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Realistic Mathematics Education Tools to Boost Higher-Order Thinking Skills

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ABSTRACT

Purpose: Higher order thinking skills (HOTS) must be strengthened to improve student quality, enabling them to compete in the Industrial 4.0 era. This study aimed to develop a feasible learning tool to enhance students' HOTS, assessed based on its validity, practicality, and effectiveness. **Methods**: The study employed developmental research using the ADDIE model, (Analysis, Design, Development, Implementation, and Evaluation). The population comprised all 8th-grade students at Ngemplak State Junior High School 1, with a sample of 32 students each drawn from Classes E and F. Research instruments included product validation sheets, a practicality sheet, and HOTS test items. Validation sheet analysis used standard deviation, while the product's effectiveness was evaluated using the General Linear Models (GLM) test. **Results**: The results indicate that Realistic mathematics education (RME) -based learning tools are feasible for enhancing students' HOTS. There are differences in pretest-posttest scores (significance value <0.05), and the Pair-wise Comparison test results demonstrate an increase in pretest-posttest scores for HOTS within each research group. Therefore, it can be observed that in both research groups, differences and increases in pretest-posttest scores are attributed to the instructional intervention. However, the multivariate statistics reveal a partial eta square of 0.852 in the experimental group. This indicates that the RME material contributes to an 85% enhancement in students' HOTS, whereas, by comparison, the HOTS enhancement in the control group reaches 56% (partial eta square score=0.561). **Implications for research and practice**: Consequently, it is evident that RME-based learning tools exhibit a greater degree of effectiveness compared to conventional instructional methods. The limitations of research are (1) changes in the activities time because the students' ability levels are very diverse. (2) The implementation of the trial is still not free from the possibility of bias. Finally, this study suggests that RME could serve as an effective alternative for enhancing students' higher order thinking skills (HOTS).

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Introduction

Educational systems must equip learners with the skills needed for success in the 21st century (Varas et al., 2023). One key skill that needs to be enhanced is higher-order thinking skills (HOTS). Specifically, improving HOTS in mathematics is crucial in a rapidly changing society and in an era of advancing technology (Hilmi & Dewi, 2021). Higher order thinking skills (HOTS) refer to a process of thinking which involves the creative and critical management of information in facing a situation or solving a problem. It includes skills in problem solving, analytical thinking, creative thinking, and critical thinking; explanation of issues, reasoning, evidence, conclusion, and evaluation (Kwangmuang et al., 2021). Meanwhile, in Bloom's taxonomy, it includes the skills of analyzing, evaluating, and creating (Bloom et al., 1956). In the content standards of high-school mathematics, 47% of the competency standards and 27% of the basic competencies have HOTS loading (Sa'adah & Misri, 2019). However, in reality, the level of HOTS of Indonesian students is still low and has not experienced significant enhancement (Payadnya et al., 2023). This is caused by the inadequacy in their background knowledge, their low level of practice in solving problems of the HOTS level, their negative perceptions of HOTS, and the fact that HOTS problem solving causes a high cognitive burden for them. On the other hand, a teacher's role is that of a facilitator designing the lesson which can help the students to constructs mathematical thoughts and concepts.

Lesson planning holds an important role in the success of an instructional process. The success of a learning-teaching process in the classroom depends largely on the teacher's competences in planning and developing instruction (Palobo & Tembang, 2019). Students will learn well if the instructional material is designed, developed, and presented well (Fitriah, 2020). Field observations reveal that teachers have not fully optimized the development of learning tools, such as lesson plans and student books. Many teachers have difficulties in developing a lesson plan (Palobo & Tembang, 2019). Another study, Hapsari et al. (2018) found that teachers' instructional tools are not complete to indicate that there are learning documents that are not developed by the teachers. The teacher can design the lesson plan and apply practical situations in daily life in the instructional activities to stimulate and improve the students' higher order thinking skills (Kwangmuang et al., 2021).

One instructional strategy that emphasizes using real-life problems as the starting point for developing mathematical concepts is Realistic Mathematics Education (RME). This method is one of the models that can be used in mathematics learning. RME is well-known for its effective and flexible approach to teaching mathematics and can increase students' learning interest and make learning effective (Ulandari et al., 2019), because RME using the real world and can be imagined in real life to understand and solve mathematical problems. RME is a mathematics learning method which integrates the constructivistic and contextual approaches in that it gives the learners a chance to construct their self-understanding on mathematical concepts by way of real-life problem solving (Wahyudi et al., 2017). The principle activities in RME emphasize on the thoughts that mathematics is a human activity and learners must be treated as active participants in the instructional processes (Bal & Seckin Kapucu, 2022; Listiawati et al., 2023).

A number of studies have shown that RME is able to elevate the learners' competencies in problem solving, critical thinking, analyses, learning achievement, and mathematics literacy (Hikayat et al., 2020; Lestari et al., 2023; Nguyen & Pham, 2023; Nugraheni & Marsigit, 2021; Putri et al., 2024; Sari et al., 2023; Wahidin & Sugiman, 2014). Hilmi and Dewi (2021) did classroom action research, only using one class, and gained value category. The instructional tools in RME showed positive supports to students' mathematics competences and their learning motivation so that the learning-teaching activities became effective (Hasibuan et al., 2018; Syafriafdi et al., 2019). Much research has been done on RME learning; however, more is needed which is related to the use of RME method to enhance HOTS. This is based on the reason that such research is regarded as a significant way to solve the problems in mathematics education (Bayrak & Aslanci, 2022).

The present study is intended to develop RME-based learning tools as a way to enhance students' HOTS. Moreover, in previous research, data analysis was conducted using N-Gain methodology (Hilmi & Dewi, 2021) and using criteria (Murni et al., 2020) hence, the researcher intends to employ a different analysis to evaluate the effectiveness level of the developed product. The study focuses on the development of an RME-based lesson plan. The RME-based learning materials developed content closely related to students' daily lives. The data analysis in this research employs General Linear Models to assess the effectiveness contribution of the developed product. The product development in this research aims to provide an alternative solution in enhancing students' higher order thinking skills, with the expectation of equipping students to face future life assessed based on its validity, practicality, and effectiveness. The gap between this research and previous research is that the current research discusses contextual problems as part of RME. Explaining contextually close to students' daily lives. In addition, it produces products in the form of teaching materials and learning plans based on RME with a more attractive appearance. Many illustrations are presented according to contextual problems. It is also equipped with contextual questions. Mathematical problems are difficult to understand because they are abstract. So, with this device it is hoped that it can bridge students to understand abstract mathematical material or concepts more easily. Many teachers have not used RME-based learning devices in schools.

Literature Review

The integration of RME into the instructional tools not only fosters a range of engaging learning activities but also cultivates students' interest in mathematics learning. This is because the RME-based approach encourages students to explore mathematical concepts within their environment, thereby making learning meaningful and relevant to their real-life situations (Ariati & Juandi, 2022; Murni et al., 2020). The RME method liberates students from rote memorization and superficial understanding, enabling them to establish connections between mathematics and everyday life, thus enhancing the learning process (Karaca & Özkaya, 2017). Students develop an appreciation for mathematics as they recognize its significance and applicability in real-life contexts (Vatiwitipong, 2021). RME-based learning activities are engaging and help develop skills for interpreting real-life information. Integrating these activities into mathematics education aims to equip students with practical life skills (Bal & Seckin Kapucu, 2022).

Sanaky (2017) illustrates that learning experiences can progress from concrete to increasingly abstract levels in teaching and learning activities, particularly in the utilization of learning media like whiteboard and LCD projectors. RME-based learning is not contingent upon constant association with real-life problems encountered by students. Rather, the primary focus lies in ensuring that abstract concepts within students' learning are effectively translated into concrete understanding within their minds (Ariati & Juandi, 2022). RME learning utilizes human activities as references to construct students' knowledge and employs daily-life problems to align with students' imaginative capacity (Bayu et al., 2023; Ulandari et al., 2019). This approach assists students in resolving problems by engaging in higher order mathematical problem-solving techniques (Karaca & Özkaya, 2017). Given the assumption that mathematics is an abstract science and considering that junior high school students are in the stage of concrete operational cognitive development, the RME-based approach emerges as a pedagogical concept wherein teachers introduce real-world situations in the classroom and facilitate students in applying their existing knowledge to practical, real-life scenarios.

According to the Directorate of Teachers and Educational Manpower Sani et al. (2023), students' higher order thinking skills can be cultivated through activity-based instructional processes, allowing students the opportunity to explore knowledge and concepts independently. Activity-based principles underscore the idea that students should play an active role in the learning process (Ndiung, 2021); learning primarily occurs through student engagement and should be closely connected to students' real-life situations. RME-based approaches should provide students the opportunity to actively engage in the instructional process by comprehending contextual problems, engaging in problem discussion, and collaboratively seeking solutions (Laurens et al., 2017). Students must be given freedom to think, discuss, and share ideas in finding mathematical concepts and building their knowledge. By way of the RME approaches, students are expected to perform well in a group work in solving real-world problems (Vatiwitipong, 2021).

In RME learning activities, students are afforded the opportunity to collaborate, share ideas, and exchange opinions within group work settings. This collaborative environment encourages students to collectively rediscover mathematical ideas and concepts by exploring real-life problems (Febriyanti et al., 2019). This aligns with research findings indicating that the adoption of RME approaches effectively enhances students' higher order thinking skills (HOTS) in mathematics learning (Ariati & Juandi, 2022; Hilmi & Dewi, 2021; Murni et al., 2020; Ndiung, 2021). The implementation of RME approaches provides students with opportunities to independently analyze and evaluate their thought processes, enabling them to draw conclusions from the knowledge they construct. This is facilitated through guidance from probing questions posed by their teachers or peers (Nuswantari et al., 2020). It is hoped that the development of PMR-based learning tools can serve as an alternative solution to enhance students' higher order thinking skills (HOTS), thereby equipping them to meet the demands of future life challenges.

Based on the results of initial observations at Banguntapan State Junior High School 3, Yogyakarta in April 2017, it was found that most students were less interested in participating in mathematics learning. This can be seen when the teacher was explaining the mathematics learning material, some students paid less attention and were busy with their own activities, some chatted with other friends. In addition, students' ability to solve mathematics problems is still low, this can be seen from the way students answer questions given by the teacher. Some students are still confused about solving the questions given by the teacher, some students do not try to solve the questions but they wait for their friends' results. After getting an answer from their friends, they write down the answer. Student creativity is also still low, as seen from the way students solve mathematics problems given by the teacher, using the usual method and lacking variety.

From the results of interviews with mathematics subject teachers, it was explained that some students still consider mathematics a boring and unpleasant subject. Researchers conducted interviews with some students, the results showed that students were less interested in mathematics and students did not like contextual questions which were problem-solving questions. Furthermore, the results of observations at Ngemplak State Junior High School 1, Yogyakarta showed that students were less motivated in participating in mathematics learning. This can be seen during learning, some students did not pay attention to the teacher's explanation. Students were seen teasing their friends or playing around by themselves. Some students looked inferior and afraid of the lesson. When given problem-solving questions by the teacher, some students still had difficulty in working on them and waited for their friends to solve them. The results of student solutions were also less varied.

Method

Research Design

This study used research & development (R&D) approach, using the ADDIE model of development: analysis, design, development, implementation, and evaluation. This research design uses a quasi-experimental technique and a pretest-posttest control group tool. The sampling technique was cluster random sampling, which enabled the researchers to divide the population into several clusters, which were randomly used as samples.

Applying the ADDIE model, in the first stage of analysis, the need for the development of RME-based learning tools was carried out. The general procedures at the analysis stage are student needs analysis, curriculum analysis, student characteristics analysis and work plan analysis. At the design stage, a product design was developed using RME-based learning tools. At the development stage, the learning tool based on the RME approach was developed and adjusted to the 2013 Curriculum. The learning tools developed consisted of a lesson plan and a student book. In the implementation stage, quasi experiment technique was utilized with pretest posttest group design. The experimental class used RME-based learning tools, while the control class used conventional learning. The independent variable of the study was the RME-based learning tools while the dependent variable was the level of students' HOTS. Finally, in the evaluate stage, products developed at each stage of ADDIE were evaluated. The evaluation was carried out to improve the product that has been prepared, so that a product is obtained that is suitable for use in the learning process. Table 1 presents the design of Pretest-Posttest of control group.

Table 1

Design of Pretest-Posttest Control Group

Class/group	Pretest	Treatment	Postest
Experiment class	E1	X	E2
Control class	C1	Y	C2

Description

E1 : Pre test in the experimental class
E2 : Post test in the experimental class
X : RME learning in the experimental class
C1 : Pre test in the control class
C2 : Post test in the control class
Y : Conventional learning in the control class

Population and Sample

The research population of this study comprised students of year 8 at Ngemplak State Junior High School 1, Yogyakarta. A sample of 32 students each from Class VIII E and Class VIII F (total n=64) was selected for this study. The selection of class was done by purposive cluster random sampling technique which was based on the category of class and certain considerations.

The Higher Order Thinking Skill (HOTS) Instrument

The HOTS pretest-posttest instrument is used to obtain data on students' HOTS which is the instructional impact of the developed learning device. HOTS pretest questions are designed to determine HOTS learning before students take part in learning with RME-based learning devices. While HOTS posttest questions are designed to determine HOTS after students take part in learning with RME learning devices. The research instruments are validation sheets, practicality sheets, and HOTS test items. The assessment of the feasibility of the RME-based student book is based on four aspects: (a) the format of the student book, (b) illustrations, layout of tables and diagrams or pictures, (c) the content of the student book, and (d) language and writing style. The assessment of the feasibility of the lesson plan encompassed the format of the lesson plan, formulation identity, learning objectives, basic competencies, teaching methods, planning of learning activities, selection of learning resources, conclusion, assessment of learning achievement, language, and writing style. The indicators for developing HOTS instruments are based on the revised Bloom taxonomy (Arifin & Retnawati, 2017). Table 2 presents these HOTs indicators.

Table 2

HOTS Indicators

No	Indicator	Sub Indicator	Information
1	Analyzing	Organizing	Analyzing and finding relationships between contextual problem information
		Attributing	Analyzing complex information. Identifying relationships between different concepts, Making logical conclusions
2	Evaluating	Checking	Checking the truth
		Critiquing	Providing justification
3	Creating	Formulating	Making connections from the information provided and presenting it in a mathematical model
		Planning	Solving a contextual problem

Data Analysis

Statistical analysis in this study used the General Linear Models (GLM) test. The feasibility of the research product was obtained from appraisal results by experts, practicality by teachers, and product effectiveness from the analysis results of the answers to the HOTS test questions. Analyses of the validation of product and practicality were conducted by deviation standard while that of effectiveness by the GLM test. Data validity and practically of the RME-based learning tools were converted into a qualitative scale according to the guidelines presented in Table 3.

Table 3

Five Scale Score Conversion

Interval	Category
$\mathbf{X > \bar{X}_i + 1,8sb_i}$	Very Good
$\mathbf{\bar{X}_i + 0,6sb_i < X \leq \bar{X}_i + 1,8sb_i}$	Good
$\mathbf{\bar{X}_i - 0,6sb_i < X \leq \bar{X}_i + 0,6sb_i}$	Quite Good
$\mathbf{\bar{X}_i - 1,8sb_i < X \leq \bar{X}_i - 0,6sb_i}$	Not Good
$\mathbf{X \leq \bar{X}_i - 1,8sb_i}$	Bad

The pretest-posttest assessment of HOTS was used to evaluate the effectiveness of the RME-based learning tools. The analysis of the effectiveness of the RME-based learning tools was conducted using the GLM test by employing SPSS (Statistical Product and Service Solution) software, ensuring that the pretest and posttest data met the prerequisites of homogeneity and normal distribution. The GLM test was conducted to examine the presence of differences in pretest-posttest HOTS scores within each group and the presence of enhancements in pretest-posttest HOTS scores within each group and to determine the extent of the effectiveness contribution of the RME-based learning tools for the enhancement of students' HOTS. The proposed hypotheses were divided into two groups as follows:

Group 1 Hypothesis Testing 1:

H0: *There is no difference in pretest-posttest HOTS scores within each research group*
H1: *There is a difference in pretest-posttest HOTS scores within each research group*

Group 1 Hypothesis Testing 2:

H0: *There is no enhancement in pretest-posttest HOTS scores within each research group*
H1: *There is an enhancement in pretest-posttest HOTS scores within each research group*

Results

Analysis stage

The analysis stage yielded results indicating that mathematics teaching activities at the school had not been implemented as expected. Observations and interviews with several mathematics teachers revealed the following: classroom mathematics teaching had not actively engaged students, it had not been connected to real-life problems, making it too abstract for students, and teachers had not developed or implemented RME-based learning suited to the needs and characteristics of students. Based on this analysis, it was clear that mathematics instruction had not fostered a learning environment conducive to developing students' HOTS.

Design stage

The design stage involved developing a product blueprint, namely RME-based learning tools. A lesson plan was prepared as a guideline for teachers in carrying out learning. The lesson plan was designed based on the syllabus that had been prepared. In compiling the lesson plan, it was adjusted to the steps of RME learning. The components in the lesson plan consisted of subject identity, core competencies, basic competencies, indicators of competency achievement, learning objectives, teaching materials, time allocation, learning methods, learning activities, learning achievement assessments, and learning resources.

The student book was developed through steps of instructions based on Realistic Mathematics Education (RME) approach. These steps consisted of: 1) understanding daily problems or contexts, 2) explaining contextual problems, 3) developing a symbolic scheme/model, 4) solving contextual problems, 5) comparing and discussing solutions, and 6) drawing conclusions (Wahyudi et al., 2017). Figure 1 presents the student book cover.

Figure 1: *Book Cover*

Development stage

Development stage involved product validation by expert lecturers and teachers. The outcome of the development stage was the assessment of whether or not the developed product was valid. The validation results comprised both validity and practicality of the product.

(i) Validity of product

The feasibility of the RME-based learning tools was assessed based on the validation results from expert lecturers and practitioners. The validation of the student book was based on aspects including the format of the textbook, illustrations, layout of tables and diagrams/images, content of the book, and language and writing style. Meanwhile, the aspects considered in the lesson plan comprised the format of the lesson plan, subject identity, formulation of learning objectives, basic competencies, learning methods, planning of learning activities, selection of learning resources, conclusion, assessment, and language and writing style. The results of the analysis are presented in Table 4.

Table 4

Lesson Plan Validation by Expert

Aspects	Expert 1	Expert 2	Maximum Scores	Category
Format of the lesson plan	24	24	25	Very Good
Subject Identity	9	10	10	Very Good
Formulation of learning objectives	9	10	10	Very Good
Basic Components	23	24	25	Very Good
Learning Methods	14	14	15	Very Good
Planning Learning Activities	51	53	55	Very Good
Selection of Learning Resources	14	15	15	Very Good
Conclusion	15	15	15	Very Good
Assessment	14	14	15	Very Good
Language and Writing Style	9	10	10	Very Good
Total Score	182	189	195	

As depicted in Table 4, based on the validation by expert lecturers, the validity of the lesson plan and student book falls within the category of "very good". Expert 1 provided a total assessment score for the lesson plan of 184, and expert 2 provided a total assessment score of 189, out of the maximum total score of 195. The results of the experts strongly suggest that the lesson plan developed in the study were suitable for use in junior high school mathematics education.

Table 5

Student Book Validation by Expert

Aspects	Expert 1	Expert 2	Maximum Scores	Category
Format of Student Book	24	24	25	Very Good
Illustrations, table layout, and diagrams/pictures	23	24	25	Very Good
Contents of the Book	32	33	35	Very Good
Language and writing style	18	19	20	Very Good
Total Score	97	100	105	

In Table 5, based on the validation by expert lecturers, the assessment of the student book indicates that its validity falls within "very good" category. Expert 1 provided a total assessment score of 97, and expert 2 provided a total assessment score of 100 for the student book, out of the maximum total score of 105. This indicates that the student book developed in the study was suitable for use in junior high school mathematics education, according to the experts.

(ii) Practicality of Product

In Table 6, it is evident that the practicality of the learning tools falls within the "very good" category. Teacher 1 provided a total assessment score of 111, and Teacher 2 provided a total assessment score of 113, out of the maximum total score of 115. This reinforces the conclusion that the RME-based learning tools were suitable for use as mathematics learning material for junior high school students, according to the teachers.

Table 6

Practicality Product by Teachers

Aspects	Teacher 1	Teacher 2	Maximum Scores	Category
Lesson Plan	43	44	45	Very Good
Student Book	33	34	35	Very Good
Learning Implementation	35	35	35	Very Good
Total Score	111	113	115	

Implementation stage

Results of Quasi Experiment

The Implementation stage was conducted to gather data regarding the effectiveness of the developed learning tools product. During the implementation stage, the product was tested with students. The effectiveness of the RME-based learning tools was assessed through field trials to measure students' HOTS. The testing was conducted by comparing classes that utilize RME-based learning tools in classes that use conventional teaching materials as employed by teachers. The analysis of normality and homogeneity for pretest-posttest data on Higher Order Thinking Skills (HOTS) was conducted using SPSS 22. The analysis yielded the following results shown in Table 7.

Table 7

The results of the Normality Test

Test	Class	Statistics	SD	Asymp. Sig. (2-tailed)	Description
Pretest	Contrast	6.751	0.103	0.200	Normal
	Experiment	5.328	0.114	0.200	Normal
Post-test	Contrast	5.675	0.107	0.200	Normal
	Experiment	4.321	0.131	0.178	Normal

Based on Table 7, the significance values of the normality test for the experimental and control classes are greater than 0.05 (Sig>0.05). These results indicate that the pretest and posttest data for the experimental and control classes are normally distributed. The homogeneity of variance data was tested using Levene's test of equality of error variances, whose results are presented in Table 8.

Table 8

Hasil Levene's test of equality of error variances

	Levene Statistic	df1	df2	Sig.	Description
Pretest HOTS	1.197	1	62	0.278	Homogenous
Post-test HOTS	1.594	1	62	0.211	Homogenous

Table 8 reveals that the significance values of the homogeneity test for pretest and posttest are greater than 0.05 (Sig>0.05). These results indicate that the pretest and posttest data for the experimental and control classes are homogenous. The pretest-posttest data indicate homogeneity and normality; thus, the testing proceeds to assess the effectiveness of the developed product. The effectiveness of the developed product was evaluated using the General Linear Model (GLM) test, utilizing the pre-test and post-test data from both the experimental and control classes. The results of the analysis are presented in Table 9.

Table 9

Test of Within-Subject Effects

Time*Class	*Type II Sum of Square*	*df*	*F*	*Sig.*
Greenhouse-Geisser	392.000	1.000	49.701	.000

Results of the Hypothesis

The first group of hypotheses regarding the presence of differences in pretest-posttest HOTS scores within each research group was examined based on the significance value. If the significance value is <0.05, then Ho is rejected. As shown in Table 10, the results of the Within-Subject Effect test indicate a significant level of < 0.05. It can be concluded that there is an interaction between the pre-test and post-test scores and the experimental and control classes. The interaction indicates that the difference in scores between the pre-test and post-test of the two research groups is significant. It is also concluded that there is a difference between the pretest and posttest HOTS scores for each research group. The results obtained indicate that there are changes in scores, both enhancements and declines. To determine whether there was an increase in pretest-posttest scores, Pair-wise Comparisons were also conducted yielding the results shown in Table 10.

Table 10

Pair-wise Comparison

Class	Time (I)	Time (J)	Mean Difference (I-J)	Std.Error	*Sig.*
Experiment	1	2	-13.250	.702	.000
	2	1	13.250	.702	.000
Control	1	2	-6.250	.702	.000
	2	1	6.250	.702	.000

The second group of hypotheses regarding the presence of enhancement in pretest-posttest HOTS scores within each research group was examined based on the significance value in the Pair-wise Comparison analysis. If the significance value is <0.05, then Ho is rejected. The analysis results presented in Table 9 indicate that both research groups exhibit significant changes in HOTS; for the experimental group, the Mean Difference (MD) is –13.250 with a significance level of $p<0.05$. Similarly, for the control group, the Mean Difference (MD) is –6.250 with a significance level of $p<0.05$. Both research groups exhibit increases in Higher Order Thinking Skills (HOTS) levels following the research treatment.

Table 11 indicates the results of the multivariate test using Wilks' Lambda. The effectiveness of the product can be observed in the partial eta square section. The statistical results in Table 11 indicate that the multivariate test for the experimental class shows a partial eta square of 0.852, signifying that the RME-based learning material implemented in the class can increase students' HOTS level by 85%. Conversely, for the control class, the partial eta square is 0.561, indicating an increase in students' HOTS level by 56%.

Table 11

Multivariate Test

	Class	Value	*F*	Hypothesis *df*	Error *df*	*Sig.*	*Partial Eta Square*
Wilks' Lambda	Control	.439	79.243	1.000	62.000	.000	.561
	Experiment	.148	356.151	1.000	62.000	.000	.852

The increase in HOTS can be visualized through a graph of estimated marginal means. Figure 2 illustrates that both research groups demonstrated enhancement in HOTS. Subsequently, it was observed that the RME-based learning tools provided a greater enhancement in Higher Order Thinking Skills (HOTS) for the experimental class compared to the control class.

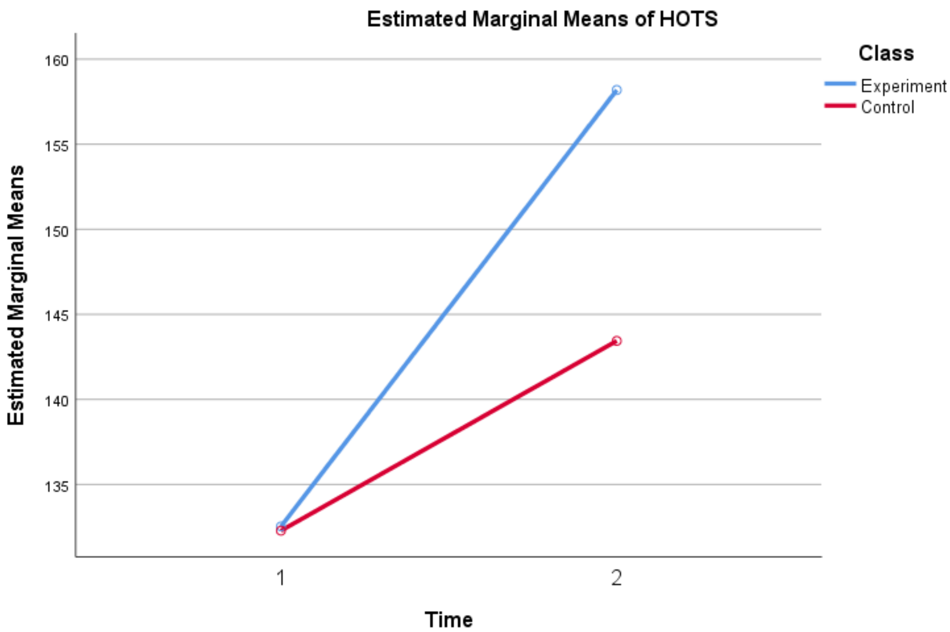

Figure 2: *Estimated Marginal Means of HOTS*

Evaluation Stage

The evaluation stage was the final step in the ADDIE development model. At this stage, the developed product was assessed. Based on the design and implementation stages, the product was deemed feasible and capable of enhancing students' HOTS, indicating that the development process had achieved its intended goals. Feedback from expert lecturers and practitioners was used as evaluation material to further improve the quality of the developed product.

Discussion

This study developed the RME-based learning material product and aligned it with the 2013 Curriculum. The learning tools comprised an RME-based lesson plan for teachers and a student book. The lesson plan was developed to serve as guidelines for teachers in implementing RME-based learning in their classes. Meanwhile, the student book contained activities for students to engage in during instructional processes, including mathematics problems that need to be solved during class. Based on the results of the feasibility analyses of the RME-based learning tools, it is concluded that, according to experts and practitioners, the RME-based learning tools are suitable for classroom use to enhance students' HOTS and their attitudes toward mathematics learning. The experts and practitioners have rated the developed products as "Very Good".

The effectiveness of the RME-based learning tools was evaluated through field trials aimed at measuring students' Higher Order Thinking Skills (HOTS). This was done by comparing the class using the RME-based material with the class using the materials typically developed by the teacher. The trial results, in the form of pre-test and post-test scores, were statistically analyzed using the General Linear Model (GLM) test. The HOTS test items utilized in the study encompass three aspects: analysis, evaluation, and creation. Each aspect consists of indicators such as organizing, attributing, studying, criticizing, synthesizing, and planning. The analyses results of the students' HOTS enhancement, as depicted in the graph of the estimated marginal means in Figure 2, indicate that both research groups experience enhancement in their HOTS. From the graph, it is evident that the experiment class exhibits the highest rate of HOTS enhancement. This leads to the conclusion that the RME-based material can induce a greater enhancement in HOTS within the experimental group compared with the control group. This can be seen from the statistics where the experimental group exhibits a gain score of 0.66, whereas the control group shows a gain score of 0.28.

Based on the findings of the Within-Subject Effect test, it is indicated that in both groups (experimental and control), there are differences in pretest-posttest scores (significance value <0.05), and the Pair-wise Comparison test results demonstrate an increase in pretest-posttest scores for HOTS within each research group (significance value <0.05). Therefore, it can be observed that in both research groups, differences and increases in pretest-posttest scores are attributed to the instructional intervention. However, the multivariate statistics reveal a partial eta square of 0.852 in the experimental group. This indicates that the RME material contributes to an 85% enhancement in students' HOTS, whereas, by comparison, the HOTS enhancement in the control group reaches 56% (partial eta square score=0.561).

Consequently, it is evident that RME-based learning tools exhibit a greater degree of effectiveness compared to conventional instructional methods.

In the development of the research tools, the steps of RME can be associated with indicators of HOTS. Step 1 of RME, which involves understanding daily problems or contexts, can facilitate students in analyzing and identifying relationships between contextual information related to linear functions. Step 2, explaining the contextual problems, can assist students in providing arguments related to linear functions. Step 3, developing a symbolic scheme/model, can aid students in establishing connections from given information and presenting it in a mathematical model related to linear functions. Step 4, solving the contextual problems, can help students in solving contextual problems related to linear functions. Step 5, comparing and discussing the answers, can enable students to verify the correctness related to linear functions. Finally, step 6, drawing a conclusion, can guide students in providing justifications related to linear functions.

The research products, namely the RME-based lesson plan and student book, incorporate RME-based steps and approaches aimed at fostering student engagement and activity within the learning-teaching process. Overall, the research findings indicate that the developed RME-based learning tools effectively enhance students' higher order thinking skills (HOTS), encompassing analysis (organizing, attributing), evaluation (examining, criticizing), and creation (formulating, planning) aspects. The RME-based lesson plan and student book provide students with learning experiences closely aligned with their everyday environments, facilitating a smoother transition from abstract concepts to concrete realities. This realistic approach enhances students' readiness and ease in learning.

Conclusion

The primary objective of this study was to develop a feasible learning tool and evaluate the effectiveness of RME-based instructional tools in enhancing students' HOTS. This study employed a quasi-experimental method to compare the effectiveness of RME-based mathematics learning with conventional mathematics instruction. The findings indicate that the RME-based instructional tools for mathematics learning, focusing on the topic of linear functions, effectively enhances students' HOTS, as evaluated by both lecturer experts and teacher practitioners. Therefore, it presents a viable alternative for enhancing students' HOTS levels.

These findings reveal that the experimental group, which utilized the RME material, experienced an 85% enhancement in students' HOTS. In contrast, the control group demonstrated a HOTS enhancement of 56%. The limitation of research are (1) The time required to complete the problems and activities in the student's book should be in accordance with the design, but when the trial is taking place, there are changes because the students' ability levels are very diverse. (2) The implementation of the trial is still not free from the possibility of bias caused by: (a) the rules and spatial arrangements that should be arranged so that students really show their respective abilities, but in this study were not well conditioned, (b) students in their respective groups solve problems and carry out activities contained in the student's book, however there are still students who cannot be maximally involved in group work due to the limitations of the students' abilities.

The implication of this study suggests that RME could serve as an effective alternative for enhancing students' higher order thinking skills (HOTS). Implementing RME based on real-life scenarios provides students with opportunities to independently analyze and evaluate their thought processes, enabling them to draw conclusions from the knowledge they construct with guidance from probing questions.

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