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Meta-Analysis : RME Impact on Junior High School Student's Critical Thinking Skills

Fairuz Hanan Nurintya[*1] , Scolastika Mariani[2], Arief Agoestanto[3], Sugiman[4]
[1,2,3,4] Mathematics Education, Universitas Negeri Semarang, Sekaran Gunung Pati, Semarang, 50229, Indonesia

Email: fairuzhanan17@students.unnes.ac.id
* Corresponding Author

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ABSTRACT
Critical thinking is an skills needed in facing revolution 4.0, it is important for students to be equipped with these skills. PISA results and previous research show that students critical thinking skills are still low, a learning approach is needed to improve them. Purpose of this research is to determine impact of RME on junior high school students critical thinking skills from previous research articles. The research method used is meta-analysis. Data collection technique use obtaining data from previous research articles with nationally accredited journals, indexed by SINTA 1 until 5, and containing RME keywords also mathematics critical thinking. There were 6 articles that fit the criteria. The data analysis technique used t-test and Cohen's test to determine the RME impact on critical thinking skills of junior high school students. The result of t-test is $t_{hitung} = 27{,}67 > 1{,}96 = t_{tabel}$ which means that the average of student's critical thinking skills with RME learning higher than the average of student's critical thinking skills with expository learning, so there is a significant impact of mathematics critical thinking skills of junior high school students who use RME learning. While a large impact use Cohen's test with the result is *d*= 0,874 which is included in the interpretation's category is large, that mean is RME learning have a large impact on junior high school student's mathematics critical thinking skills. The implications of this research can be a reference for educators that RME learning can improve junior high school student's mathematics critical thinking skills.
Keywords: critical thinking skills, meta-analysis, realistic mathematics education (RME)

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INTRODUCTION

Skills needed by millennial era and z's generation in facing the era of society 5.0 are called 4C skills (Suyitno et al., 2021). These skills are designed through 21st century learning (Rosnaeni, 2021). One of the 4C skills is critical thinking, which is an important focus in higher education to achieve good academic achievement (Stupple et al., 2017). Along with the rapid advancement

of technology and science, the ability needed is to analyze information to develop arguments (Basri et al., 2019). Critical thinking is an important skill in this case because considering the interpretation of results and developing conclusions from the information or data obtained (Ariza et al., 2024). Creating logical solutions and examining suitable options or information is also a critical thinking process (Alsaleh, 2020). Mathematics is a subject that studies broad thinking skills such as the skills to think logically, analytically, critically and abstractly (Arisoy & Aybek, 2021; Cresswell & Speelman, 2020). Mathematical critical thinking is a systematic process that makes it possible to formulate and evaluate opinions held (Hendriana et al., 2017). Through reasoning, analyzing, asking, and solving problems become important components in critical thinking activities (Arisoy & Aybek, 2021). Facione (2011) states that the aspects of critical thinking include interpretation, analysis, evaluation, inference, explanation, and self-regulation. Meanwhile, Ennis (Kusumawati et al., 2022) explained that there are indicators in critical thinking contains basic support (building basic skills), elementary clarification (providing further explanations), advance clarification (making further explanations), inference, and strategies and tactics.

However, students' abilities in critical thinking still need to be improved, especially for junior high school students. Wilujeng & Sudihartinih (2021) shows that the skills of class VII students at Kalianda Middle School in analyzing and evaluating problems related to arithmetic is still low. In line with this research, Sitompul (2021) in his research shows that class IX students at SMPN 4 Bilah Hulu only take notes on things that the teacher explains, so that when they are given non-routine problems students find it difficult to analyze and solve problems. Hikayat, et al. (2020) in their research found that class VII students in Patuk Gunung Kidul were not able to analyze the questions given and draw conclusions, because the students were too passive when learning took place. PISA is a program that surveys 15-year-old students on their knowledge and skills in analyzing, reasoning, communicating, identifying, interpreting, and solving problems in various situations (OECD, 2023). OECD (2023) explains that mathematics proficiency in PISA 2022 is divided into 8 levels. At level 1c, students can answer easy-to-understand questions where all information is given clearly in a simple format. At level 1b, students can answer questions with simple representations (graphs or tables). At level 1a, students can use basic algorithms, formulas, procedures or conventions to solve problems that most often involve whole numbers. At level 2, students demonstrate a basic understanding of functional relationships and can solve problems involving simple ratios. At level 3, students can interpret and use representations based on different information sources and reason directly from them, including conditional decision-making using a two-way table. At level 4, students construct and communicate explanations and arguments based on their interpretations, reasoning, and methodology. At level 5, students reflect on their work and consider mathematical results with respect to the real- world context . At level 6, students capable of critical thinking and have a mastery of symbolic and formal mathematical operations and relationships that they use to clearly communicate their reasoning. Based on the PISA 2022 results, only 18% of Indonesian students can reach level 2 in mathematics, where the average for OECD countries is 69%, which means it is still far below the average and no one reached level 5 or 6. From the PISA results and the explanation of the division of levels from PISA, shows that critical thinking skills of students in Indonesia are still low and need to be improved. That is also supported that critical and

creative thinking is an important contribution to the development of the thinking process required by PISA (OECD, 2023).

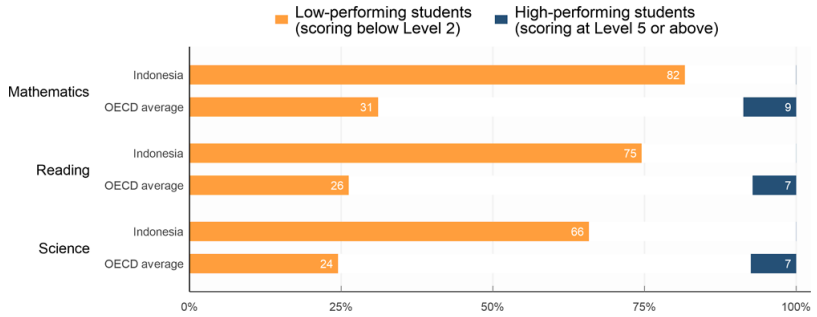

Figure 1. Indonesia's PISA results and OECD average

Ratnawati et al. (2020) explained that one of the causes of students' low critical thinking skills is due to learning strategies that do not actively involve students. Improving critical thinking skills can be done through a learning model that contains processes of material mastery, internalization, and material transfer in different cases, especially in the *transfer of learning process* (Saputra, 2020). So learning strategies are needed, one of which is a learning approach that provides facilities for students to be active in learning. *Realistic Mathematics Education* (RME) is a learning approach that does not start with abstract rules but with concrete principles or rules, where the important process is the construction of knowledge by students themselves (Cobb et al., 2008). The main principles of RME approach include (1) guided *discovery* ; (2) progressive mathematics; (3) didactive phenomena; and (4) self-development model (Gravemeijer, 1994). With characteristics namely (a) use of real world context; (b) use of models that bridge between instruments; (c) student contribution; (d) interactivity or two-way communication; and (e) interrelated (Palinussa, 2013). Apart from that, there are several things that characterize learning using RME approach, namely (1) students who are active in learning; (2) student-centered learning, where the teacher is only a facilitator; (3) the learning used is in the form of guided inquiry, where students discover mathematical concepts and principles on their own; (4) contextual learning, which is connected to students' experiences or daily lives; and (5) constructivist learning, students find and solve problems through discussion (Wahyudi et al., 2017).

Through RME approach, students are facilitated to be more active in class. Putri et al. (2022) in her research explains that RME approach can help students improve their high-level thinking skills, where critical thinking is one of the high-level thinking skills (Ndiung, 2021). In line with this research, Taubah et al. (2018) stated that RME is effective in improving students' critical thinking abilities. Active student activities in class through RME approach influence students in critical thinking, especially in discussion activities with friends (Setiawan & Wijaya, 2022). Based on previous research, critical thinking skills need to be improved, especially at junior high school level, one of which is using RME. From the background, researchers are interested in conducting research related to the influence of RME on junior high school students' critical thinking abilities.

METHODS

Method in this research uses meta analysis. This method is a research method that combines published research to collect a lot of data from the same topic so that the impact of the topic taken is known (Hernandez et al., 2020). The data obtained is in the form of quantitative data which is then analyzed statistically to obtain empirical conclusions on certain topics (Saputri & Wardani, 2021; Anadiroh, 2019). The population taken in this research is accredited journals that have been published nationally. The samples in this research are national articles that are accredited, indexed by SINTA 1 until 5, and related to the keywords critical mathematical thinking skills and RME. Instrument used to make it easier to collect and analyze data in this research is coding . This research uses an instrument in the form of a coding sheet which contains information regarding the researcher's name, research title, year of research, number of samples used, as well as the average and standard deviation of the posttest from the experimental and control classes in the research. There are 6 articles used and in accordance with the criteria, the data of which will be collected and analyzed. The meta analysis research steps used are: (1) collecting data, (2) statistical analysis, (3) identifying the influence of variables caused by the subject, and (4) drawing conclusions (Saputri & Wardani, 2021).

At the data collection stage, the articles obtained in this research were national articles that were accredited, indexed by SINTA 1 until 5, and related to *the keywords* critical mathematical thinking skills and *Realistic Mathematics Education* (RME). The articles obtained were grouped as follows.

Table 1. Grouping of article sources used

No.	Code	Research Title	Researcher Name	Year	Journal Source
1.	A1	Efektifitas Pembelajaran *Realistic Mathematics Education* (RME) terhadap Kemampuan Berpikir Kritis Siswa SMP	Fadilah, N.A.S. and Hakim, D.L.	2022	Jurnal Ilmiah Wahana Pendidikan (Sinta 5)
2.	A2	Pengaruh Pendekatan RME dengan Model Pembelajaran *Hybrid Learning* terhadap Kemampuan Berpikir Kritis Matematis	Putri, D.P., Holisin, I. and Efendi, J.F	2022	Jurnal Ilmiah Pendidikan Matematika (Sinta 3)
3.	A3	Pengaruh Pendekatan Realistic Mathematics Education (RME)Terhadap Kemampuan Berpikir Kritis Siswa Kelas VII SMP Negeri 2 Kota Jambi	Oktaviani, R., Harman, H. and Dewi, S.	2018	PHI: Jurnal Pendidikan Matematika (Sinta 5)
4.	A4	Pengaruh Pembelajaran Etno-RME Terhadap Kemampuan Berpikir Kritis Matematis Siswa Kelas Viii Di Smp Negeri 1 Bangkinang Kota	Herlinda, N. and Hidayat, A.	2023	Pendas: Jurnal Ilmiah Pendidikan Dasar (Sinta 4)

5.	A5	Kemampuan Berpikir Kritis Matematis Siswa SMP melalui Pendekatan Realistic Mathematics Education (RME) Berbantuan Video Berbasis Kontekstual	Sofyan, I.Y., Setiani, Y. and Rafianti, I.	2021	Wilangan: Jurnal Inovasi dan Riset Pendidikan Matematika (Sinta 5)
6.	A6	Penerapan Pendekatan Pendidikan Matematika Realistik (PMR) Terhadap Peningkatan Kemampuan Berpikir Kritis Matematis Siswa Smp Negeri 1 Dewantara	Ulaimi, U., Muhammad, I. and Isfayani, E.	2021	Malikussaleh Hournal of Mathematics Learning (Sinta 4)

After grouping the article sources used, the following article analysis was obtained.

Table 2. Article analysis

	Group	Many Articles
Year of Publication	2018-2020	1
	2021-2023	5
Educational Level	Junior High School	6
Sample Size	Less than or equal to 30	3
	31 or more	3
Publication Source	Journal	6

Then to determine the effect size of the variable, it is calculated using the effect size value with Cohen's formula (d) using the help of SPSS version 29. The effect size results obtained are interpreted based on the following classification (Morgan et al., 2004) .

Table 3. Interpretation *of Effect Size*

***d* (*Effect Size*)**	**Interpretation**
$0 \leq d \leq 0{,}2$	Weak
$0{,}2 < d \leq 0{,}5$	Medium
$0{,}5 < d \leq 1$	Large
$d > 1$	Very large

Apart from that, the aim of this research is to determine the effect of RME on junior high school students' mathematical critical thinking abilities, so hypothesis testing using the t-test is required. The hypothesis used in this research is.

$H_0: \mu_1 \leq \mu_2$ (the average critical thinking skills of students with RME learning is less than the average critical thinking skills of students with expository learning)

$H_1: \mu_1 > \mu_2$ (the average critical thinking skills of students with RME learning is higher than the average critical thinking skills of students with expository learning)

The formula used to test the t-test hypothesis according to Lestari & Yudhanegara (2017) is as follows.

$$t_{hitung} = \frac{\overline{x_e} - \overline{x_k}}{s_{gab}\sqrt{\left(\frac{1}{n_e} + \frac{1}{n_k}\right)}}$$

with

$$\overline{x_e} = \frac{\overline{x_1}.n_1 + \overline{x_2}.n_2 + \cdots + \overline{x_m}.n_m}{n_1 + n_2 + \cdots + n_m}$$

$$s_{gab} = \sqrt{\frac{(n_e - 1){s_{gab\ eksp}}^2 + (n_k - 1){s_{gab\ kontrol}}^2}{n_e + n_k - 2}}$$

Explanation:

$\overline{x_e}$: average of the experimental class

$\overline{x_k}$: control class average

s_{gab} : standard deviation of the combined experimental and control classes

$\overline{x_1}$: sample average in the first article's experimental class

$\overline{x_m}$: sample average in the m-th article experimental *class*

n_1 : number of samples in the first article's experimental class

n_m : number of samples in the mth article experimental class

${s_{gab\ eksp}}^2$: combined variance of experimental classes

${s_{gab\ kontrol}}^2$: combined variance of the control class

n_e : the number of all experimental class samples

n_k : the number of all control class samples

with test criteria, namely reject H_0 if $t_{hitung} > t_{tabel}$, where $t_{tabel} = t_{1-\frac{1}{2}\alpha}$ with $\alpha = 0{,}05$ and $dk = (n_1 + n_2 - 2)$

RESULT AND DISCUSSION

Statistic Analysis

The research results from the articles are grouped, described and analyzed to determine the effect of Realistic Mathematics Education (RME) on the critical thinking skills of junior high school students. The following are the results of the Cohen's (d) article statistical test using SPSS.

ID	Cohen's d	Std. Error	Lower	Upper	p-value	Weight	Weight (%)
A1	1.80	0.26	1.28	2.31	0.00	3.01	16.93
A2	1.08	0.27	0.55	1.62	0.00	2.98	16.74
A3	0.43	0.25	-0.07	0.92	0.09	3.07	17.25
A4	0.64	0.29	0.08	1.21	0.03	2.89	16.24
A5	0.20	0.28	-0.35	0.74	0.48	2.95	16.57
A6	1.10	0.29	0.53	1.66	0.00	2.89	16.27

Figure 2. Results of SPSS Cohen's test (d) articles

From the test results, it is found that :

Table 4. Statistical analysis of articles

Article Code	*d* (*Effect Size)*	Criteria
A1	1.80	Very large

A2	1.08	Very large
A3	0.43	Medium
A4	0.64	Large
A5	0.20	Weak
A6	1.10	Very Large

The following are the results of the combined Cohen's (d) statistical test from several articles

Effect Size Estimates

	Effect Size	Std. Error	Z	Sig. (2-tailed)	95% Confidence Interval Lower	Upper
Overall	.874	.2371	3.687	<,001	.410	1.339

Figure 3. SPSS results of the combined Cohen's (d) test

The results of the statistical test found that the effect of RME on the mathematical critical thinking skills of junior high school students was 0.874, which means that RME has a large effect on the critical thinking skills of junior high school students.

Next, statistical analysis was carried out to determine whether there was an influence of *Realistic Mathematics Education* (RME) on junior high school students' mathematical critical thinking abilities.

1. **Determine the hypothesis**

   H_0: $\mu_1 \leq \mu_2$(the average critical thinking skills of students with RME learning is less than the average critical thinking skills of students with expository learning)

   H_1: $\mu_1 > \mu_2$(the average critical thinking skills of students with RME learning is higher than the average critical thinking skills of students with expository learning)

2. **Determine the significance level**

   The significant level used is $\alpha = 0{,}05$

3. **Test criteria**

   Reject H_0 if $t_{hitung} > t_{tabel}$

4. **Determine t_{tabel}**

   $t_{tabel} = t_{1-\frac{1}{2}\alpha} = t_{1-\frac{1}{2}(0{,}05)} = t_{0{,}975}$ with $dk = n_1 + n_2 - 2 = 181 + 182 - 2 = 361$

   obtained $t_{tabel} = 1{,}96$

5. **Determine t_{hitung}**

   $$s_{gabeksp} = \sqrt{\frac{(n_1-1){s_1}^2+\cdots+(n_m-1){s_m}^2}{n_1+n_2+\cdots+n_m-m}} = \sqrt{\frac{(40-1)(15{,}26)^2+\cdots+(27-1)(1{,}28)^2}{40+31+\cdots+27-6}} = 9{,}54$$

   $$s_{gab} = \sqrt{\frac{(n_e-1){s_{gab\ eksp}}^2+(n_k-1){s_{gab\ kontrol}}^2}{n_e+n_k-2}} = \sqrt{\frac{(181-1)(9{,}54)^2+(182-1)(8{,}89)^2}{181+182-2}} = 3{,}07$$

   so that

   $$t_{hitung} = \frac{\overline{x_e} - \overline{x_k}}{s_{gab}\sqrt{\left(\frac{1}{n_e}+\frac{1}{n_k}\right)}} = \frac{50{,}59 - 41{,}64}{3{,}079\sqrt{\left(\frac{1}{181}+\frac{1}{182}\right)}} = 27{,}67$$

6. **Conclusion**

   From the data calculations obtained $t_{hitung} = 27{,}67 > 1{,}96 = t_{tabel}$ it was H_0rejected. This means that the average critical thinking skills of students using RME learning is higher than the average critical thinking skills of students using expository learning.

Identifying the influence of variables

Based on table 4, the results of the effect size identification of the 6 articles obtained in the categories of weak, medium, large, and very large. The average effect size of the six articles obtained is 0.874, which means that RME learning has a large effect on the mathematical critical thinking skills of junior high school students.

1. ***The effect size*** **category is weak**
   The weak effect size category was obtained by Sofyan & Rafianti (2021). The study explains that there is an increase in the critical thinking skills of students who use RME learning. With an effect size of 0.20, it means that RME learning has a significant effect with a weak category on the mathematical critical thinking skills of junior high school students.
2. ***The effect size*** **category is medium**
   The medium effect size category was obtained by Oktaviani et al. (2018) with an effect size of 0.43, meaning that RME learning has a significant effect on the mathematical critical thinking skills of junior high school students even though with a medium effect. Oktaviani et al. (2018) stated that junior high school students who received RME learning had a higher mathematical critical thinking skills than students who received conventional learning.
3. ***The effect size*** **category is large**
   The large effect size category was obtained by Herlinda et al. (2023) with an effect size of 0.64, meaning that RME learning has a significant effect with a large category on the mathematical critical thinking skills of junior high school students. Research by Herlinda et al. (2023) states that the critical thinking skills of students who use ethno-RME learning are better than students who use conventional learning.
4. ***The effect size*** **category is very large**
   The very large effect size category was obtained by (Fadilah & Hakim, 2022) with an effect size of 1.80 and (Putri et al., 2022) with an effect size of 1.08. In addition, the (Ulaimi et al., 2021) article also received a very large effect size category of 1.10. From the effect size results, it is found that RME learning has a very large and significant effect on the mathematical critical thinking skills of junior high school students. Fadilah & Hakim (2022) and Ulaimi, et al (2021) in their research stated that RME learning is effective in improving students' mathematical critical thinking skills. In addition, Putri, et al. (2022) also stated that the average mathematical critical thinking skills of students who use RME learning is higher than the conventional class.

In addition to knowing a large impact of RME on junior high school students mathematics critical thinking skills, an analysis of the significant impact on these problems was also carried out. By using t test, the results obtained $t_{hitung} = 27{,}67 > 1{,}96 = t_{tabel}$ mean that the average critical thinking skills of students using RME learning is higher than the average critical thinking skills of students using expository learning , so there is a significant impact of mathematics critical thinking skills of junior high school students who use RME learning, with a large impact is d= 0.874 which means the interpretation of the impact is large.

From the article by Fadilah and Hakim (2022), it was found that students lacked indicators of explanation and self-regulation. This can be anticipated by having group learning, because students will present, compare and discuss answers simultaneously in front of the class after a

group representative makes a presentation or explains the answers. In addition, RME learning provides opportunities for students to build concepts through discovery based on student's experience and knowledge, it can help students interpret and analyze problems to draw conclusions (Susandi & Widyawati, 2022). One of indicators of students in critical thinking is being able to provide explanations, this is achieved if in learning students to be active and can learn independently also in groups, RME learning provides these facilities to students so that student's critical thinking skills can develop (Hikayat et al., 2020). Implementing RME in class need heterogeneous group divisions, to influence process of discussing student's answers in class. Meanwhile, according to the article by Sofyan, et al (2021), it was found that class with conventional learning were better at providing simple explanations than class with RME learning, where students in conventional learning class provided illustrations in the form of simple pictures. However, other indicators include inference, advance clarification, strategy and tactics, and building basic skills still low. Apart from that, in discussion activities students tend to think more about winning and losing, rather than arguing based on facts and data, so the class is not conducive. The article by Oktaviani, et al (2018) shows that students in classes using RME approach are still dominated by students who are good at interacting, while students who are less confident in interacting do not have more opportunities to express their opinions or ideas.

CONCLUSION

Based on data collection from 6 articles analyzed through t-test, it was found that $t_{hitung} = 27{,}67 > 1{,}96 = t_{tabel}$ means the critical thinking ability of students with RME learning is higher than the critical thinking ability of students with expository learning. In addition, through the Cohen's test, it was found that the effect of RME on the critical thinking skills of junior high school students is large with a value of d = 0.874. So it can be concluded that RME has a large impact on junior high school student's critical thinking skills.

In addition, the analysis of each article found that the impact of RME on junior high school student's critical thinking skills in several different categories. There is 1 article that has a weak, medium, and large effect size respectively, namely 0.20, 0.43, and 0.64. While the rest have a very large effect size, namely 1.80, 1.08, and 1.10. This shows that in general, RME can have an influence in improving the critical thinking skills of junior high school students and can be applied in the classroom by teachers. From this article we have some suggestion for teacher or the next researcher

- RME is an alternative learning approach to improving students' mathematical critical thinking skills, especially at the junior high school level.
- Heterogen's group division is an important indicator in RME learning to improve students' critical thinking skills.
- RME approach emphasizes interaction between students, teachers can be fair moderators for students, especially in providing opportunities for students who are less confident in conveying their ideas.

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