A Lakatosian Systematic Review of Realistic Mathematics Education Research (2020−2024)

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Abstract: This literature review analyzes the historical development and theoretical frameworks proposed by key philosophers in Realistic Mathematics Education (RME). This study is important because recent RME research has largely focused on empirical implementation, leaving a theoretical gap in understanding how RME evolves as a scientific programme. A Scopus database search using the keyword "Realistic Mathematics Education" (conducted in March 2024) yielded 130 documents, from which 17 met the inclusion criteria for review. Using a descriptive and Lakatosian coding approach, each article was categorized into hard core, protective belt, theoretically progressive, and empirically progressive classifications, with double-coding applied to ensure reliability. The analysis results show that (1) most RME studies between 2020 and 2024 remain within the protective-belt category of Lakatos' framework, focusing on confirming existing models; (2) a smaller number of studies demonstrate empirically progressive characteristics by introducing new context-based designs; and (3) two emerging topics−RME in Indonesian cultural contexts and RME based on Islamic values−represent the most progressive theoretical contributions. These findings imply that future RME research should move toward theoretical innovation and broaden its epistemological foundation beyond classroom implementation to strengthen its position as a developing scientific programme.

INTRODUCTION

Mathematics is a study of science that cannot be separated from thinking activities. Mathematics has until now become one of the most important scientific studies to be discussed because it is considered related to other subjects. Ray, (2010) assume that all science is centered on mathematics. The validity of a science is very relevant to its mathematical value. In accordance with the notion of science that is "scientific" exactly insofar as it is mathematical. Math, which is considered a game of symbols and numbers, is not just that (Muhali, 2019). Furthermore, mathematics in it has a scientific paradigm that is central to other sciences. Mathematics is not just a formalist game, an arbitrary manipulation of symbols that are intrinsically meaningless. What makes mathematics the paradigm of science is its exemplary autonomous nature.

Mathematics learning in schools often requires approaches that bridge abstract concepts with students' real-world experiences. One of the most effective ways to improve students' mathematical achievement and conceptual understanding is through Realistic Mathematics Education. Over the past few decades, RME has emerged as a major trend in mathematical research. RME is an approach to learning mathematics that focuses on using realistic or contextual situations to help students understand mathematical concepts more deeply (Kartikasari et al., 2022). This approach was developed by a Dutch mathematician named Hans Freudenthal in the early 20th century (Becker & Shimada, 1997). RME aims to develop a deep understanding of mathematics and can be relevant to students. The focus of RME is the application of mathematical concepts in real contexts

In real practice, RME is increasing, attracting academics to conduct further research on this topic. However, most of these studies focus on classroom practices, teaching models, or student outcomes, while the theoretical growth of RME as a scientific program remains underexplored. This creates a gap in understanding how RME develops and evolves conceptually within the broader framework of educational

research. There have been many mathematics education experts who examine RME from various perspectives, such as innovations related to the mathematics learning process in schools (Laurens et al., 2018), training using the RME theory approach to teachers and prospective teachers (Punyasettro, Santhanat, 2021) or the link between RME and contextual (Uyen et al., 2021). This article contains an analysis of RME using philosophical theory.

Previous reviews of RME have mainly addressed implementation, effectiveness, or contextual learning designs. However, none have analyzed the evolution of RME from a philosophical or theoretical perspective. To address this limitation, this study adopts the framework of Lakatos' Methodology of Scientific Research Programmes (MSRP) to reinterpret RME as a developing scientific theory. Two 20th-century philosophers of science have powerfully shaped the way scientists today view what science is and how it works. Jorritsma (2022) explained that Karl Poper considered that scientific and non-scientific theories are characterized by falsifiability, that is, false but provable statements. Thomas Kuhn, on the other hand, argues that in practice, scientists do not attempt to falsify theories or paradigms—their most important paradigms—but rather seek to preserve them. The conflicting views of Karl Poper and Thomas Kuhn were synthesized by Imre Lakatos, a Hungarian philosopher who formed Methodology of Scientific Research Programmes (MSRP). Imre Lakatos mixed Poper's and Kuhn's theories. Lakatos form research programmers which classifies a theory into Hard core and protective belt. Protective belt is an additional hypothesis from the background. Every time there is odd data, hard core Protected from disclaimers by adding something in protective belt.

In each of these classifications, Lakatos provides formulations in the form of criteria for articles to be included in Hard core or Protective Belt. The author has summarized these criteria according (Firmansyah et al., 2024; Jorritsma, 2022; Kuhn, 2020; Shearmur, 2010). The article can be said Hard core If in the article found new parameters, the introduction of new types of experimental errors, and the proposal of new hypotheses. In addition, the initial condition assumption written in the article is different from the previous findings. Articles included Hard core It is also research that has activities to test or develop an innovation. These innovations make new contributions to the development of a theory. But still use proven scientific methods to test his hypothesis. Finally, an article with theory hard core using established and widely accepted theories. While a theory in the article can be said Protective belt if it has the following characteristics: The findings in the article are supported by empirical data that researchers do themselves in the field, relevant sources of knowledge, and science is widely accepted by the academic community. However, research Protective belt Further research is still needed to test new hypotheses and develop new paradigms. This article also provides a practical benefit that contributes to quality improvement as well as provides opportunities for further development. This article provides a broader understanding of science and innovation which will later contain practical recommendations for future research developers. The findings in the article not only confirm previous discoveries but provide new insights. With regard to methodology, protective belt Using previously developed research methodologies but opening up new topics that have not been fully explored but have been touched upon in previous findings. In addition, it uses new technology for an existing knowledge. The most important thing in this protective belt article is that its application is limited to a certain field.

In addition to classifying theory into hard core and protective belts, the research program also has heuristics. It is a set of tools and principles (mathematical or experimental) that guide researchers as they develop programs. Heuristics have both positive aspects and negative aspects. In the positive aspect, it is clearly detailed about several things, including: questions to ask, where researchers look for data, and how to make hard cores more sophisticated. Lakatos has a way of assessing a research program based on the progress of his research, namely Theoretically progressive and degenaritive.

As well as hard core and protective belt, the author has summarized the criteria of science based on progress or setback based on Lakatos's analysis. According to (Firmansyah et al., 2024; Jorritsma, 2022; Kuhn, 2020; Shearmur, 2010), science can be said Theoretically progressive if the research program changes. In addition, there are positive aspects that are clearly detailed about the research question, where the data was taken, and how to make an original research protective belt can be hard core. In addition, the study revealed a change that resulted in new facts. Research also provides practical benefits for readers, contributing to quality improvement in this regard especially the quality of education. In

addition, it makes new and valuable contributions through testing and expanding understanding. Research with theoretically progressive also make positive and ongoing contributions through testing and development of existing theories. However, the results of the article make researchers still look for more effective ways of a finding. Through appropriate and empirical methods, the use of his innovations paved the way for the advancement of survival science. If a science or research contains the above criteria, and there is reinforcement in the form of empirical data, then the science is not only theoretically progressive but rather empirically progressive. While science can be said to happen degenerative If there is no continued effort to test the discovery and the findings cannot be replicated by other researchers so as to accommodate only known facts.

Among the many studies that have been done, not many have analyzed using the theory of Lakatos in relation to RME. However, the Freudenthal 100 symposium Erich Ch Wittmann (2005) mentions that the RME shows an important trend in Mathematics education. The relevance of Lakatos' framework to RME lies in its ability to explain how educational theories evolve through refinement and adaptation. In the context of RME, the hard core can be identified as the fundamental belief that mathematics should be learned as a human activity and connected to reality, as emphasized by (Freudenthal, 1973). The protective belt represents the supporting instructional models, such as contextual problems, model-of/model-for transitions, and guided reinvention, which are continually refined by researchers to address classroom challenges. When new empirical findings or contextual needs arise, these models are adjusted without changing the core principle of RME. The heuristic aspect of Lakatos' theory is also visible in how RME guides researchers and teachers to explore new ways of mathematizing real situations and designing learning trajectories. For example, studies linking RME to cultural contexts in Indonesia or integrating Islamic values into RME demonstrate how the approach remains progressive while adapting to local realities. Thus, Lakatos' concepts provide a philosophical lens for understanding RME not only as a teaching approach but also as an evolving research programme that progresses through theoretical innovation and contextual adaptation.

Therefore, this study aims to fill this gap by attempting to document and synthesize previous RME research patterns over the previous decades. The significance of this study lies in providing a philosophical reflection that strengthens the theoretical foundation of RME and offers new directions for future research in mathematics education. Specifically, the following three research questions (RQs) will be examined:
1. How did Lakatos analyze for each selected article?
2. Among the articles classified as Theoritically Progressive, which articles What can be classified as Empirically Progressive?
3. What is the best topic on RME based on Lacatous Analysis?

METHOD

Research Design

This study employed a Systematic Literature Review (SLR) design with a qualitative descriptive approach to synthesize research trends and theoretical orientations of Realistic Mathematics Education (RME) using Lakatos' framework. The procedure followed the general structure of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model, including identification, screening, eligibility, and inclusion stages. According to (Tong et al., n.d.) many various research topics related to mathematics are analyzed by this method. For example, research by Ali (2018) as many as 9,941 Web of Science documents which were limited to publication in 1980-2018 to analyze and map the location of science and communication structures, especially in the field of mathematics. In line with these studies, this study analyzed 130 documents indexed by Scopus between 2020-2024 for analysis according to Lakatos.

Data Source and Search Strategy

The document selection process in this study followed four main stages in accordance with the PRISMA framework. During the identification stage, a total of 130 documents were initially retrieved from the Scopus database. In the screening stage, 88 documents were excluded because they were conference

papers or incomplete publications that did not meet the inclusion criteria. The eligibility stage involved reviewing the full text of 23 articles to assess their relevance to Realistic Mathematics Education and theoretical orientation. Finally, in the inclusion stage, 17 articles were selected for detailed analysis based on Lakatos' theoretical framework.

A comprehensive document search was conducted using the Scopus database with the keyword "Realistic Mathematics Education." The document retrieval followed Harzing's Publish or Perish procedure. The author draws up the criteria of the article and the identification of sources. The first thing the author does is choose an academic database for the author to access the article. There are two most important academic databases commonly used for bibliometric analysis: Scopus and Web of Science. However, in this study, only Scopus was chosen as the source of the document. The author has three considerations, including: first, the standard chosen by Scopus in choosing documents to be included in its index is very consistent. Second, compared to the Web of Science, Scopus has a more diverse appearance of documents, especially research in the field of education and social sciences. Lastly, several studies (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020; Nguyen et al., 2020). emphasize that there are important educational journals indexed in Scopus but not in Web of Science, such as Mathematics Learning and Mathematics Enthusiast (Tong et al., n.d.). With these considerations, the authors chose Scopus in this study.

Inclusion and Exclusion Criteria

After determining the database and data sources, the following inclusion criteria were applied to refine the scope of analysis. To ensure that only relevant and high-quality studies were analyzed, specific inclusion criteria were established for selecting the reviewed articles. The criteria were as follows:
1. Articles published between 2020 and 2024;
2. Indexed in the Scopus database;
3. Written in English to maintain consistency and accessibility of interpretation;
4. Classified as journal articles, excluding conference proceedings, book chapters, or unpublished reports;
5. Focused on Realistic Mathematics Education either in theoretical discussions or empirical implementations; and
6. Containing explicit theoretical or conceptual components relevant to mathematics education.

Articles that did not meet these criteria—such as studies outside the RME context, those lacking theoretical foundation, or those unavailable in full-text form—were excluded from the review process. Based on these criteria, the document selection proceeded through several PRISMA stages (see Figure 1). From each included article, the following information was extracted: title, author(s), year of publication, research focus, methodology, and theoretical orientation. The data were organized in a table and coded according to the Lakatosian categories of hard core, protective belt, theoretically progressive, empirically progressive, and degenerative.

PRISMA Selection Process

Based on the inclusion criteria described above, the document search and selection process was conducted systematically as follows. To collect the data, the study followed Harzing's Publish or Perish guidelines for document search. The first identification step that researchers do is to write the keyword 'Realistic Mathematics Education' in the search field in the Scopus database. Using these keywords, all documents with identified headings and abstracts are filtered. The goal is to ensure that the documents related to the search are relevant documents. A search conducted by researchers yielded 130 documents. Next, the researcher performs screening in the second step, namely by adopting a series of parameters to fine-tune the document accordingly. These parameters include: the type of document in the form of an article, the language chosen is an English article, the field of study is not limited, and the publication year is between 2020-2024. Through this stage, as many as 82 documents were not selected by researchers because they included scientific conference proceedings, which were considered preliminary and not final research reports and was still in the seminar stage. A further 42 documents were continued at a later stage. After research, many of the 42 documents only contain abstracts without being able to access the entire document as a whole. Then the researcher has only 23 documents. A total of 23 articles will be

included in the eligibility process. In this third stage, the researcher observes the title and abstract. With various considerations, researchers make recommendations to selected and excluded articles. There are several activities that researchers do, namely re-investigating the title, abstract, and reading the full document to provide appropriate recommendations about the suitability of the selected article. In this step, 7 documents were omitted because their contents were too complex to analyze based on Lakatos' analysis. The final dataset consists of 17 documents all stored in Publish or Perish files for further analysis.
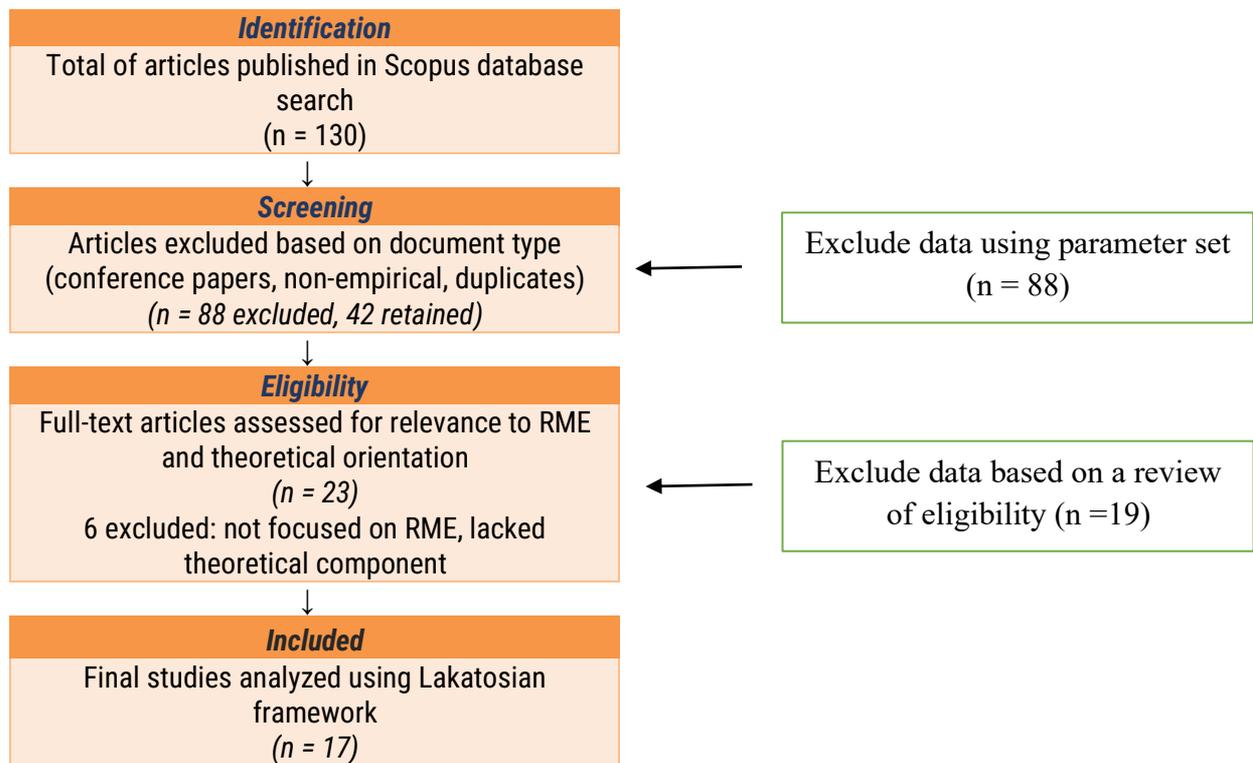
Identification
Total of articles published in Scopus database search (n = 130)

↓

Screening
Articles excluded based on document type (conference papers, non-empirical, duplicates) *(n = 88 excluded, 42 retained)*

Exclude data using parameter set (n = 88)

↓

Eligibility
Full-text articles assessed for relevance to RME and theoretical orientation *(n = 23)* 6 excluded: not focused on RME, lacked theoretical component

Exclude data based on a review of eligibility (n =19)

↓

Included
Final studies analyzed using Lakatosian framework *(n = 17)*

Figure 1. PRISMA Flowchart for the Systematic Review and Lakatos Analysis

The PRISMA flowchart (Figure 1) summarizes the four stages of document selection: identification, screening, eligibility, and inclusion. A total of 130 Scopus-indexed articles were initially identified. During screening, 88 documents were excluded for being conference papers, non-empirical studies, or duplicates. From the remaining 42 articles, 19 were excluded at the eligibility stage due to incomplete data or lack of theoretical orientation, leaving 17 studies that met all inclusion criteria and were analyzed using Lakatos' framework.

The analysis was conducted qualitatively using Lakatos' Methodology of Scientific Research Programmes (MSRP). Each article was examined against Lakatos' theoretical criteria, as summarized from Firmansyah et al., (2024), Jorritsma (2022), and Shearmur (2010). The classification process involved iterative reading and conceptual comparison among studies to determine whether each article represented hard core, protective belt, progressive, or degenerate research development.

Research Procedure Diagram

To provide a clearer overview of the overall research procedure, the stages of this Lakatosian systematic review are summarized in Figure 2. The diagram illustrates the sequential process of the study, beginning from research problem identification, database selection, PRISMA-based screening, Lakatosian classification, and concluding with theoretical synthesis.
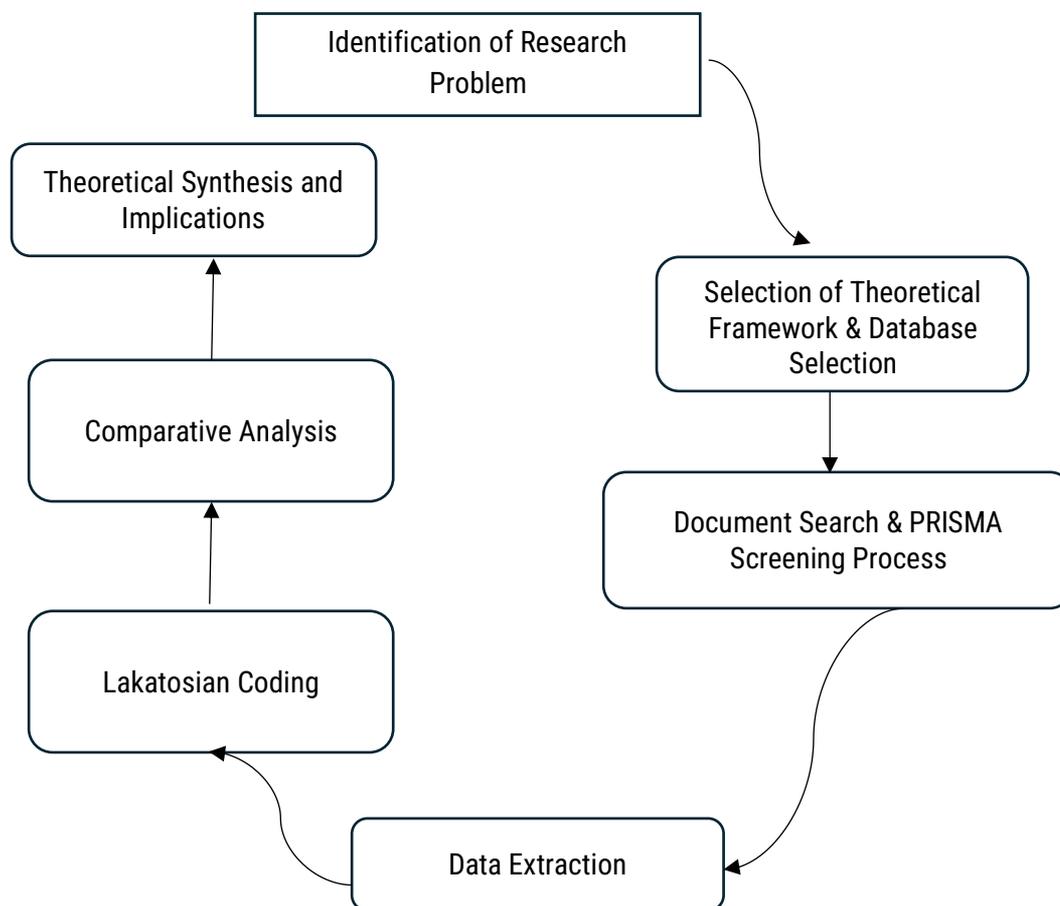
Figure 2. Research Procedure of the Lakatosian Systematic Review

RESULT AND DISCUSSION

The purpose of this study is to provide an understanding of the knowledge and significance of selected references specifically about RME for future research. Based on the System Literature Review and through careful selection, a total of 17 selected documents were considered to be in harmony with the systematic literature review that in previous studies was considered aligned. The subsequent review provides a brief summary of these papers, highlighting their relevance to the research field of Realistic Mathematics Education based on Lakatos Analysis.

Table 1. Lakatos analysis on selected articles

No	Author, year	Lakatos Analysis			
		Research Programmes		Heuristic	
		Hard core	Protective Belt	Progressive	Degene-rative
1	(Kurniasih & Ngastiti, 2024)	√			√
2	(Syutaridho et al., 2024)		√		√
3	(Listiawati et al., 2023)		√	√	
4	(Lestari et al., 2023)	√		√	
5	(Sukri, A., Rizka, M. A., Purwanti, E., Ramdiah, S., & Lukitasari, 2022)	√		√	
6	(Armiati et al., 2022)	√			√

No	Author, year	Lakatos Analysis			
		Research Programmes		Heuristic	
		Hard core	Protective Belt	Progressive	Degene-rative
7	(Juandi et al., 2022)		√	√	
8	(Revina & Leung, 2021)		√	√	
9	(Punyasettro, Santhanat, 2021)		√	√	
10	(Tong et al., n.d.)		√		√
11	(Uyen et al., 2021)		√		√
12	(Palinussa et al., 2021)	√		√	
13	(Do et al., 2021)		√		√
14	(Muslimin et al., 2020)	√		√	
15	(Hikayat et al., 2020)	√			√
16	(Yilmaz, 2020)		√		√
17	(Nguyen et al., 2020)		√		√

Research Question 1: How did Lakatos Analyze for Each Selected Article?

Researchers analyzed 17 articles based on theoretical approaches pioneered by Imre Lakatos, especially the review of the content of documents. The aim is to broaden horizons, especially about the development and transformation of RME and mathematics topics. With Lakatos' theory, paradigm shifts and intellectual perspectives in related midwives can be fully understood.

Lakatos analysis in the first article (Kurniasih & Ngastiti, 2024)indicates that the article belongs to the hardcore category. This is because researchers developed the game puzzle using a realistic approach and testing the development. Of course, the developed media make a new contribution to theory development;, especially RME. In addition, this article belongs to science degenerative because it makes new contributions especially to RME in the field of education. The innovations introduced by the author provide opportunities for other researchers to pave the way for educational progress so that they can be a positive and sustainable contribution. But further research still needs to be tested.

Second article (Syutaridho et al., 2024) included in the protective belt because the source of knowledge is relevant and the findings are supported by empirical data. In addition, the results of the research will be easily accepted by the academic community as important information, especially RME which affects students' creative thinking abilities. However, this research can also be said to be included in the seat belt because close examination is still required to test new hyst and cultivate new paradigms. As well as its application is limited to a specific field. When viewed based on scientific progress according to Lakatos, the article can be said to be the degeneration of science. There have been no follow-up attempts to test the findings so limited. In addition, his findings are very difficult to replicate by other researchers because they only accommodate existing facts.

Third article (Listiawati et al., 2023) indicates that the journal article belongs to the protective belt because the source of knowledge regarding realistic mathematics education comes from the main source of knowledge, namely from the inventor of the RME model. In addition, the idea of RME provides practical recommendations for future research. However, because the ideas given have never been tested, the data is not empirical and can be categorized as protective belt Because further research is needed to turn the idea into empirical data through field trials. Journal articles (Listiawati et al., 2023) have theoretically progressive Because the ideas offered have positive aspect in neuristic put forward by (Jorritsma, 2022) among other things, it offers questions to ask in research, the most appropriate places to collect data, as well as how to improve protective belt about suggestions for implementing learning strategies of function concepts in the field. The innovations contained in the article paved the way for the advancement of education.

Lakatos analysis in the fourth article (Lestari et al., 2023)indicates that the article belongs to Hard core because researchers are trying to develop LKS and test it in the field so that it can provide new contributions to the development of special theories for RME. In addition, the scientific method that the

researcher chooses, in this case RME combined with ADDIE has been proven to test the researcher's hypothetical. In addition, when viewed based on the progress of knowledge, the article can be said theoretically progressive. The research offers new and valuable contributions using appropriate and empirical methods so that they can be trusted. Although, the development carried out by researchers is limited to certain materials, its innovative use can pave the way for the advancement of education especially in RME.

Fifth article (Sukri, A., Rizka, M. A., Purwanti, E., Ramdiah, S., & Lukitasari, 2022) based on Lakatos analysis is included in hardcore. The research is very good because it develops a comprehensive learning tool ranging from teacher books and student books using RME. This development greatly contributes new innovations to the development of science. Moreover, it is very useful for the needs of students at school. In addition, the methods used are scientifically proven, well-established, and easily widely accepted. In addition, the article is included in Theoretically progressive Because there are positive aspects of practical benefits, offering new and valuable contributions, and testing and expanding readers' understanding. In addition, the innovations offered by researchers provide opportunities to be developed by other researchers thus paving the way for progress.

Lakatos' article in the sixth article (Armiati et al., 2022) shows that the journal article is included in the hard core category because the research discussed in the article contributes to the development of Realistic Mathematics Education theory, especially in the introduction of multiplication concepts in elementary school students. The third article also conducts trials and develops new ideas based on established and widely accepted methods so as to produce empirical data for future research. Based on its progress or decline, this article is considered to be in the category of progressive science. This article offers new and valuable contributions in the field of education by providing fresh insights into the use of RME models in the context of learning multiplication concepts and practical recommendations for developers to design effective RME models. The research is also based on empirical research conducted using appropriate methods and valid data, thus ensuring that the findings are reliable and useful for the advancement of the field.

Seventh article (Juandi et al., 2022) based on Lakatos' analysis, the article is included in Protective Belt Because it contains an analysis of various articles that finally researchers provide practical recommendations for the next research developer. This means that researchers have relevant sources of knowledge that have certainly been accepted by various academic communities. Although of course the research still needs further research to test new hypotheses and the development of new paradigms. In addition, articles (Juandi et al., 2022) included in progressive knowledge because it provides practical benefits for contribution to improving the quality of education in the field of RME. With its analysis, the article tests all findings to broaden the reader's understanding.

Eighth article (Revina & Leung, 2021) included in protective belt Because the data findings that the author put forward are empirical data that the author has tested in the field. The second article expands a new understanding of RME principles relevant to Indonesian culture to be adopted into a learning model used in Indonesia with the new title of Indonesian Mathematics Realistic Learning or PMRI. When viewed based on the development of the article according to Lakatos, this article has empirically progressive Because it offers new and valuable contributions to further test and expand understanding. In addition, the article has positive aspects that are corroborated with empirical data and relevant sources.

Lakatos analysis in the ninth article (Punyasettro, Santhanat, 2021) indicates that the article belongs to Protective Belt because the researcher conducted an analysis of the collection of previous articles on RME. The findings of researchers are certainly supported by relevant sources of knowledge. However, no novelty was found, so further research is still needed to test new hypotheses and develop new paradigms. Despite this, thanks to the analysis that the researcher carried out, the article (Punyasettro, Santhanat, 2021) of course, it provides practical benefits that can later be used as a reference by subsequent research. With these various considerations, when viewed based on scientific advances according to Lakatos, articles (Punyasettro, Santhanat, 2021) can be said to be Progressive Science.

Analysis of Lakatos in the 10th article (Tong et al., n.d.) indicates that the article belongs to Protective Belt. Although the findings are supported by empirical data, contribute to improving the quality

of learning especially in EMR, as well as discussing new topics that have not been fully explored, unfortunately the research in the article is limited to one particular topic. Thus, when viewed from scientific advances based on Lakatos's analysis, the article can be said to be degenerative. The facts contained in the article are mostly known so there are no new conclusions about RME.

The 11th Article (Uyen et al., 2021) based on analysis Lakatos is included in Protecrive Belt. The main thing that underlies this conclusion is that the findings of the researcher in the article are supported by empirical data so that the source of knowledge is relevant. In addition, although still using previously developed research methodologies, the application of the article is limited to a certain field, namely one school in Vietnam and limited to a certain topic, namely grade 7 Statistics material. This means that the article only accommodates pre-existing facts. Thus, if analyzed based on technological advances according to Lakatos, this article can be said to be a Degenerative Science.

Lakatos analysis in the 12th article (Palinussa et al., 2021) shows that the article is included in the Hard core because the researcher tried to test RME combined with cultural values so that the suggestions that the researcher expressed, made a new contribution to the development of RME theory. Because it was tested in the field, the research has empirical evidence that cannot be refuted so that it can be widely accepted. Article (Palinussa et al., 2021) based on Lakatos analysis, it can be said to be Empirically Progressive because there are positive aspects that lead to new facts, in this case the application of cultural values in every RME learning carried out in rural schools.

The 13th Article (Do et al., 2021) if associated with the analysis Lakatos is included in the Protective Belt, because although the findings are supported by empirical data, further research is still needed to test new hypotheses and develop new paradigms. In addition, this article can be said to be the Degeneration of Science. The reason, can not be replicated by other researchers because there are no further attempts to test the findings.

The 14th Article (Muslimin et al., 2020) based on Lakatos' analysis, including Hardcore. Apart from the research carried out by developing and testing empirical data, research provides a new construction of the RME theory because it combines with Islamic values. Thus, research provides a new innovation as material for further research that will be carried out by other researchers. Based on this explanation, based on Lakatos' analysis when viewed whether science has progressed or regressed, the article is classified as Empirically Progressive.

Lakatos analysis in the 15th article (Hikayat et al., 2020) indicates that the article belongs to Hardcore because it develops a learning module in the hope of making a new contribution to RME-based education. In addition, the data obtained come from empirical sources as well as well-established and widely accepted methods. However, because it is limited to a specific topic, the article is included in the Science of Degenerate.

The 16th Article (Yilmaz, 2020) based on Lakatos' analysis, it is included in the Protective belt because it provides practical recommendations for future research developers because in addition to not trying to reject existing theories, the article opens up opportunities for further development. However, if you look at whether the article has science that has progressed or regressed, based on Lakatos's analysis, it is included in the Degeneration of Science because the discussion in the article only accommodates facts that have been discussed by previous researchers.

Last article (Nguyen et al., 2020) based on Lakatos' analysis, it is included in the Protective Belt because it contains assumptions about the initial conditions of education in Vietnam that are different from the conditions of education should be, so the researcher proposed a new hypothesis about the application of RME in education. However, the science discussed in the article, based on Lakatos' analysis, can be dismissed as Degenerative because it only accommodates facts that have been discussed by previous research.

Research Question 2: Among the articles that belong to Theoritically Progressive, which articles can be classified as Empirically Progressive?

Realistic Mathematics Education assisted learning combined with Islamic values.theoretically progressive but contains empirical data so that it can be said empirically progressive, based on this analysis, there are five articles included in the empirically progressive.

Table 2. Lakatos Analysis in Theoritically Progressive Articles Becomes Empirically Progressive.

No	Writer	Empirical Data
1	(Lestari et al., 2023)	Development of Student Worksheets based on Realistic Mathematics Education which is effectively used as a support for mathematics learning in schools.
2	(Sukri, A., Rizka, M. A., Purwanti, E., Ramdiah, S., & Lukitasari, 2022)	Testing and development and teaching materials (teacher books and student books) that are effectively used in the classroom and prototypes that can be utilized by schools.
3	(Revina & Leung, 2021)	Realistic Mathematics Education-assisted learning that can be related to Indonesian culture
4	(Muslimin et al., 2020)	Realistic Mathematics Education assisted learning combined with Islamic values.

The above article is a selected article that researchers feel is theoretically progressive based on Lakatos' analysis if seen the progress or decline of science. However, because it has empirical data, it can be said to be empirically progressive. All selected articles are testing and developing ideas that have proven effective and useful for the advancement of science, especially in elementary schools

Research Question 3: What is the best topic on RME based on Lacatous Analysis?

To answer this research question, we directly analyze in table 2. The reason is because a good article according to Lakatos Analysis is an article that is part of Hard core and empirically progressive. Based on the analysis of the 5 articles in table 2, the author concludes the two best topics discussed in the article based on Lakatos' analysis. The selected articles include: Article entitled "Issues involved in the adoption of Realistic Mathematics Education in Indonesian Culture" written by (Revina & Leung, 2021) dan "Learning Integers With Realistic Mathematics Education Approach Based On Islamic Values" yang ditulis oleh (Muslimin et al., 2020). In addition to being included in the hard core, this article is also empirically progressive because it has findings that can be proven by empirical data. The two articles above contain new ideas that are very unique and relevant to the circumstances of the times. Their findings both link RME to a value. (Revina & Leung, 2021) associate RME with cultural values in Indonesia, while (Muslimin et al., 2020) associate RME with Islamic values. Both articles have proven to be effectively applied and some have even created a product that is useful for the advancement of science

The integration of RME with local cultural and religious values reflects a progressive shift in mathematics education research. It shows that RME can evolve beyond its original Dutch context into a culturally adaptive framework, making mathematics more meaningful for diverse learners. These findings imply that future research should explore how RME can be contextualized across different cultural, ethical, and religious dimensions. Such efforts can strengthen its pedagogical foundation and deepen students' engagement in learning mathematics.

Nevertheless, this review is limited to Scopus-indexed articles published between 2020 and 2024, which may not fully capture earlier foundational or regional studies of RME. Including grey literature or non-indexed publications might reveal more diverse theoretical perspectives. Therefore, further studies are recommended to examine how these contextual adaptations influence higher-order thinking and mathematization processes, as well as to conduct longitudinal research that evaluates the long-term impact of progressive RME approaches.

Research Limitations

This research has several limitations that need to be considered. First, this study only analyzes articles indexed by Scopus in the range of 2020–2024, so it does not include earlier foundational studies on Realistic Mathematics Education that may have contributed historically to the development of this theory. In addition, the restriction to Scopus-indexed journal articles may limit the comprehensiveness of the review, as relevant studies published in other databases or formats were not included.

Second, the analysis carried out is entirely secondary, because it uses data and research results from published articles. This makes the interpretation of the findings highly dependent on the clarity, rigor, and completeness of reporting from previous studies. Any limitations in the original publications may indirectly influence the conclusions of this review.

Third, the use of Lakatos' criteria in analyzing theoretical developments also has limitations because it is conceptual and philosophical in nature. Although systematic procedures were applied in classifying the studies, the interpretation of whether research belongs to the hard core, protective belt, progressive, or degenerative category requires deep contextual understanding and may involve a degree of interpretative judgment.

Research Implications

Nevertheless, the results of this study provide several important implications for the development of mathematics education research, especially in the context of Realistic Mathematics Education. The findings show that most of the RME research is still in the protective belt category, which focuses on strengthening existing learning models without making many theoretical updates. This indicates the need for more progressive research, both theoretically and empirically, so that the RME approach is not only a contextual learning strategy, but also develops as a scientific program that is dynamic and adaptive to cultural contexts and contemporary educational developments.

Recommendations for Future Research

Based on these limitations and implications, there are several recommendations for further research. First, the expansion of time spans and data sources is strongly recommended by involving national and international publications that have not been indexed by Scopus, in order to provide a more comprehensive picture of the development of RME. Second, future research can combine bibliometric analysis and philosophical approaches to validate the direction of progress of RME theory both quantitatively and qualitatively. Third, further exploration is needed on the integration of cultural, religious, and ethical values into RME so that this approach becomes more relevant to the characteristics of students in various social and educational contexts.

CONCLUSION

This literature review provides an analysis of the contributions and perspectives of influential philosophers. such as Imre Lakatos in the research Realistic Mathematics Education. In recent years, this study contains descriptions and analyses of developments, themes and other topics in the field of RME. Its development shows that RME is increasingly attracting experts, especially in the field of mathematics which is getting better. This reflects that a more realistic approach to teaching maths is increasingly needed. By examining the theoretical framework proposed by these philosophers, this article provides an understanding of RME and its evolution in related fields of research. It is expected to be useful as a valuable resource for researchers interested in gaining more knowledge about RME in interactive research.

Answering the research questions, the analysis found that most RME studies (RQ1) are situated within the protective belt of Lakatos' framework, focusing on strengthening existing models rather than proposing new theoretical structures. A smaller number of studies (RQ2) were identified as empirically progressive, showing theoretical advancement supported by data through the development of innovative learning designs and context-based applications. Meanwhile, two studies (RQ3) were highlighted as representing the best topics in progressive RME research—those integrating RME with Indonesian cultural values (Revina & Leung, 2021) and with Islamic values (Muslimin et al., 2020)—demonstrating that RME can evolve into a culturally adaptive and theoretically expanding framework.

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Future research should explore broader theoretical perspectives and expand data sources to strengthen the analysis of RME. Empirical studies are needed to validate theoretical insights and bridge the gap between research and practice. Integrating progressive methodologies in teaching and

incorporating RME principles into curricula can enhance mathematics education. Additionally, supporting policies and funding for RME-based research will ensure its continued development and impact.

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