https://doi.org/10.12973/eurasia.2016.1299a

Kamid, K., Huda, N., Syafmen, W., Sufri, S., & Sofnidar, S. (2021). The relationship between students' mathematical disposition and their learning outcomes. *Journal of Education and Learning (EduLearn)*, *15*(3), 376-382. https://doi.org/10.11591/edulearn.v15i3.17604

Kelley, T. R., Knowles, J. G., Holland, J. D., & Han, J. (2020). Increasing high school teachers self-efficacy for integrated STEM instruction through a collaborative community of practice. *International journal of STEM education*, *7*(1), 14. https://doi.org/10.1186/s40594-020-00211-w

Kühl, T. (2021). Prerequisite knowledge and time of testing in learning with animations and static pictures: Evidence for the expertise reversal effect. *Learning and Instruction*, *73*, 101457. https://doi.org/10.1016/j.learninstruc.2021.101457

Kumar, S., Tiwari, P., & Zymbler, M. (2019). Internet of things is a revolutionary approach for future technology enhancement: A review. *Journal of Big Data*, *6*(1), 111. https://doi.org/10.1186/s40537-019-0268-2

Lady, A., Utomo, B. T., & Chikita, L. (2018). Improving mathematical ability and student learning outcomes through realistic mathematic education (RME) approach. *International Journal of Engineering and Technology*, *7*(2), 55-57. https://doi.org/10.14419/ijet.v7i2.10.10954

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2018). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569-578. https://doi.org/10.12973/ejmste/76959

Lestari, R., Prahmana, R. C. I., Chong, M. S. F., & Shahrill, M. (2023). Developing realistic mathematics education-based worksheets for improving students' critical thinking skills. *Infinity Journal*, *12*(1), 69-84. https://doi.org/10.22460/infinity.v12i1.p69-84

Li, M., Zhang, Y., Liu, H., & Hao, Y. (2018). Gender differences in mathematics achievement in Beijing: A meta-analysis. *British Journal of Educational Psychology, 88*(4), 566-583. https://doi.org/10.1111/bjep.12203

Lin, S., Zhou, Y., & Wijaya, T. T. (2020). Using hawgent dynamic mathematics software in teaching arithmetic operation. *International Journal of Education and Learning, 2*(1), 25-31. https://doi.org/10.31763/ijele.v2i1.97

Lin, Y.-W., Tseng, C.-L., & Chiang, P.-J. (2017). The effect of blended learning in mathematics course. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(3), 741-770. https://doi.org/10.12973/eurasia.2017.00641a

Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological bulletin*, *136*(6), 1123-1135. https://doi.org/10.1037/a0021276

Logan, R. M., Johnson, C. E., & Worsham, J. W. (2021). Development of an e-learning module to facilitate student learning and outcomes. *Teaching and Learning in Nursing*, *16*(2), 139-142. https://doi.org/10.1016/j.teln.2020.10.007

Makonye, J. P. (2014). Teaching functions using a realistic mathematics education approach: A theoretical perspective. *International Journal of Educational Sciences*, *7*(3), 653-662.

Mulyono, D. (2021). The influence of learning model and learning independence on mathematics learning outcomes by controlling students' early ability. *International Electronic Journal of Mathematics Education*, *12*(3), 689-708. https://doi.org/10.29333/iejme/642

Ni, Y., Zhou, D.-H. R., Cai, J., Li, X., Li, Q., & Sun, I. X. (2018). Improving cognitive and affective learning outcomes of students through mathematics instructional tasks of high cognitive demand. *The Journal of Educational Research*, *111*(6), 704-719. https://doi.org/10.1080/00220671.2017.1402748

Palinussa, A. L. (2020). Comparison of algebra learning outcomes using realistic mathematics education (RME), team assisted individualization (TAI) and conventional learning models in junior high school 1 Masohi. *Infinity Journal*, *9*(2), 173-182. https://doi.org/10.22460/infinity.v9i2.p173-182

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education*, *10*(2), 522-534. https://doi.org/10.11591/ijere.v10i2.20640

Pertiwi, C. M., Rohaeti, E. E., & Hidayat, W. (2021). The students' mathematical problem-solving abilities, self-regulated learning, and VBA Microsoft Word in new normal: A development of teaching materials. *Infinity Journal*, *10*(1), 17-30. https://doi.org/10.22460/infinity.v10i1.p17-30

Poçan, S., Altay, B., & Yaşaroğlu, C. (2023). The effects of mobile technology on learning performance and motivation in mathematics education. *Education and Information Technologies*, *28*(1), 683-712. https://doi.org/10.1007/s10639-022-11166-6

Prahmana, R. C. I., Sagita, L., Hidayat, W., & Utami, N. W. (2020). Two decades of realistic mathematics education research in Indonesia: A survey. *Infinity Journal*, *9*(2), 223-246. https://doi.org/10.22460/infinity.v9i2.p223-246

Radišić, J., Buchholtz, N., Yang-Hansen, K., Liu, X., & Kaarstein, H. (2024). Do teachers' beliefs about the nature and learning of mathematics affect students' motivation and enjoyment of mathematics? Examining differences between boys and girls across six countries. *European Journal of Psychology of Education*, *39*(2), 1587-1613. https://doi.org/10.1007/s10212-024-00809-6

Revina, S., & Leung, F. K. S. (2021). Issues involved in the adoption of Realistic Mathematics Education in Indonesian culture. *Compare: A Journal of Comparative and International Education*, *51*(5), 631-650. https://doi.org/10.1080/03057925.2019.1650636

Rizaldi, R., Syahwin, S., & Ramadani, R. (2022). Efektifitas e-modul praktikum fisika berbasis model problem based learning menggunakan smart apps creator terhadap keterampilan proses sains siswa SMA/MA [The effectiveness of e-module physics practical work based on problem based learning model using smart apps creator on science process skills of high school students]. *Jurnal Pendidikan MIPA*, *12*(3), 720-725. https://doi.org/10.37630/jpm.v12i3.647

Saptono, L. (2022). The effect of personal competence and pedagogical-didactical competence of high school economics teachers in media literacy on teaching effectiveness. *International Journal of Media and Information Literacy*, *7*(2), 545-553. https://doi.org/10.13187/ijmil.2022.2.545

Sibomana, A., Nicol, C. B., Nzabalirwa, W., Nsanganwimana, F., Karegeya, C., & Sentongo, J. (2021). Factors affecting the achievement of twelve-year basic students in mathematics and science in Rwanda. *International Journal of Learning, Teaching and Educational Research*, *20*(7), 61-84. https://doi.org/10.26803/IJLTER.20.7.4

Stewart, C., Root, M. M., Koriakin, T., Choi, D., Luria, S. R., Bray, M. A., Sassu, K., Maykel, C., O'Rourke, P., & Courville, T. (2017). Biological gender differences in students' errors on mathematics achievement tests. *Journal of Psychoeducational Assessment*, *35*(1-2), 47-56. https://doi.org/10.1177/0734282916669231

Stoian, C. E., Fărcașiu, M. A., Dragomir, G. M., & Gherheș, V. (2022). Transition from online to face-to-face education after COVID-19: The benefits of online education from students' perspective. *Sustainability*, *14*(19), 12812. https://doi.org/10.3390/su141912812

Sutarni, S., Sutama, S., Prayitno, H. J., Sutopo, A., & Laksmiwati, P. A. (2024). The development of realistic mathematics education-based student worksheets to enhance higher-order thinking skills and mathematical ability. *Infinity Journal*, *13*(2), 285-300. https://doi.org/10.22460/infinity.v13i2.p285-300

Tang, K. H. D. (2023). Student-centered approach in teaching and learning: What does it really mean? *Acta Pedagogia Asiana*, *2*(2), 72-83. https://doi.org/10.53623/apga.v2i2.218

Van Zanten, M., & Van den Heuvel-Panhuizen, M. (2021). Mathematics curriculum reform and its implementation in textbooks: Early addition and subtraction in realistic mathematics education. *Mathematics*, *9*(7), 752. https://doi.org/10.3390/math9070752

Xie, G., & Liu, X. (2023). Gender in mathematics: how gender role perception influences mathematical capability in junior high school. *The Journal of Chinese Sociology*, *10*(1), 10. https://doi.org/10.1186/s40711-023-00188-3

Yokoso, V., Kabutey, D. T., Ansah, S., Ntow, Y. M., & Ofotsu, S. (2024). Errors and misconceptions in linear inequalities among senior high students in mfantseman municipality. *International Journal of Mathematics and Statistics Studies*, *12*(2), 56-70.

Yuanita, P., Zulnaidi, H., & Zakaria, E. (2018). The effectiveness of realistic mathematics education approach: The role of mathematical representation as mediator between mathematical belief and problem solving. *PLoS One*, *13*(9), e0204847. https://doi.org/10.1371/journal.pone.0204847

Zhang, D., & Wang, C. (2020). The relationship between mathematics interest and mathematics achievement: mediating roles of self-efficacy and mathematics anxiety. *International Journal of Educational Research*, *104*, 101648. https://doi.org/10.1016/j.ijer.2020.101648