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THE EFFECT OF REALISTIC MATHEMATICS EDUCATION APPROACH AND LEARNING MOTIVATION TO IMPROVING HIGHER ORDER THINKING SKILLS BY CONTROLLING STUDENTS INTELLIGENCE QUOTIENT

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ABSTRACT

This study aimed to determine whether students' HOTS could be improved by using the Realistic Mathematics Education (RME) approach. More specifically, this research wants to know the effect of the RME approach on HOTS, it will be studied from students' learning motivation and will be controlled for students' Intelligence Quotient (IQ). The research design used was pretest-posttest control group design with covariables and the implementation of the research design was factorial design by level (2 X 3). The research samples were 110 twelfth grade students from two schools in East Jakarta in the 2022/2023 academic year. The results of the study showed that the increase in HOTS of students who were taught using the RME approach was higher than students who were taught with conventional learning after controlling for students' IQ. There are differences in HOTS abilities between students with high, medium, and low motivation after controlling for student IQ. There is an influence between the learning approach and learning motivation on HOTS abilities after controlling for students' Intelligence Quotient.

Keywords: RME Approach, Learning Motivation, HOTS, IQ

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PRELIMINARY

In this era of globalization, schools need to equip students with Higher Order Thinking Skills (HOTS) in order to adapt to the rapidly changing times. HOTS include the ability to analyze, the ability to evaluate, and the ability to create, (Bloom, 1956). Schools need to design a learning process that can improve students' HOTS. According to HOTS is not just learning facts and concepts, but requires different learning and teaching techniques, to best fulfil the indicators in HOTS, the best design should be used when planning teaching and learning with stages that train students' abilities, (Hasanatul Hamidah, 2018).

The development of students' HOTS is a priority for education in Indonesia. Various

efforts have been made by the Government of Indonesia, among others, by implementing HOTS-based curriculum in the 2006 curriculum (KTSP), 2013 curriculum, and independent curriculum as outlined in the content standards in learning mathematics. The three curricula state that the purpose of learning mathematics in Indonesia is to develop students' HOTS which include criticism, creativity, communication, and collaboration. The government made this effort because the HOTS of Indonesian students is still low. This is reflected in the low PISA test results of Indonesian students. Table PISA results on Mathematics Achievement in Indonesia by (OECD, 2018).

Table 1. Table PISA results on Mathematics Achievement in Indonesia

No	Year	Mean Score	Rank	Participant	Student achievement (%)	
					Level 5 or 6	Below Level 2
1	2003	362.2	38	40		
2	2006	399.0	48	56		
3	2009	371.0	61	65		
4	2012	375.0	64	65	0.30	75.70
5	2015	386.0	65	72	0.90	42.30
6	2018	379.0	74	79	0.60	51.70

Sources : PISA Report : 2003-2018

Data shows that the results of PISA in the last year, 2018, indicates that Indonesia is still ranked 74th out of 79 participating countries, (OECD, 2018). The weak results of Indonesian students in the PISA mathematics survey and the previous year led to the decision of the Ministry of Education and Culture (Kemendikbud) of the Republic of Indonesia to place more emphasis on the inclusion of HOTS in the curriculum starting in 2018. As a result of this policy, the Government through MoEC organized HOTS-based National Examinations (UN). The results of the UN in the data from the Ministry of Education and Culture (2018) show that the percentage of high school and vocational school students who answered correctly the mathematics questions in the UN are less than 50%, (Fitri & Revita, 2019).

Facts in the field related to the low HOTS occur in vocational schools in the East Jakarta area. Based on interviews with subject teachers at SMK Al Wahyu and SMK Karya Dharma 2 Jakarta, information is obtained that Student learning outcomes are still low, especially on mathematics questions that require higher order thinking skills (HOTS), especially on the material of area and volume of rotating objects. Next, HOTS learning in mathematics is rarely explicitly programmed by school teachers. As a result, students' HOTS are at the lowest level, especially in national or international assessments. Next,

Mathematics learning in Indonesia, especially in Vocational High Schools, is still traditional and mechanistic. Mathematics teaching lacks emphasis on developing students' reasoning, logic, and thinking process. Maths teaching is dominated by the application of formulas and verbal definitions, without adequate attention to student understanding, (Siagian & Sagala, 2021).

Considering the fact that Indonesian students' HOTS is still low, both from the PISA and UN 2018 data, many studies have been conducted related to students' HOTS. Some teachers are less prepared to carry out teaching and learning by integrating HOTS, (Hanik et al., 2020). This is due to the lack of diversity in HOTS teaching strategies used by teachers. Stated that teachers also do not have guidelines on HOTS teaching methods. This contributes to the limitations in diversifying HOTS teaching methods and strategies during class, (Pius et al., 2019).

Appropriate learning approaches can be used to improve students' HOTS. One of the learning approaches that can be used is Realistic Mathematics Education (RME). Stated that RME originated from the idea that mathematics is part of human life, (Freudenthal, 1971). Stated that RME aims to empower mathesmatics as a key process in learning mathematics by (Laurens et al., 2017). Furthermore, stated that RME refers to teaching that reconstructs mathematical concepts so that students learn them in their own way using realistic problems that are real events in their minds as a stimulus, (Noviani et al., 2017). Next, One of the mathematics learning that allows students to develop mathematical thinking skills is RME by (Palinussa, 2013). Mentioned that the RME approach is unique in that it provides rich and realistic situations in learning activities that are easy to understand by (Juandi et al., 2022).

Several studies on how to improve students' HOTS with the RME approach have been conducted. Next, students' HOTS ability is positively and significantly influenced by the Realistic Mathematics Education (RME) approach and the CPS model by (Sasmi et al., 2020). The application of the RME approach, as indicated by the principles of RME, can support students' HOTS ability in problem solving and facilitate students to develop higher order thinking skills by (Ndiung, 2021) and (Pangestika & Cahyaningsih, 2022).

Apart from being influenced by the learning approach, students' HOTS abilities can also be influenced by other factors, namely motivation. Motivational factors can potentially influence students' HOTS ability. Learning motivation plays a role in determining learning outcomes and how students can train and develop other abilities such as HOTS. It was concluded that motivation is one of the aspects that influence learning

success by (Purnama & Nurdianingsih, 2019). Furthermore, researchfound that learning activities carried out through the application of HOTS learning will produce good achievement if accompanied by high motivation by (Yunus, 2021).

Another factor that can affect HOTS is students' Intelligence Quotient (IQ). IQ is a measure of a person's intelligence level. Research linking IQ and HOTS has been conducted by (Wulandari et al., 2022). The results reported are that students' IQ affects students' mathematical communication skills in solving HOTS problems, where students who have high IQ tend to have higher mathematical communication skills than students who have lower IQ levels.

Research conducted by (Sasmi et al., 2020), (Ndiung, 2021), and (Pangestika & Cahyaningsih, 2022) have used the RME approach to see its effect on HOTS. This study use the RME approach to see its effect on improving students' HOTS, and more specifically in this study the effect will be examined from various levels of student motivation and by controlling the effect of student IQ. Another distinctive feature of this study is that it is conducted on vocational school students whose focus is more skill-orientated. The mathematics topic that will be used in this study is about rotating objects. The selection of this topic is based on preliminary research conducted by (Minarti & Hakim, 2022) which concluded that the understanding of the concept of rotating objects in vocational school students is not optimal. The selection of this research topic is also based on the results of bibliometric analysis with the vosviewers application of research on HOTS that has been done before which mostly discusses topics in the realm of Bloom's taxonomy, learning, design, models, analysis, activities, and curriculum.

METHODS

This type of research was quantitative research using a pseudo-experimental method. The research design used was pretest-posttest control group design with covariates and the implementation of the research design was factorial design with levels (2 X 3). As the dependent variable is Higher Order Thinking Skills (Y), the independent variables are Realistic Mathematics Education and Conventional approaches (A) and Motivation to Learn Mathematics (B), while as a covariate is Students' Intelligence Quotient (X).

Table 2. Experimental Research Design Pretest-Posttest of Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Class	Y_1	A_1	Y_2
Control Class	Y_1	A_2	Y_2

Descriptions: Y_1, Y_2 = measurement of observed variables through pretests and posttests; A=treatment given to the treatment group

The population in this study were all the twelve grade students from two vocational schools majoring in Office Management Automation in East Jakarta with 283 students in the academic year 2022/2023. The samples were taken randomly as many as 110 students consisting of 50 students in the experimental class and 60 students in the control class.

The instruments used were mathematics learning motivation questionnaire, HOTS skill test, and IQ test. The questionnaire of motivation to learn mathematics consisted of 21 valid items out of 36 items with a correlation coefficient in the range of 0.405 to 0.787 and a reliability of 0.8800.

Tabel 3. The Results of the Calculation of the Empirical Validity of the Mathematics Learning Motivation Questionnaire Instrument

No.	r_{count}	r_{tabel}	Result	No.	r_{count}	r_{tabel}	Result
1.	0,474	0,404	Valid	19.	0,009	0,404	Invalid
2.	0,535	0,404	Valid	20.	0,466	0,404	Valid
3.	0,787	0,404	Valid	21.	0,673	0,404	Valid
4.	0,088	0,404	Invalid	22.	0,385	0,404	Invalid
5.	0,249	0,404	Invalid	23.	0,456	0,404	Valid
6.	0,001	0,404	Invalid	24.	0,109	0,404	Invalid
7.	0,628	0,404	Valid	25.	0,602	0,404	Valid
8.	0,380	0,404	Invalid	26.	0,587	0,404	Valid
9.	0,479	0,404	Valid	27.	0,361	0,404	Invalid
10.	0,442	0,404	Valid	28.	0,499	0,404	Valid
11.	0,201	0,404	Invalid	29.	0,708	0,404	Valid
12.	0,405	0,404	Valid	30.	0,356	0,404	Invalid
13.	0,446	0,404	Valid	31.	0,299	0,404	Invalid
14.	0,434	0,404	Valid	32.	0,397	0,404	Invalid
15.	0,586	0,404	Valid	33.	0,477	0,404	Valid
16.	0,557	0,404	Valid	34.	0,424	0,404	Valid
17.	0,186	0,404	Invalid	35.	0,034	0,404	Invalid
18.	0,567	0,404	Valid	36.	0,029	0,404	Invalid

The HOTS skills test consisted of pretest and posttest in the form of essays with a total of 8 questions each, with validity in the range of 0.401 to 0.704 and 0.407 to 0.705 and reliability of 0.5917 and 0.5958 respectively.

The IQ test used is a standardized test conducted in Indonesia by several hospital agencies in collaboration with schools to check students' IQ ability, namely the Intelligent Structure Test (IST) because this test focuses more on students' Intelligence Quotient specifically not just general Intelligence. Data analysis was conducted using two-way analysis of covariance (ANCOVA).

RESULT AND DISCUSSION

1. Data Description

The summary statistical description of HOTS improvement data (N-Gain HOTS) in experimental and control classes based on motivation level groups is presented in Table 4. The motivation level was categorized into high (score ≥ 86), medium (72 - 85), and low (< 72). The linear relationship between IQ and HOTS N-Gain is presented in Figure 1.

Table 4. Statistical Description of HOTS N-Gain Data with the RME Approach and Conventional Learning Based on Students' Learning Motivation Level

Mathematics Learning Motivation	RME					Conventional				
	Number of Students	Min N-Gain	Maks N-Gain	$\bar{x}$	SD	Number of Students	Min N-Gain	Maks N-Gain	$\bar{x}$	SD
High	12	0,70	0,82	0,76	0,04	9	0,13	0,68	0,45	0,18
Medium	35	0,25	0,82	0,58	0,14	35	0,04	0,62	0,30	0,14
Low	3	0,21	0,29	0,25	0,04	16	0,06	0,45	0,27	0,12
Total	50	0,21	0,82	0,60	0,16	60	0,04	0,68	0,32	0,15

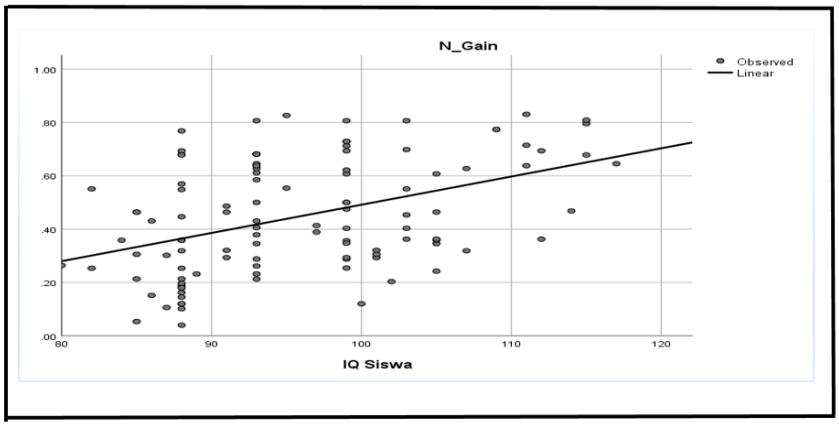

Figure 1. Scatter diagram and regression line between IQ and HOTS N-Gain

The regression line equation relating IQ and HOTS N-Gain is N-Gain HOTS Estimation = -0,566 + 0,011 × IQ.

2. Hypothesis Testing

Hypothesis testing was conducted to test the research hypothesis that learning approach and motivation have an effect on HOTS improvement, and there was also an interaction effect between learning approach and learning motivation on HOTS improvement after controlling for students' IQ. Hypothesis testing was carried out with the help of SPSS 21 for windows software with the results as follows:

Table 5. ANOVA test results of the effect of learning approach and learning motivation on HOTS improvement by controlling student's IQ Tests of Between-Subjects Effects
Dependent Variable: NGain_HOTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31596.599[a]	6	5266.100	31.201	.000
Intercept	683.439	1	683.439	4.049	.047
IQ	3237.129	1	3237.129	19.180	.000
Approach	2140.338	1	2140.338	12.681	.001
Motivation	1427.958	2	713.979	4.230	.017
Approach * Motivasi	1531.894	2	765.947	4.538	.013
Error	17384.092	103	168.778		
Total	268860.000	110			
Corrected Total	48980.691	109			

a. R Squared = .645 (Adjusted R Squared = .624)

Table 5 shows that F count in the learning row is 12.681 with p-value (Sig.) = 0.001. With a significance level of 0.05, it can be concluded that there is an effect of the RME approach and the conventional approach on HOTS improvement by controlling for students' IQ. In the Motivation row, the F value is 4.230 and the p-value is 0.017 so it can be concluded that at the 0.05 significance level there is a difference in HOTS between students who have high, low, and medium motivation after controlling for student IQ. Furthermore, from the table above, the calculated F value to test the interaction of learning approach and motivation is 4.538 with a p-value of 0.013, so that with a significance level of 0.05 it can be concluded that there is an interaction between learning approach and learning motivation on HOTS by controlling students' IQ.

The interaction between learning approach and motivation on students' HOTS improvement by controlling IQ is interesting to be analyzed further. Table 4 shows that in classes taught with the RME approach for groups of students with high, low, and medium learning motivation, the average HOTS improvement was 0.76, 0.58, and 0.25, respectively. This showed that for students taught with the RME approach, the HOTS

improvement of students with high motivation was better than the HOTS improvement of students with medium motivation, and the HOTS improvement of students with medium motivation was better than the HOTS improvement of students with low motivation after controlling for student IQ. Furthermore, the class taught with the conventional approach for groups of students with high, low, and medium learning motivation had an average HOTS improvement of 0.45, 0.30, and 0.27, respectively. Slightly different from the experimental class, for students taught with the conventional approach, the HOTS improvement of students with high motivation was better than the HOTS improvement of students with medium motivation, but the HOTS improvement of students with medium motivation was not different from the HOTS improvement of students with low motivation after controlling for student IQ. The above conclusions have been confirmed by the post hoc test with Tukey test.

Next, we analyzed the differences in HOTS improvement in each learning motivation group. Table 5 shows that for the group of highly motivated students, the average HOTS improvement of students taught with the RME approach was 0.76 and higher than the average HOTS improvement of students taught with the conventional approach which was only 0.45. Furthermore, for the group of students with medium motivation, the average increase in HOTS of students taught with the RME approach was 0.58 and also higher than the average increase in HOTS of students taught with the conventional approach which was 0.30. Finally, for the group of students with low motivation, the average increase in HOTS of students taught with the RME approach was 0.25 which was not significantly different from the average increase in HOTS of students taught with the conventional approach, which was 0.27.

DISCUSSION

The results of data analysis showed that the realistical mathematics learning approach had a significant effect on improving students' higher order thinking skills or HOTS. From the results of the analysis of covariance, significant differences were obtained for students' higher order thinking skills. This result is consistent with other research by (Sasmi et al., 2020), (Arnellis et al., 2020) and (Puspita et al., 2018), namely that the RME approach can effectively improve students' HOTS skills. Explained the interaction between RME and learning motivation on students' mathematics learning outcomes by (Mustaqim et al., 2022). The RME approach and learning motivation are closely related to higher order thinking skills.

Realistic Mathematics Education strongly emphasises the use of context when teaching mathematics. According to research by (Laurens et al., 2017), (Quroidah & Amir, 2021), and (Ardiansah et al., 2019) by choosing a context that really suits the situation or student activities, all crucial stages in RME are established. Then, the transition from informal to formal mathematics is carried out gradually, one of which is the use of off models and for models so that students contribute in finding concepts or solving mathematics. The RME approach through the "teaching and learning process involves an interactive learning process. In other words, interaction occurs between students and teachers, between fellow students, and between students and learning resources that produce contributions to student learning. In these activities, students are trained to improve HOTS.

Realistic mathematics learning is based on the idea or principle that students rediscover mathematical ideas. RME aims to strengthen mathematics as an important process in mathematics learning by (Laurens et al., 2017). RME refers to teaching that reconstructs mathematical concepts so that students learn them in their own way using realistic problems that are real events in their minds as a stimulus by (Ardiansah et al., 2019). Furthermore, according to One of the mathematics learning that allows students to develop mathematical thinking skills is Realistic Mathematics Education (RME) by (Palinussa, 2013). RME approach is unique in that it provides a rich and realistic situation in learning activities so that it is easy to understand by (Juandi et al., 2022).

The results also show that students who have high-level thinking skills with high motivation will produce higher results compared to students who have low and "medium" motivation. This means that student learning motivation greatly affects student learning outcomes, in this case student HOTS results. This means that motivation has an influence on students' higher order mathematical thinking skills scores after controlling for the covariate effect of students' IQ. Furthermore, another result of this study shows that there is a difference in HOTS between the RME approach for high, medium and low motivation students and conventional learning for high, medium and low motivation students after controlling for students' IQ. This is in accordance with research conducted by (Ardiansah et al., 2019); (Muflihah et al., 2022); (Widana, 2021); (Wulandari et al., 2022).

Student motivation in learning is also influential in developing HOTS thinking skills. This is in line with (Purnama & Nurdianingsih, 2019) reporting that students who have low motivation should force themselves to have high motivation because motivation is one of the elements that influence learning success. Next, learning activities carried out

through the application of HOTS learning accompanied by high motivation result in more optimal learning achievement by (Yunus, 2021).

This study reveals that there is an interaction between learning approaches and motivation on the improvement of HOTS by controlling student IQ. RME learning is beneficial in improving HOTS for students with high and medium motivation. The application of RME makes students more creative and independent in communicating their ideas and helps them understand mathematics through problems. Each student will learn to build knowledge by creating a learning plan related to concepts and topics in mathematics, as well as the relationship between mathematics and other sciences, and the daily life experienced by students. Through RME learning, students can connect mathematical problems with everyday life and transform them into more abstract mathematical models.

Learning with the RME approach is more effective than conventional learning in improving students' HOTS. In addition, learning with the RME approach and high learning motivation are very significant in improving students' HOTS. Therefore, realistical mathematics learning can be used as an alternative to learning mathematics in the classroom to improve students' higher order thinking skills.

CONCLUSION

The conclusions obtained from this study are as follows. (1) The HOTS improvement of students taught with RME approach was higher than that of students taught with conventional learning after controlling for students' IQ. (2) There was a difference in HOTS ability among students with high, medium, and low motivation after controlling for students' IQ. (3) There was an interaction between learning approach and learning motivation on HOTS ability after controlling for students' IQ. (4) In the "class taught with RME approach, students with high motivation had higher HOTS ability than students with medium motivation, and students with medium motivation had higher HOTS ability than students with low motivation, after controlling for students' IQ. (5) In the class taught with the conventional approach, students with high motivation had higher HOTS skills than students with medium motivation, and students with medium motivation had higher HOTS skills than students with low motivation, after controlling for students' IQ. Medium motivation have higher HOTS skills than students with low motivation, after controlling for students' IQ. (6) In the group of students with high motivation, HOTS ability of students taught with the RME approach was higher than that of conventional learning after controlling for students' IQ. (7) In the group of students with moderate

motivation, HOTS ability of students taught with the RME approach was higher than that of conventional learning after controlling for students' IQ. (8) In the group of students with low motivation, the HOTS abilities of students taught using the RME approach were no different from those of conventional learning after controlling for students' IQ.

Based on the conclusion of the research results, the following suggestions are given:

1. Teachers need to know students' motivation. If students' motivation is high or medium, it is recommended that teachers use the RME approach because it is better for improving students' HOTS compared to using the conventional approach, and in this case the effect of students' IQ has been taken into account.
2. Further similar research can be conducted with other control variables.
3. For further research, HOTS improvement can also be investigated on other subjects that are adjusted to the characteristics of the selected learning model.

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