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REALISTIC MATHEMATIC EDUCATION ON HIGHER-ORDER THINKING SKILL MATHEMATICS OF STUDENTS

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ABSTRACT

The literature on the effect of the Realistic Mathematics Education (RME) approach on high-order thinking skills (HOTS) students is massive. There is a diversity of research results. So a systematic and comprehensive review is needed to justify and describe its effect, which includes problem-solving, critical, creative, and reasoning abilities. This research used a systematic literature review (SLR) technique to search the Semantic Scholar, ERIC, Google Scholar database, and direct URLs from 2013 to 2022, yielding 49 studies that matched the inclusion criteria. Every paper was recorded and then categorized for analysis based on the title, education level, year of publication, sample size, and kind of HOTS. The findings indicated that RME positively impacted students' HOTS when learning activities were applied with student-centered, contextual problems, and the teacher was the facilitator. Working together in small groups allowed students to carry out individual exploration activities, reconstruct concepts from their own experiences, and connect these concepts to the mathematical ideas studied. RME thus becomes appropriate for use in achieving learning's aims and urgency, particularly in raising students' mathematical HOTS. The study's findings also offer information on the trends and heterogeneity of research into applying RME on mathematical HOTS in Indonesia. It is thus anticipated that it will serve as a recommendation and a focus for further study.

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Keywords

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Realistic Mathematics Education
Systematic Literature Review
PRISMA Protocol

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INTRODUCTION

Education is essential in preparing individuals to face the difficulties and increasing demands of life in the twenty-first century. An individual must be able to control a broad range of abilities and skills. The capacity to think at a higher level, also known as Higher Order Thinking Skills (HOTS), must be developed (Abdullah et al., 2017; Benidiktus Tanujaya, 2016). Based on the 2013 curriculum, the skills emphasized and demanded are HOTS (Gradini, 2019; Saraswati & Agustika, 2020; Suryapuspitarini et al., 2018). Increasing students' HOTS at this time is also one of the priorities for learning mathematics in schools.

Numerous data sources indicate that Indonesian students' HOTS is still low (Rahmayanti et al., 2020). One indication of this condition can be seen from the results of international studies such as the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), which show that the achievement of Indonesian students is still not satisfactory. TIMSS (McComas, 2014) and OECD (2016, 2019) show that Indonesian students' ability to learn mathematics is still deficient. The low student ability level is predicted because Indonesian students are not familiar with and routinely work on TIMSS and PISA questions. TIMSS provides questions not only measuring the ability to understand concepts but also other mathematical abilities, such as critical thinking analysis, creative thinking, mathematical reasoning, and problem-solving. These abilities are higher-order thinking skills (Brookhart, 2010).

To assist in the advancement of HOTS in learning and to encourage students to become accustomed to working on HOTS-related problems, it is essential to use an appropriate learning approach to help students enhance these skills (Hodiyanto, 2019; Jailani & Retnawati, 2016). They laid out a learning model that allows students to interact and emphasizes student-centered learning using unstructured problems. Many problem solutions can potentially trigger students to get used to working on questions belonging to the HOTS category (Tarmizi & Bayat, 2012).

Math teachers have adopted the learning strategy known as Realistic Mathematics Education (RME) as the best solution to improving problem-solving, reasoning, and critical thinking and students with the limited creative ability (Cahyaningsih & Nahdi, 2021; Laurens et al., 2018; Tan, 2013). The RME is an approach that starts from reality or the actual context surrounding students to initiate learning activities and is finally used to solve problems in

daily life (Rismawati & Komala, 2018). This does not mean that RME learning must always use real issues related to students' lives. However, the most important thing is that abstract problems are made real in students' minds. This enables students to solve existing problems and makes learning more meaningful (Rini & Hidayati, 2021).

To date, many studies related to the RME approach's effect on the types of abilities are classified as HOTS, namely critical thinking skills (Ariani & Batubara, 2017; Oktaviani et al., 2018; Puspita et al., 2018; Ridha et al., 2019), creative thinking (Durachman & Cahyo, 2020; Indira et al., 2017; Iskandar & Riyanti, 2015; Ismunandar & Taufan, 2020; Suciati et al., 2021), problem-solving ability (Amri & Abadi, 2013; H. P. Dewi et al., 2018; Herdiansyah & Purwanto, 2022; Mayasari, 2019; Wulandari et al., 2020; Zulaini Masruro Nasution, Edy Surya, 2017), and mathematical reasoning abilities (Dani et al., 2017; Fauzan et al., 2018; Kusumaningrum, 2016; Merina et al., 2019). Various study results from individual studies do not guarantee that the RME approach application can positively influence developing and improving students' HOTS. There is a diversity of research results, and there is a possibility that some studies may be biased. So that a systematic and comprehensive review is needed to justify and describe the effect of the RME approach when applied to mathematics learning in improving students' mathematical HOTS; therefore, this study applies a systematic literature review (SLR) method. SLR offers a thorough, unbiased, and reliable assessment of the current state of knowledge for a precisely specified topic (Sovacool et al., 2018).

Previous SLR research examined the diversity of mathematical abilities, such as idea problem-solving, understanding, mathematical literacy, and critical thinking (Ariati & Juandi, 2022; Juandi, 2021; Ramadhanti et al., 2022). Other discussd HOTS and mathematical abilities. This current research focuses on examining the area of mathematical HOTS by implementing the RME approach. Another SLR study and meta-analysis emphasizes the effect of using the RME approach on HOTS (Ramdani & Minarni, 2022; Shoffa, 2022; Widana, 2021). However, the characteristics of HOTS are limited to three types of mathematical skills: creative thinking, critical thinking, and problem-solving skills. The study also has not examined the moderator variables likely to affect the application of the RME method to students' mathematical HOTS.

To date, no SLR research has discussed the overall RME approach to abilities that fall into the HOTS category, including critical thinking, problem-solving creativity, and

mathematical reasoning skills. This SLR research updates and clarifies the discussion by adding one type of ability as a characteristic of HOTS, namely mathematical reasoning ability, accompanied by explanations of moderator variables that have the potential to cause heterogeneity of HOTS. This research aims to contribute to science by conducting a comprehensive literature review to explain and evaluate the impact of the RME on students' mathematical HOTS, including critical thinking, reasoning, problem-solving, and creative abilities, evaluated based on level of study, year of study, and sample size.

METHOD

The systematic literature review (SLR) strategy is used in this research. SLR is a scientific approach used to review the literature relevant to a structured and executed protocol previously set (Ariati & Juandi, 2022), (Juandi, 2021). The protocol used in This study refers to The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement that includes four stages as follows: (1) identification, (2) screening, (3) eligibility, (4) included (Liberati et al., 2009).

Inclusion Criteria

In selecting the primary study, inclusion criteria were used as a standard for research feasibility. To ensure that the systematic literature review in this study is more focused and precise, all primary study papers found through the first search were examined and evaluated using inclusion criteria. The PICOS approach (Population, Intervention, Comparator, Outcomes, Study design) can be applied to determine more specific inclusion criteria (Liberati et al., 2009).

As a result, the inclusion criteria for this SLR study were defined using the PICOS technique as follows: (1) a preliminary study that focuses on learning at various levels of education in Indonesia (population), (2) an early investigation of the use of the Realistic Mathematics Education model (intervention), (3) In the primary research, the comparison group intervention involves the use of standard learning models or alternative models as a control class, (4) critical thinking, creative, problem solving, and reasoning abilities (outcomes), (5) primary studies utilizing experimental research with a comparative causal one (study design), (6) Research published during the last ten years (2013-2022) in national and international journals and proceedings, both Scopus-indexed and non-Scopus-indexed (publication years).

Research Instruments

Based on the academic year, this SLR research applies research tools in the type of observation forms or procedures connected to the criteria for inclusion and exclusion, education level, and the number of samples.

Literature Search Strategy

Collection of primary studies through examination of the google scholar database, semantic scholar, science direct, Atlantis Press, Education Resources Information Center (ERIC), directory open-access journal (DOAJ), and IOP science, with the keywords "realistic mathematics education" and "thinking ability mathematical critical thinking" or "mathematical creative thinking ability" or "mathematical problem-solving ability" or "mathematical reasoning ability." These keywords and databases aim to obtain relevant primary studies that match the inclusion criteria.

Study Selection Process and Data Analysis

At the identification stage, 321 main studies were obtained based on the findings of a literature search through the database of Google scholar, semantic scholar, science direct, Atlantis press, education resources information center (ERIC), directory open-access journal (DOAJ), and IOP science. In the screening stage, the researcher reads the title and abstract related to the topic of this SLR study. From this process, 221 primary studies were removed because they did not match the criterion for inclusion. There were 81 studies published not in the form of articles or proceedings, and 140 studies whose study design or type of research was not quasi-experimental. So that leaves 100 pieces to read entirely to be re-selection at the feasibility stage. The 24 primary studies did not have a control class at this stage. In addition, 27 preliminary studies reported the application of RME, but the statistical data were incomplete. As a result, 51 articles were excluded leaving 49 primary studies in the SLR process. The analytical technique used for the articles or preliminary studies collected is that each prior study is recorded, then classified based on the title, sample size, year of study, education level, and type of HOTS. Furthermore, a one-by-one analysis of the articles included in this study was carried out to obtain the findings and discussion until the conclusion of this SLR study.

RESULT AND DISCUSSION

Realistic Mathematics Education Approach

Realistic Mathematics Education in Indonesia is known as the Pendekatan Matematika Realistik Indonesia. This approach was introduced by Freudenthal, who came from the Netherlands, with the view that mathematics is a human activity (P. S. Dewi, 2018). RME is a learning approach that begins with contextual problems to direct students in understanding a mathematical concept (Siregar et al., 2020). RME is also a method of teaching mathematics relevant to real life. Therefore, this learning approach is expected to build students' understanding independently and develop HOTS. According to the literature study that the author did, there are several characteristics of the realistic mathematics education approach that can improve students' HOTS. The aspects of RME approach include students being more active because the teacher acts as a facilitator (P. S. Dewi, 2018; Hidayat et al., 2019; Siregar et al., 2020) and provides contextual problems (P. S. Dewi, 2018; Hidayat et al., 2019; Rijal et al., 2014; Siregar et al., 2020; Wicaksono et al., 2021). Furthermore, there are small group discussions (P. S. Dewi, 2018; Wicaksono et al., 2021), and students can reconstruct concepts from experience and relate them to previously studied mathematical concepts (P. S. Dewi, 2018; Hidayat et al., 2019; Utami & Ilyas, 2019; Wicaksono et al., 2021).

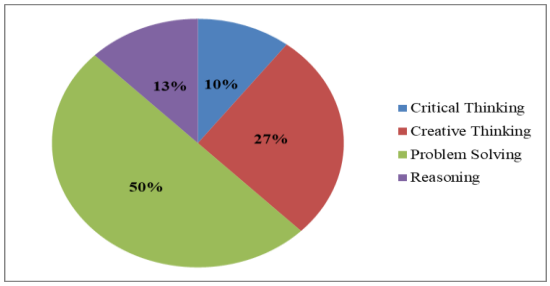

Figure 1. Percentage of primary studies application of RME to capabilities higher order mathematical thinking

Figure 1 presents the percentage of primary studies that discuss applying the RME model to students' mathematical HOTS, including creativity, critical thinking, reasoning abilities, and problem-solving. Most research is on the RME model of problem-solving ability. To find out, meta-analysis research might be undertaken for the impact of the application of RME on each of these skills, particularly the one that has been the subject of significant research, namely problem-solving.

The primary studies in this SLR study are assumed to have the potential to have a sizeable heterogeneous effect on each other (Borenstein, 2009). So that several factors that

have the potential to cause heterogeneity in students' mathematical HOTS will be explored to provide clear and precise information to improve the quality of students' mathematical abilities.

Criteria Based Study

This study resulted in an analysis and summary of the systematic review of literature obtained from the Semantic Scholar, ERIC, Google Scholar database, and direct URLs of national journals related to the effect of the RME approach on students' HOTS. Based on the application of the PRISMA Protocol, 48 kinds of literature were obtained, which were then categorized based on the characteristics of the study. The data are presented in Table 1. There is a diversity in research related to the effect of the RME approach on students' HOTS.

Table 1. Number of Studies Based on Criteria

Characteristic Study	Criteria	Mathematical Higher Order Thinking Ability Frequency			
		Creative Thinking	Critical thinking	Problem Solving	Reasoning Ability
Publication Year	2013-2015	2	0	1	1
	2016-2018	2	3	9	4
	2019-2022	9	2	14	1
educational level	Elementary	1	2	7	0
	Middle	11	1	13	6
	High	1	2	4	0
Sample Size	<=30	6	3	15	4
	>30	7	2	9	2
Total		13	5	24	6

Table 1 shows the number of studies of the RME approach on HOTS. The results of data analysis in Table 1 are obtained from 48 primary studies where the results of research on the effect of the RME approach on HOTS have diversity or heterogeneity. The moderator variables that the authors found were the education level, year of publication of the article, and sample size. Based on Table 1, research on applying RME to HOTS in the problem-solving ability category has dominated in the last ten years. In addition, several researchers have studied and conducted research at various levels of education, ranging from elementary school to university levels, with varying sample sizes ranging from small samples or less than or equal to 30 students and large samples of more than 30 students.

Overall, the RME approach significantly affects HOTS, namely critical thinking, creative thinking, problem-solving, and mathematical reasoning. In addition, differences were found between the experimental and control classes that used the RME technique with conventional learning and other learning models. Furthermore, the distribution of primary studies or articles will be discussed based on moderator variables or study characteristics that

have been determined, namely the education level, year of study, and sample size, to obtain more explicit information.

Publication Year

The article categorization based on the study year is divided into three periods, namely, 2013-2015, 2016-2018, and 2019-2022. Figure 2 presents a line diagram of the distribution of articles for that period.

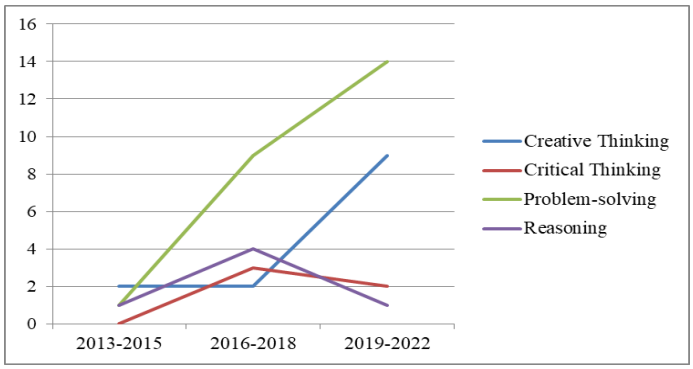

Figure 2. Data by year of publication

Figure 2 represents the number of research that investigated the influence of the RME technique on higher-order thinking skills. The line graph in figure 2 shows that problem-solving skills and creative mathematical abilities have increased every three years. In contrast, critical thinking and reasoning abilities have decreased in the 2019-2022 range. This finding is of concern because the problems of twenty-first-century development require mastery of various abilities, including critical thinking, creativity, problem-solving, and mathematical reasoning skills, which are part of HOTS and are very important to be developed (Griffin et al., 2012; Noer, 2018). RME research on problem-solving and mathematical creative thinking abilities has dominated the most recent research in the previous four years (2019–2022).

Educational level

The distribution of articles based on There are three levels of schooling available, starting from Elementary School (ES), Junior High School (JHS), and Senior High School (SHS). Figure 3 depicts the number of publications dependent on education level.

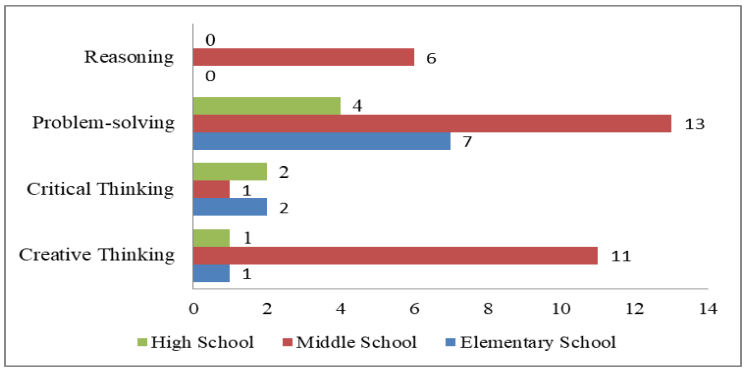

Figure 3. Data based on education level.

Figure 3 shows that most HOTS ability categories are researched and studied at the junior high school level. This finding is in line with the previous SLR study, which stated that at the junior high school level, mathematical abilities, including creative thinking, problem-solving, and understanding mathematics, were more widely studied (Juandi, 2021). As for the elementary level, research on reasoning and creative thinking skills remains limited. Reasoning ability is a vital competence to be developed from the primary school to higher education level (university) to raise educational standards.

Sample Size

The articles were divided into two groups based on the sample size: small samples (less than or equal to 30) and extensive samples (more than 30). The distribution of articles is presented in a bar chart in Figure 4.

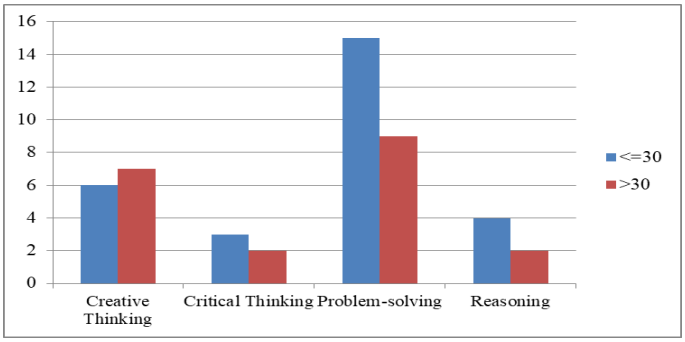

Figure 4. Sample size-based data

According to Figure 4, only creative thinking skills are dominated by research with more than 30, while problem-solving, mathematical reasoning, and critical thinking abilities are dominated by research with samples less than or equal to 30 from 2013 to 2022. This

implies that most studies studying HOTS by applying the RME approach were conducted in classes with small sample sizes.

This study presents findings related to trends in mathematics education research on applying the RME approach to HOTS in the form of years of study, level of education, and sample size so that they can become recommendations and ideas for future research. Based on data on the heterogeneity of the RME approach to students' mathematical HOTS, information was obtained that overall there was an increase in publications every three periods on problem-solving abilities and creative thinking skills. In addition, more research is conducted at the junior high school level and in classes with a sample size of no more than 30 students (small sample).

CONCLUSION

Higher-order mathematical thinking skills (HOTS), which include mathematical creativity, mathematical problem solving, and mathematical reasoning, can be positively impacted by the RME approach if learning activities are used with contextual problems focused on the students. At the same time, the teacher serves as the facilitator and engages the students in independent discovery. Another aspect that strengthens this finding is the large percentage of primary studies that examine the effect of the RME approach on students' HOTS in mathematics. Studies on this topic have received good attention because the number of prior studies has increased every three years. In addition, research has also been carried out at various levels of education in Indonesia. These findings indicate that the RME approach affects students' higher-order mathematical thinking skills. Thus, The RME approach effectively achieves learning objectives and increases students' ability for mathematical high-order thinking (HOTS). This systematic literature review recommends that subsequent researchers conduct more substantial research, a meta-analysis study involving several moderator variables, such as those studied in this SLR study, to determine the magnitude of the effect of implementing the RME approach on HOTs. In addition, it is necessary to do more individual studies that compare the impact of implementing the RME approach on higher-order thinking skills, including especially reasoning abilities at the elementary and high school levels.

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