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Ratio and proportion through realistic mathematics education and *pendidikan matematika realistik Indonesia* approach: A systematic literature review

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Abstract

Foundational mathematical concepts like ratios and proportions are indispensable for solving both everyday problems and those encountered in professional settings. However, many students need help to grasp and apply these concepts effectively, often due to ineffective teaching methods, variations in students' levels of comprehension, and shortcomings in existing learning models. Realistic Mathematics Education (RME) and *Pendidikan Matematika Realistik Indonesia* (PMRI) have emerged as promising solutions to address these challenges. This study aims to systematically review the literature on ratio and proportion learning design using RME and PMRI approaches. It focuses on three specific research inquiries: profiling the literature, analyzing employed learning designs, and identifying gaps and recommendations for further research in learning design development. Conducted through a Systematic Literature Review (SLR) approach, the research involved planning, implementing, and disseminating review results. One hundred forty-four documents were scrutinized, leading to the identification of 19 pertinent papers. This study provides a comprehensive analysis of the literature on learning design in the context of ratio, proportion, scale, and level, utilizing RME and PMRI approaches while highlighting research gaps and offering insights for future studies. Its findings hold significant implications for educators and researchers seeking to enhance mathematics education through RME and PMRI approaches.

Keywords: *pendidikan matematika realistik Indonesia*; proportion; ratio; realistic mathematics education; systematic literature review

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Introduction

Ratio and proportion are essential mathematical concepts commonly encountered in everyday scenarios and the workforce (Ben-Chaim et al., 2012). Nonetheless, students frequently need help understanding and applying these concepts (Wahyuningrum et al., 2017). Furthermore, Peñaloza and Vásquez (2022) found that elementary school students struggle to formalize their comprehension of ratio due to difficulties in applying mathematical strategies correctly when solving tasks. These challenges stem from several factors, including insufficient instructional practices, disparities in students' formal and informal education, overly standard and superficial teaching methods, and the implementation of unsuitable learning models (Ayan et al., 2019; Zuhra et al., 2018; Andinasari et al., 2020). Moreover, the absence of relevant context and visual aids also contributes to students encountering difficulties when attempting to comprehend the concepts of proportion and ratio (Nasution et al., 2014) and creates a MOOC (Massive Open Online Course) during mathematics teacher training improved trainee teachers' content, pedagogical, and technological knowledge for teaching ratio and proportion (Anat et al., 2020). This is often why researchers create lessons or develop learning materials to help students comprehend the concepts of ratio and proportion.

Researchers agree that the Realistic Mathematics Education (RME) approach and its adaptation, known as *Pendidikan Matematika Realistik Indonesia* (PMRI), can address these issues (Muttaqin et al., 2017; Ohtani, 2007; Nursa, 2020). RME or PMRI methods, which prioritize real-life contexts, can facilitate mathematical abstraction and the transformation of mathematical concepts from informal to formal forms for students (Hadi, 2017; Soedjadi, 2007). The principles and characteristics of RME and PMRI aim to promote higher-order thinking skills among students. This facilitates the reception of teacher-transferred knowledge and comprehension through tasks and practical problem-solving applicable to everyday and professional situations (Meirisa et al., 2018; Hadi, 2017). Therefore, mathematics learning needs to start using approaches that can bridge students' real lives with the mathematical material they learn at school so that they can easily imitate, understand, and apply it when dealing with problems.

Teaching modern mathematics in schools has the potential to further abstract mathematics; however, it is also the source of pedagogical difficulties (Gravemeijer & Terwel, 2000). Freudenthal (2006) argues that mathematics is derived from humans' common-sense experiences of reality, subsequently formulated into a rule and utilized to solve real-life problems and phenomena. He refers to the process as mathematizing or organizing mathematics. New mechanistic approaches to mathematics need to adequately consider the process of mathematizing but rather leap away from mathematical structures (Gravemeijer & Terwel, 2000). Consequently, students often need help comprehend mathematics' structure and its practical applications in everyday life. A realistic approach, also known as RME, is needed as an alternative to modern mathematics' mechanistic approach, which is anti-didactic (Gravemeijer & Terwel, 2000). RME and PMRI approaches are forerunners in learning design, which includes designing for ratio and proportion learning.

Many educators have utilized the RME or PMRI approach to design lessons on ratio and proportion between 2000 and 2023. However, numerous students need help comprehending this material (Fauziah, 2021; Wahyuningrum et al., 2017). A comprehensive and methodical literature review is necessary to analyze the current ratio and proportion learning design status objectively. This review will address the existing gap and identify areas of improvement in the learning design process. By providing such insights, this literature review will be an essential resource for educators and researchers developing learning designs, particularly those using the RME or PMRI approach and materials related to ratio and proportion. In this study, the Systematic Literature Review (SLR) approach is utilized to comprehensively examine multiple ratio and proportion learning designs that implement both the RME and PMRI approaches. This literature review aims to address the following research inquiries:

RQ1: What is the literature profile of ratio and proportion learning design research using RME and PMRI approaches? What is the keyword and author network of the literature?
RQ2: How is ratio and proportion learning designed in the existing literature? What content, context, and modeling tools are used, and what are the activities?
RQ3: What are the gaps and limitations in ratio and proportion learning design in the existing literature? And what suggestions does the literature provide for further research to improve and advance the quality of future learning designs?

RQ1 aims to profile the research literature on ratio and proportion learning design using RME and PMRI approaches. This section will describe the key characteristics of scientific publications, including year of publication, publisher, author, country, affiliation, type of research, and methodology. RQ2 will then review and synthesize the main findings from research on ratio and proportion learning design. This section presents the learning design's context, achieved content, modeling tools used, and learning activities objectively. Following that, RQ3 aims to identify the research's gaps and limitations while suggesting future researchers follow them to advance knowledge in learning design, particularly for ratio and proportion materials.

This Systematic Literature Review (SLR) contributes to the existing knowledge, particularly in mathematics education. Moreover, it assists educators and researchers in conducting further studies on the design of learning for ratio and proportion based on the foundation of this review. The SLR offers an extensive overview of available research on learning design through RME and PMRI approaches, encompassing a comprehensive understanding of various design outcomes that past researchers have created. The review performed a comprehensive analysis of the literature profile and content to uncover the theoretical basis for developing the learning design ratio and achieving content proportion and the contextual factors, modeling tools, and activities employed. The review identifies gaps in the literature to offer insights and recommendations for new research on learning design utilizing the RME and PMRI strategies, particularly with respect to ratio and proportion materials. This may assist educators and researchers in objectively enhancing math education.

Methods

The study utilized the SLR approach to identify and assess pertinent research. The method involves collecting and analyzing data from the studies and critically appraising them. The approach is a research method and process (Liberati et al., 2009; Synder, 2019). This research aims to identify all empirical evidence that meets the predetermined inclusion criteria to address specific research questions or hypotheses. The goal is to provide conclusive findings that can inform decision-making (Moher et al., 2009).

In this research, we chose SLR as it aligns with our objectives of identifying the design of ratio and proportion learning by past researchers and uncovering the gaps and limitations. These findings will allow us to draw conclusions and make informed decisions regarding future research. The review of the SLR method entails three primary phases: planning, conducting, and reporting, presented in Figure 1 (Kitchenham & Charters, 2007; Brereton et al., 2007; Xiao & Watson, 2019).

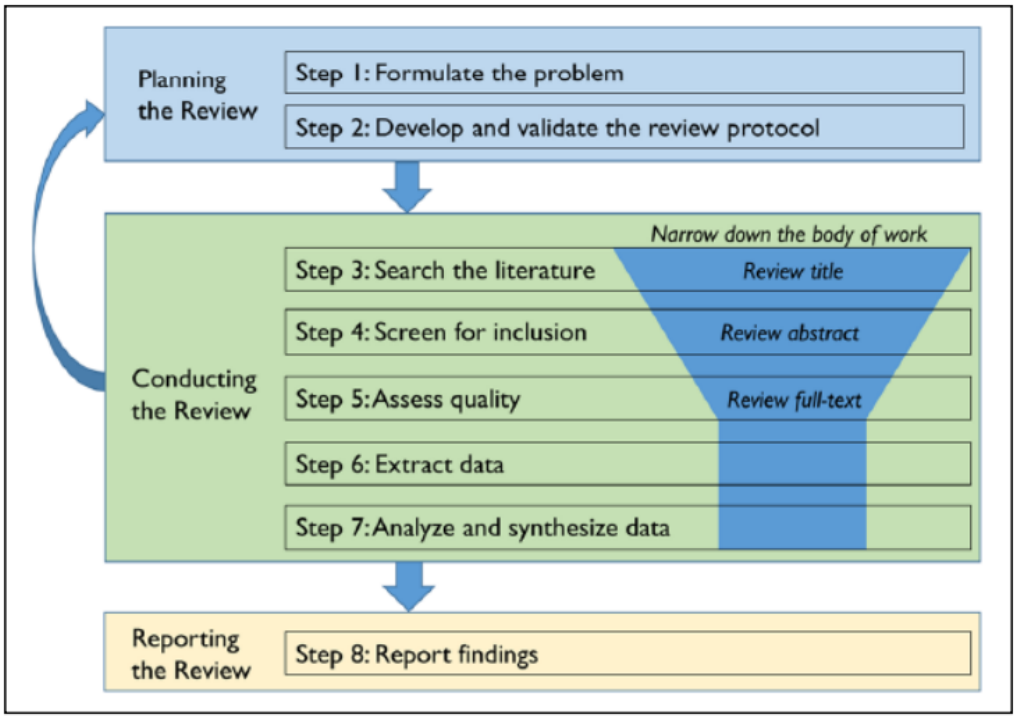

Figure 1. Steps of systematics literature review

Planning the review

In the planning a review, researchers identify the necessary elements, determine applicable research questions, and develop a review protocol (Kitchenham & Charters, 2007; Brereton et al., 2007; Xiao & Watson, 2019). During the review protocol development stage, after identifying the requirements and formulating the research questions, researchers make three crucial determinations concerning keyword choice, database selection, and inclusion and exclusion criteria (Khizar et al., 2023). First, researchers should carefully select appropriate keywords to identify relevant literature. Next, databases such as Scopus and Google Scholar should be utilized to identify studies that meet the criteria for inclusion in this review. Finally,

researchers must establish inclusion and exclusion criteria to ensure that the identified literature is relevant to the review (Xiao & Watson, 2019).

Conducting the review

The review commenced with several steps: a literature search, inclusion screening, data extraction, data analysis and synthesis, and review reporting. The literature can be sought from three primary sources: electronic databases and backward and forward searching. As the main database, Scopus was utilized in this study to identify pertinent literature to be integrated into this review. Google Scholar was used as a supplementary database to locate additional articles about the study. The inclusion and exclusion criteria were established to guarantee the literature's significance and quality. Table 1 presents the inclusion and exclusion criteria utilized in this investigation.

Table 1. Search keywords, database, exclusion and inclusion criteria

Database	Scopus (primary database) Google Scholar (second database)
Title Words	"Ratio" "Proportion
Keywords	"Ratio" and "Realistic Mathematics Education" "Ratio" and "*Pendidikan Matematika Realistik Indonesia*" "Proportion" and "Realistic Mathematics Education" "Proportion" and "*Pendidikan Matematika Realistik Indonesia*"
Exclusion Criteria	- Any of the selected keywords not appearing tittle, abstract, keywords, full text - Not in English - Publisher is unclear - Beyond the scope of mathematics design learning
Inclusion Criteria	- Any of the selected keywords appeared in the title, abstract, keywords, full-text - Be published in any of the selected databases - Be a journal article or Thesis - Be in the English Language

Initial filtering was performed using relevant title words, keywords, and databases, which led to the identification of 144 documents from Scopus (n = 10) and Google Scholar (n = 134), as presented in Table 2. Then, the researchers appraised the articles obtained and discarded duplicated and inaccessible documents, resulting in 93 remaining documents. Next, researchers analyzed the title and abstract using exclusion and inclusion criteria.

Table 2. Literature search results based on database, title words, and keywords

Title Words	Keywords	Scopus	Google Scholar
Ratio	"Ratio" and "Realistic Mathematics Education"	4	107
	"Ratio" and "*Pendidikan Matematika Realistik Indonesia*"	0	5
Proportion	"Proportion" and "Realistic Mathematics Education"	5	67
	"Proportion" and "*Pendidikan Matematika Realistik Indonesia*"	1	5
	Total documents	10	134
	Total of all documents		**144**

We identified 36 documents that met the requirements, while 57 papers still needed to meet them. Of the 36 eligible documents, 19 were identified as having the potential to address the research questions. These 19 documents include seven from the Scopus database and 12 from the Google Scholar database. The researchers employed a meticulous and rigorous selection process to synthesize the literature thoroughly. Please refer to Figure 2 for a visual representation of the document selection process.

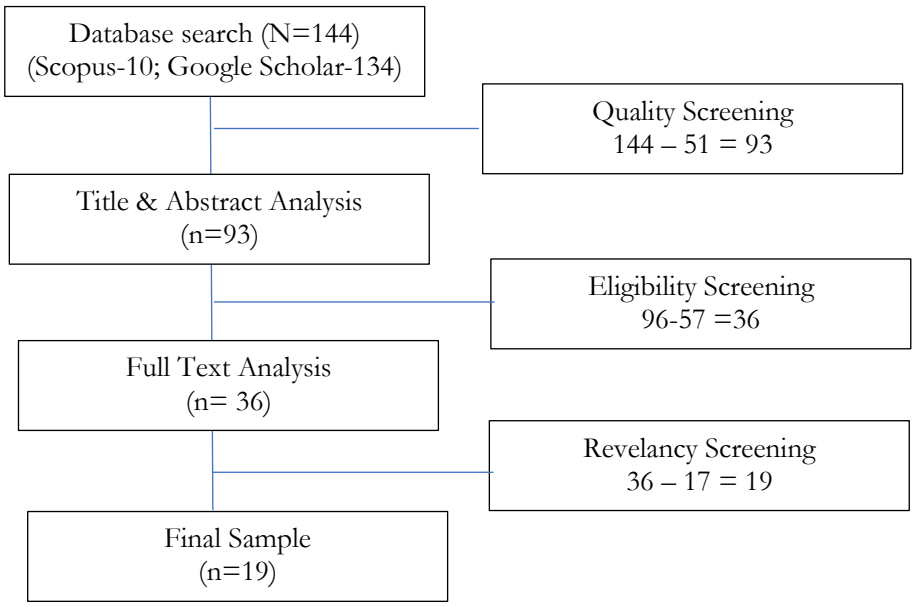

Figure 2. PRISMA selection process

After selecting 19 pertinent documents for further review and analysis, each article was coded on several dimensions, including author name, year of publication, publication source, paper title, paper type, methods used, geographical context, research objectives, research questions, main findings, limitations, and suggestions for future research. A distinct database was developed using MS Excel to perform the scraping. Additionally, we utilized Word Cloud and bibliometric VOSViewer software to examine literature and network profiles quantitatively. Furthermore, the researcher employed quantitative analysis to assess the

outcomes of learning design development, identify gaps, and propose further actions from the literature.

Reporting the review

Creating a dependable and replicable literature review involves providing comprehensive documentation of systematic studies, which should detail the rationale behind each inclusion and exclusion criterion. Additionally, it is essential to report the literature search findings, screening, and quality assessment. The review findings in this study were analyzed using Word Cloud and VOSViewer applications to examine literature and network profiles. The literature content analysis was reported descriptively, and the review report was structured as follows: first, a quantitative descriptive analysis of the literature profile; second, network analysis; third, qualitative literature analysis; fourth, a critical review analysis.

Results

In this study, we reviewed three analyses: research profiling and network analysis, content analysis or qualitative analysis, gap/limitation research analysis, and suggestions for future research. This section summarizes the literature on learning ratio and proportion design. Technical term abbreviations used throughout this section are defined upon their first mention. Our literature review indicates a growing trend in scientific publications, with nearly all selected studies published in the past decade (see Figure 3). The studies primarily utilized design research methods and were mainly conducted in Indonesia. The highest number of publications gathered were 15 studies from Indonesia, followed by 1 study from Turkey, two from the Netherlands, and one from Japan.

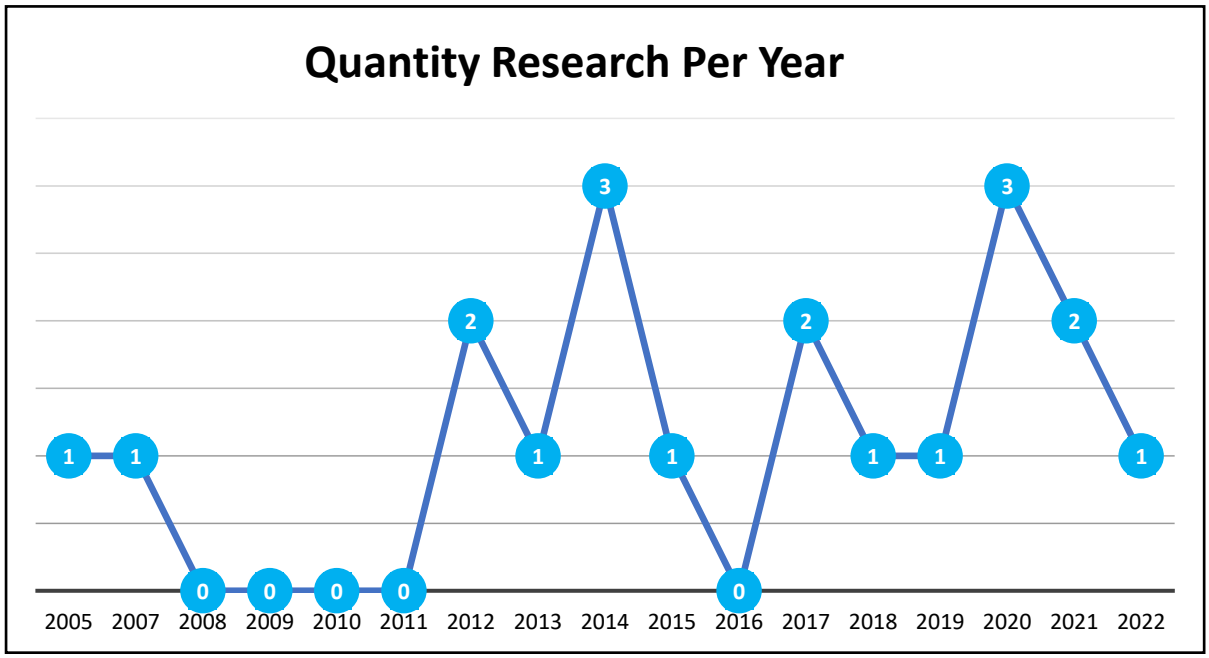

Figure 3. Publications per year of research on ratio learning design and proportion with RME and PMRI

Of the 19 pieces of literature collected, 42 authors contributed, with 30 authors from Indonesia, three from Turkey, one from Japan, and eight from the Netherlands. The most collaboration between countries occurs between Indonesia and the Netherlands, made possible by a joint research and education project. Turkey and Japan have developed learning designs for ratio and proportion using the RME approach, yet there has yet to be collaboration with other nations, presented in Figure 4.

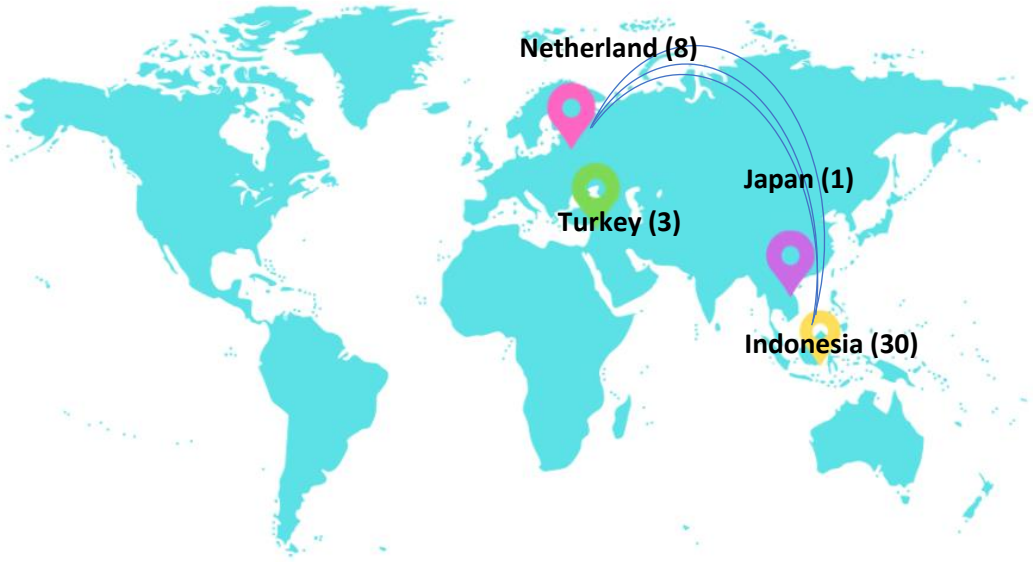

Figure 4. Distribution of research authors on ratio and proportion learning design with RME and PMRI Approach

This study presents two types of keyword-based data visualization: word cloud and co-occurrence. Figure 5 illustrates the keyword visualization with the use of a word cloud. The varying font sizes in bibliometric word clouds generally represent the frequency or importance of specific keywords or terms in the analyzed bibliometric dataset. Using bibliometric word clouds, researchers and readers can identify significant keywords or terms for formulating hypotheses, research focus, and objectively exploring trends in particular scientific literature.

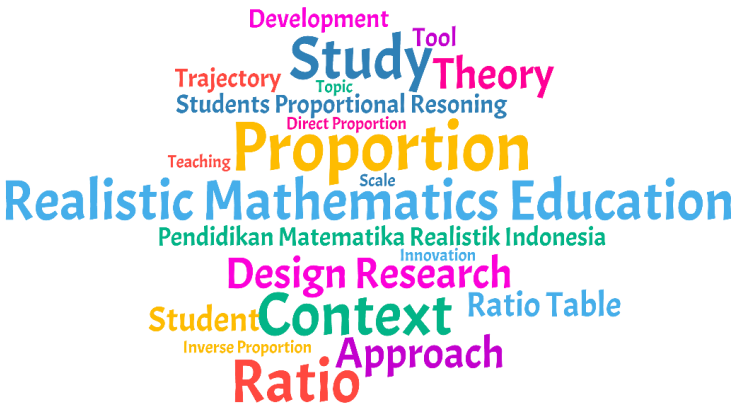

Figure 5. Bibliometric word cloud of research literature on ratio and proportion learning design with RME and PMRI

Among the keywords in the Word Cloud, "Realistic Mathematics Education" and "Proportion" are comparatively more prominent, suggesting that these keywords frequently occur in most of the collected literature. The data indicates that "Realistic Mathematics Education" and "Proportion" are current scientific literature's most prevalent and emerging topics. Additionally, "research design," "context," "ratio," and "ratio table" are relatively prominent keywords, although not to the same extent as RME and proportion.

The study analyzed the keyword network using Vos Viewer. Figure 6 displays the visual keyword mapping, while Figure 7 demonstrates a visible cluster comprising three main clusters. Table 3 provides specific information about the keywords in each cluster, including their occurrence and link strength. This network analysis of keywords serves an essential function in identifying the relationships between them and concepts within the literature, visualizing the structure of the literature, identifying clusters of closely related keywords, measuring their significance, mapping trends, and assisting in keyword selection. Researchers can use this technique to comprehend the structure of the literature and identify essential topics for further research.

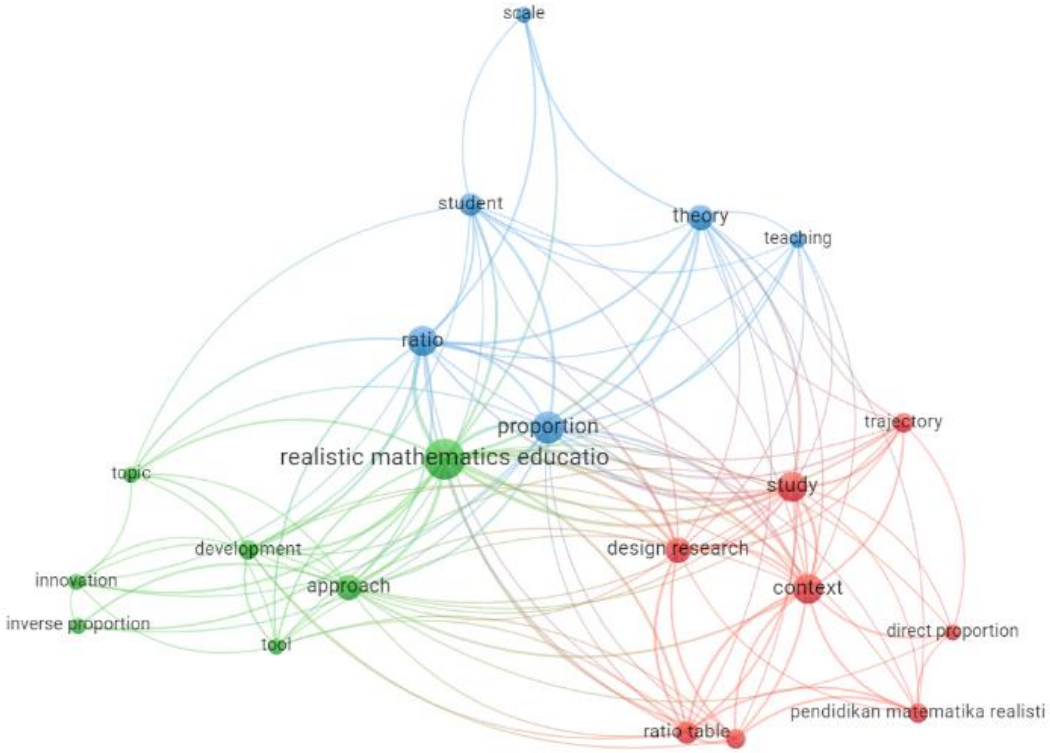

Figure 6. Keyword network literature research learning design ratio and proportion with RME and PMRI Approach

Figure 7 illustrates distinct clusters from the keyword mapping analysis. The initial cluster contains keywords like "Design Research," "Indonesian Realistic Mathematics Education," and other related terms such as "context," "direct proportion," "study," etc., denoting research centered on the Indonesian Realistic Mathematics Education approach through design research techniques, emphasizing comparative content in the Mathematics

Education context. The second cluster contains keywords associated with Realistic Mathematics Education, strategy, and development. The presence of the term "inverse proportion" indicates a focus on the concept of inverse comparison in mathematics education. "Tool" and "topic" refer to the modeling tools and research topics utilized in Realistic Mathematics Education. The third cluster emphasizes terms that closely tie to the comparison concept, including "proportion," "ratio," "scale," and "student."

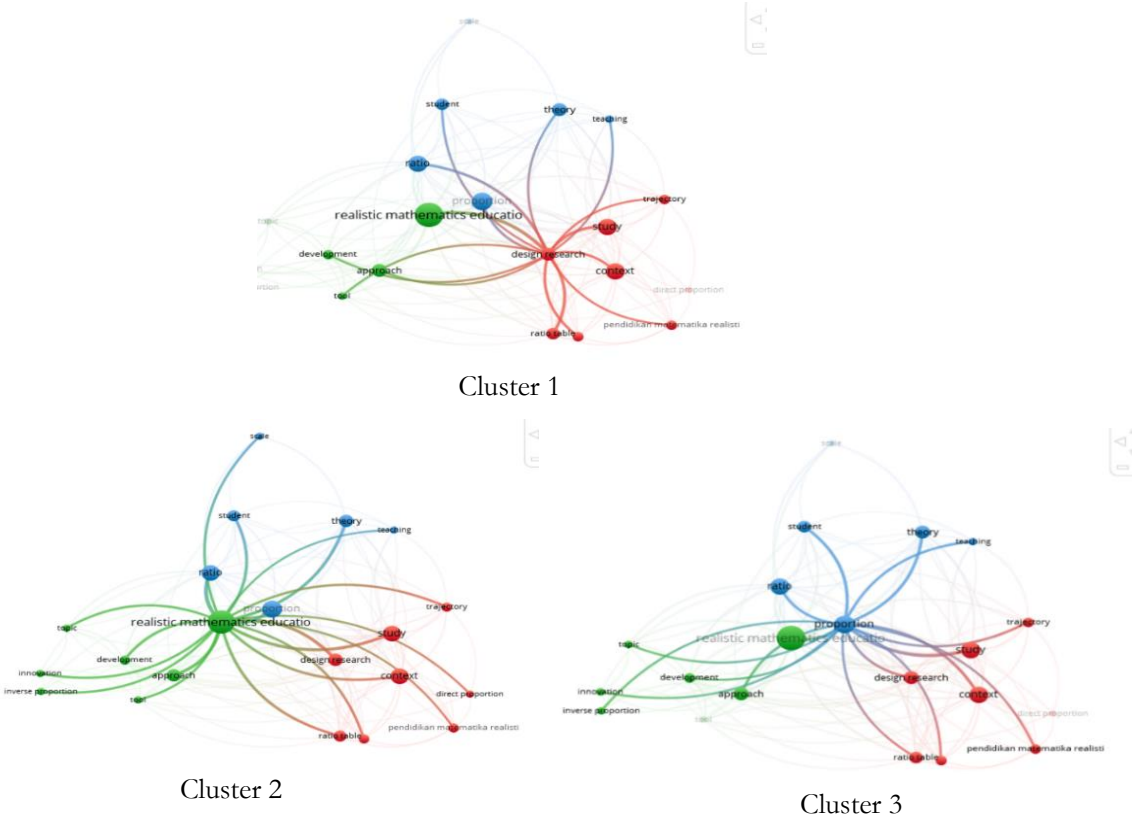

Figure 7. Clusters on keyword network research literature ratio and proportion learning design with RME and PMRI Approach

This suggests a concentration on comprehending comparison in mathematics education and its related theories. These clusters demonstrate the various aspects of realistic mathematics education and comparison within mathematics lesson design research. This cluster analysis can assist researchers in gaining a better comprehension of the research focus within the analyzed literature.

Table 3 presents the frequencies of occurrence and link strength of keywords in the nine texts analyzed in this study. The first cluster of keywords has varying occurrences, with "study" and "context" appearing most frequently at seven instances each. The total link strength for this cluster is relatively high, suggesting a strong relationship between the keywords in this analyzed literature. "Study" has the highest link strength in this cluster at 36. The second cluster is populated by various occurrences, featuring "realistic mathematics education" most frequently, at 13 times.

Moreover, the total link strength in this cluster is significantly high. Notably, the keyword "realistic mathematics education" boasts the highest link strength of 60, evidencing its strong correlation to other concepts in the literature. The third keyword cluster displays varied occurrences, with "proportion" and "ratio" being the most frequent at eight appearances each. This cluster also exhibits a high total link strength, with "ratio" having the highest link strength at 38. Examining the occurrence and link strength aids in comprehending the focus and correlation among keywords or concepts in the literature being analyzed. The analysis highlights that the literature heavily concentrates on realistic mathematics education, emphasizing ratio and comparison content, design development, and innovative approaches in the Indonesian context.

Table 3. Keywords, cluster, occurrence, and link strength

Cluster	Keywords	Occurrence	Total Link Strength
1	Context	7	32
	Design Research	5	28
	Direct Proportion	2	7
	Pendidikan Matematika Realistik Indonesia	3	12
	Ratio Table	4	23
	Students Proportional Reasoning	3	18
	Study	7	36
	Trajectory	3	15
2	Approach	5	22
	Development	3	19
	Innovation	2	9
	Inverse Proportion	2	6
	Realistic Mathematics Education	13	60
	Tool	3	13
	Topic	2	11
3	Proportion	8	36
	Ratio	7	38
	Scale	2	7
	Student	4	17
	Teaching	2	10
	Theory	5	23

Discussion

Content analysis/ Qualitative analysis

In this section, we conducted a content analysis of the literature reviewed to address our second research question. Specifically, we examined how ratio and proportion learning design is portrayed in existing literature, including the content, context, modeling tools, and learning activities utilized. Please refer to Table 4 for further details.

Table 4. Content, context, and modeling tools used in literatures

Code	Title	Author	Year	Country	Content	Context	Modelling Tools
A1	Designing Instruction on Proportional Reasoning with Average Speed	Gravemeijer, K Van Galen, F Keizer, R	2005	Netherland	Speed	Bicycle	Double Number Line
A2	Designing unit for teaching proportion based on cultural-historical activity theory: Process of symbolizing through collective discourse	Ohtani, M	2007	Japan	Proportion	Water Vase/Pot	Ratio Table
A3	Design Research: Ratio Table and Money Context as Means to Support the Development of Students' Proportional Reasoning	Sumarto S.N Zulkardi Darmowijoyo Van Galen, F	2012	Indonesia	Proportion	Money	Ratio Table
A4	Student's Modelling in Learning the Concept of Speed	Khikmiyah, F Lukito, A. Patahudin, S.M.	2012	Indonesia	Speed	Toy Car	Ratio Table
A5	Design Research on Mathematics Education: Ratio Table in Developing the Students' Proportional Reasoning	Sumarto, S.N	2013	Indonesia	Proportion	Butterfly Caterpillar Chocolate	Ratio Table
A6	Educational Design Research: Supporting Fifth Grade Students to Learn about Proportion	Nasution, A.A Amin, S.M Lukito, A Abels, M Dolk, M	2014	Indonesia	Proportion	Rice	Ratio Table
A7	Supporting The Students' Proportional Reasoning Using Palembang Culture as Context and Ratio Table as Model	Utari, R.S Putri, R.I.I Hartono, Y	2014	Indonesia	Proportion	Songket Ampera Bridge	Ratio Table
A8	Using Double Line to Support in Learning Ratio and Scale	Wirani, W Amin, S.M Lukito, A Van Eerde, D	2014	Indonesia	Ratio Scale	Bali Map	Double Number Line
A9	Developing A Local Instruction Theory on Ratio and Scale	Wirani, W	2015	Indonesia	Ratio Scale	Map Traveling	Double Number Line
A10	Design Research on Ratio and Proportion Learning by Using Ratio Table and Graph with Oku Timur Context at the 7th Grade	Muttaqin, H Putri, R.I.I Somakim	2017	Indonesia	Proportion	OKU Timur Landscape	Ratio Table Ratio Graph
A11	A Proposed Local Instructional Theory for Teaching Instantaneous Speed in Grade Five	de Beer, H Gravemeijer, K Van Eijck, M	2017	Netherland	Speed	Filling Glassware	Graph
A12	Learning Direct Proportion by Using the Context of Timpan Recipes	Zuhra, S.F Zubainur, C.M Abidin, T.F	2018	Indonesia	Proportion	Timpan Recipe	Ratio Graph Equation

Code	Title	Author	Year	Country	Content	Context	Modelling Tools
A13	Innovation in Learning Proportion using Proportion Table	Oktaviani, M	2019	Indonesia	Proportion	Army Cloth Necklaces Bracelets Marmer Transjakarta Bus	Proportion Table
A14	A Math Teacher's Participation in Classroom Design Research: Teaching of Ratio and Proportion	Ayan, R Isikal-Bostan, T Stephan, M	2020	Turkey	Ratio Proportion	Fish Fish Feed	Ratio Table
A15	Learning Design of Proportion using Tangram Context	Andinasari Jayanti Wasiran Y	2020	Indonesia	Proportion	Tanggram	Ratio Table
A16	On Teaching Learning for Proportion using Musi Tour Context	Nursa, N.F Hartono, Y Somakim	2020	Indonesia	Proportion	Musi Tour	Ratio Table
A17	Learning Direct and Inverse Proportion using Pen and Money for Slow Learner Student	Wardani, K.D Prahmana, R.C.I	2021	Indonesia	Proportion	Pen Money	Ratio Table
A18	The Development of Learning Media with Realistic Mathematics Education Approach for Topic of Ratio and Proportion	Maryam, R Sampoerno, P.D	2021	Indonesia	Ratio Proportion	Scout	Ratio Table
A19	Hypothetical Learning Trajectory in Scientific Approach on Material Direct Proportion: Context of Rice Farmers' Activities Pandanwangi Cianjur	Sugiarni, R. Herman, T Juandi, D Supriyadi, E	2022	Indonesia	Direct Proportion	Rice Farmer	Ratio Table

Specific content of ratio and proportion

The 19 reviewed works discovered a range of learning designs on ratio and proportion employing RME and PMRI approaches. The study investigated the specific concepts of speed, direct proportion, inverse proportion, ratio, and scale. Of these topics, proportion was the most thoroughly scrutinized. A portion of the examined literature revealed that students often face challenges comprehending the notion of proportion (Sumarto et al., 2013). Proportional problem-solving presents various challenges, including the utilization of multiplication strategies, difficulty identifying smaller numbers in proportional scenarios, as well as other hindrances: recognizing whole number ratios and grappling with complex numbers such as fractions and decimals (Nasution et al., 2014; Zuhra et al., 2018).

Competency

Some literature does not mention the improved competencies, but most highlight the improvement of proportional reasoning. Research focusing on enhancing proportional

reasoning is crucial as this ability plays a pivotal role in students' mathematical literacy and problem-solving skills (Sumarto, 2013). Understanding proportions is relevant in everyday life and the foundation for more complex mathematical concepts (Gravemeijer et al., 2005; Utari et al., 2015). Proportional reasoning abilities support academic performance in mathematics and lay the groundwork for skills required in the workplace. In addition, improving proportional reasoning can help positively contribute to the overall development of students' mathematical literacy.

Context

The literature refers to various contexts including the bicycle, water, vase/pot, money, toy car, butterfly, caterpillar, chocolate, rice, songket, Ampera Bridge, Bali map, map, travel activities, Oku Timur landscape, glassware filling activities, timpan recipe, army cloth, necklaces, bracelets, marble, Transjakarta bus, pancake, fish, fish feed, tangram, Musi tour, pen, scout, and rice farmer. The choice of contexts in ratio and proportion education varies with the objective of creating significant, compelling, and pertinent learning experiences for the students. Each context, sourced from diverse aspects of life, culture, and the environment, presents an opportunity to link mathematical concepts to real-life situations, promoting a better understanding.

Concrete, real-life situations, such as rice farming, preparing timpan, or constructing the Ampera Bridge, can demonstrate to students how to apply concepts of ratio and proportion in their daily lives (Sugiarni et al., 2022; Zuhra et al., 2018; Utari et al., 2015). In addition, selecting diverse contexts ensures cultural diversity and representation in learning. This allows students to understand the relation between mathematical concepts and different aspects of life and cultures (Nursa et al., 2020). Furthermore, it enhances student motivation by making learning more engaging and relevant.

Modeling tools

Several modeling tools for ratios and proportions are discussed in the literature review, such as double number lines, ratio graphs, equations, proportion tables, and the most frequently used ratio table. Despite suggestions to implement concrete models, like ratio tables, in mathematics education, some studies reveal that the use of modeling tools by math teachers still needs to be improved (Ohtani, 2007; Oktaviani, 2019). Therefore, certain studies we researched aimed to investigate the necessity for additional research into the methods that can aid students' proportional thinking, such as using student visualizations and ratio tables.

Activity

Our literature review found a range of activities for teaching ratio and proportion. For example, Gravemeijer et al. (2005) developed an exercise where students must solve a problem based on two girls' bicycle trip. The activity involves measuring the distance and confirming that the trip was successful. The students' queries included assessing performance within a specific

timeframe, examining the correlation between the distance already covered and the remaining distance to be covered, and accounting for other variables that may impact the estimation of travel duration. Another study conducted by Ohtani (2007) introduced an activity wherein students collected data by pouring water into a vase, identified proportional rules from data patterns, predicted unknown values using a ratio table, and communicated thinking strategies to the teacher in relation to the concept of proportion.

Sumarto et al. (2013) also designed activities that involved students in exploring ratio tables by recording the price of chocolate, applying mathematical strategies in solving problems, and even understanding the concept of proportionality through the activity "Best Buying." Similarly, Khikmiyah et al. (2012) study designed an activity in which students compared the velocity of two toy cars with paper tape, measured time and distance to investigate the cars' speed, developed a ratio table based on the results, and utilized it to solve speed, distance, and time-related problems. Furthermore, Sumarto's (2013) research outlines a sequence of exercises, ranging from constructing butterflies by identifying the number of wings, body, and antennae to employing the ratio table to select the more cost-effective option, incorporating proportional problem-solving skills and utilization of the ratio table as a cognitive instrument for students. Nasution et al. (2014) designed an activity where students use visualization and ratio tables to solve the rice problem, determining the number of days needed to cook 20 packs of rice daily. Then, Utari et al. (2014) created two activities for their study. The first required the participants to complete a ratio table for the Palembang Songket motif problem. The second activity involved the students taking on the role of architects to determine the size of the components of the Ampera Bridge by utilizing unit conversions and ratio tables.

Wirani (2015) developed a five-lesson curriculum that covers key skills from comparing data in Lesson 1 to constructing mathematical models and determining equivalent ratios through multiplicative comparisons in Lesson 5. The curriculum encourages students to think critically and apply mathematical concepts in practical contexts. Muttaqin et al. (2017) study required students to identify and create ratio tables, convert ratios to mathematical equations, create comparison graphs using the straight-line equation $y = mx$, and solve problems involving missing values and comparisons. In addition, de Beer et al. (2017) designed activities for students to observe the relationship between the width of a cocktail glass and the amount of water required. Additionally, Zuhra et al. (2018) study encourages students to select different flavors of timpan, examine various timpan recipes, calculate the ingredient ratios of multiple recipes, and display the ratios using graphs and mathematical equations.

Oktaviani (2019) developed an activity for students to observe and count the number of berets, shoes, and weapons in an army ceremony. Additionally, students participated in counting beads for necklace and bracelet making, dividing marbles, calculating travel time via Transjakarta bus, and identifying examples of proportion in everyday life. Ayan et al. (2019) conducted a study in which students were tasked with recognizing and comparing images of fish and fish food sticks. The study required various cognitive strategies such as pictorial, numerical, and mental linking and the ability to solve scale-up problems, use length ratio tables, and change ratio rules. The research aimed to enhance understanding of the relationship between fish and food sticks through an objective, clear, and concise approach. Andinasari et

al. (2020) created exercises that engaged students in investigating tangrams as an introductory activity, fostering an understanding of comparison before beginning authentic comparison learning. Student activities involve exploring equivalent and reciprocal values concepts through solving tile or marble floor installation problems and analyzing the relationship between completion speed, site size, and tile installation time.

Nursa et al. (2020) developed activities to comprehend proportionality by reflecting on the journey to the Musi River. They compared quantities with the same and different units and taught direct and inverse proportionality via problem-solving utilizing ratio tables and boat modelling. The Musi Tour was used to deliver contextualization and link the understanding of proportions. Wardani and Prahmana's (2021) research presents activities that introduce the concept of direct proportion in the context of purchasing pens, utilizing problem formulation and discussion. Student activities entail experimenting and discovering the correlation between mathematics and scouting. Concrete scenarios are utilized to verify comprehension and develop effective problem-solving strategies via ratio problems. Sugiarni et al. (2022) devised activities incorporating both Pandanwangi cultural literacy and comprehension of rice farmers' practices via e-worksheets. Student activities included asking problems, analyzing fertilizer needs, trying to solve them in a simple context, and communicating concept findings.

Various approaches and activities designed for ratio and proportion learning design are presented in the literature review. Gravemeijer et al. (2005) employ a bicycle trip context to engage students in problem-solving related to time, distance, and achievement evaluation. Technical terms are explained upon first use and a logical flow of information is maintained throughout the writing. Ohtani (2007) offers hands-on experience through activities such as pouring water into a vase, identifying proportional rules, and using ratio tables to predict unknown values. Other activities proposed by Sumarto et al. (2012) and Khikmiyah et al. (2012) and later by Sumarto (2013) can help students comprehend the concepts of ratio and proportion. These activities include exploring ratio tables, comparing car speeds, and selecting items by price.

The significance of daily life context is apparent in the work of Wirani (2015), Muttaqin et al. (2017), and de Beer et al. (2017). Their studies involved activities centered around creating butterflies, comparing recipes, and investigating the correlation between the width of a cocktail glass and the volume of water needed. These examples illustrate the importance of incorporating practical, relatable scenarios into research practices. In addition, recent studies by Ayan et al. (2019) and Nursa et al. (2020) have demonstrated effective methods for comprehending proportion, including the utilization of visuals, dialogue related to travel experiences, and problem-solving with ratio tables. Regarding the development of mathematical thinking, Wirani (2015) and Ayan et al. (2019) demonstrated that the activities were designed progressively, beginning with differentiating between variations and culminating in solving scale-based problems and utilizing lengthy ratio tables.

Moreover, several studies emphasized the significance of discourse and cooperation in math education, permitting students to establish and develop their comprehension jointly. This literature review suggests that the ratio and proportion learning design emphasize mathematical concepts while integrating real-life situations, visual aids, and a progressive approach to

developing students' mathematical thinking. This approach aims to enhance students' motivation and engagement in mathematics while providing a deeper understanding of ratio and proportion concepts relevant to their daily lives.

Research Gaps and suggestions for future research

A critical analysis of existing ratio and proportion learning design literature utilizing RME and PRMI approaches has revealed numerous gaps and limitations. This section highlights some of these ratio and proportion learning design research gaps. The literature reviewed indicates a need for more cultural context and variation in learning design, which can be remedied by developing more inclusive approaches and using modeling tools that reflect cultural diversity. Furthermore, expanding the use of modeling tools beyond commonly used ratio tables can address the obstacle of limited variety in modeling tools. A detailed analysis of each modeling phase and the symbolization of ratios and proportions is yet to be accomplished.

Therefore, future research should entail a more comprehensive analysis to involve mathematicians, conducting a small-scale trial, and gathering feedback from teachers and students. Additionally, recognizing the importance of implementing the learning design for lower-grade students, research suggestions involve creating a learning design that aligns with their cognitive level and needs. Finally, the study identified teachers' lack of implementation of socio-normative aspects. Suggestions were made to prioritize teacher training, create learning environments that promote RME or PMRI approaches, and apply socio-norms in learning. Overall, the research leads to the development of a more holistic, contextualized learning design that caters to the diverse needs of students regarding ratio and proportion learning, presented in Table 5.

Table 5. Research gap and suggestion for future research

No	Research Gap	Suggestion for Future Research
1	Lack of diverse contexts that are culturally relevant and closer to students, or model tools that are culturally specific for solving problems related to ratio and proportion.	Need to create greater diversity in learning designs that are more closely tied to students and their cultural backgrounds or employ modeling tools developed by specific cultural groups.
2	Limited use of modeling tools beyond ratio tables is prevalent in most studies, leading to a lack of variety in ratio and proportion modeling. However, there exist numerous modeling tools that can be utilized to improve the quality of studies.	
3	Insufficient examination of each stage of ratio and proportion modeling and symbolization to verify the accuracy of the modeling and symbolization activities performed in each task.	Further investigation is necessary to analyze thoroughly each phase of modeling and symbolization of ratio and proportion in learning activities. It is recommended to involve mathematicians and conduct small trials while considering feedback from both teachers and students.
4	The use of learning design is primarily in junior high and upper elementary school, but there is a	There is a need to develop instructional designs that integrate ratio and proportion modeling tools for elementary-level students.

No	Research Gap	Suggestion for Future Research
	necessity to try out the application on younger students via basic modeling tools.	
5	Lack of implementation of socio-norms by teachers in classroom learning so that students can actively participate in learning.	Teacher training or development of a learning environment for teachers emphasizing understanding the RME or PMRI approach and socio-norms in classroom learning is necessary.
6	Insufficient attention by teachers to shaping the classroom environment that fosters students' conceptual development of math with a focus on socio-norms.	
7	The teacher is less able to conduct explorations that can encourage students to be able to find their own answers with the guidance of questions	
8	Learning designers should conduct a detailed examination of the specific challenges that students face when solving ratio and proportion problems. This will enable the resulting learning design to be more suitable and effective.	Need for in-depth preliminary research on students' obstacles in solving ratio and proportion problems before designing lessons
9	Many learning designs produced are still limited to ratio and proportion visualization activities and are less accompanied by activities that can hone students' abilities in solving ratio and proportion problems.	Developing a comprehensive learning design which integrates activities involving ratio and proportion problem-solving skills is essential to enhance students' ability to apply these concepts in practical settings.
10	Limited use of modeling tools beyond ratio tables is prevalent in most studies, leading to a lack of variety in ratio and proportion modeling. However, there exist numerous modeling tools that can be utilized to improve the quality of studies.	Need to develop ratio and proportion learning design with the use of more modeling tools
11	Many studies lack comprehensive insight from interviews or questionnaires regarding student outcomes and the factors that impact learning outcomes through learning design.	It is necessary to design more comprehensive assessment instruments to quantitatively measure student understanding, along with the development of learning designs.
12	Many studies lack comprehensive insight from interviews or questionnaires regarding student outcomes and the factors that impact learning outcomes through learning design.	In conducting retrospective analysis, researchers need to more deeply explore students' thinking strategies, students' understanding and students' learning process.
13	Some lesson designs fail to account for individual differences in students' learning experiences, including factors such as prior knowledge, learning styles, and perceptions of mathematics.	It is essential to create a ratio and proportion learning plan that focuses on student differentiation and considers factors within students that affect their comprehension in the classroom.

This study reviews the research profiling and network analysis pertaining to learning design on ratio, proportion, scale, and level. The literature summary indicates an upward trend in scientific publications over the past decade. The dominant research design employs design research methods, and most studies were conducted in Indonesia, with 14 out of 16 articles originating from this country. The remaining two studies came from Turkey and Japan, respectively. Collaboration among countries is most prevalent between Indonesia and the Netherlands, aided by collaborative research and education projects. However, Turkey and

Japan concentrate on developing learning designs independently, without international cooperation. The bibliometric analysis, including a word cloud, reveals "realistic mathematics education" and "proportion" as the most prominent keywords, reflecting the primary trends and focus on scientific literature. The VOSViewer analyzed the keyword network, which yielded three primary clusters: (1) Indonesian realistic mathematics education contextualized in Indonesia, (2) realistic mathematics education, and (3) proportional and comparative concepts, like scale and ratio.

The content analysis discovered that the learning design for ratios and proportions utilizes RME and PMRI methods, dealing with content variations like speed, proportion, ratio, and scale. The aim is to develop students' skills, particularly their proportional reasoning. Various learning contexts are included, such as money, flowers, and everyday activities like cooking. Modeling tools are diverse, but ratio tables are the most frequently employed. Learning activities encompass creating ratio tables, observing object relationships, and utilizing real-life situations, like cooking or travel, as contexts.

The study identified several gaps and limitations, including the need for more cultural and contextual diversity in instructional design. Future research directions should prioritize the development of more inclusive methodologies, incorporating modeling tools and investigating wider contexts and cultures. The content and activity review underscored various strategies and exercises in learning design for ratio and proportion. Daily life contexts integrate mathematical concepts and progressive approaches to develop students' mathematical thinking. This is expected to enhance students' motivation and engagement in mathematics learning while providing a more profound understanding of ratio and proportion concepts in a context that holds significance to their daily lives.

This research provides valuable insight into the design of mathematics learning related to ratio, proportion, scale, and level. Its impact extends to the fields of science and education. Key contributions include thoroughly analyzing literature trends over the past decade and establishing a solid foundation for advancing mathematics scholarship and research. In addition, the cross-border collaborations identified in this research enhance intercultural perspectives and promote a worldwide comprehension of the design of mathematics learning.

In the field of education, this study provides a pragmatic contribution through its identification of essential areas in learning design. It offers valuable guidelines for developing a more effective curriculum. The bibliometric analysis, keyword clusters, and resulting recommendations enhance educators' understanding and provide valuable guidance for education policymakers. This study offers a genuine contribution to improving the quality of global mathematics education by exploring various approaches, modeling tools, and learning methods. Additionally, it identifies associated concepts that are fundamental to the development of ratio and proportion learning design, thereby paving the way for scientific advancement. This serves as a basis for future research and innovation in mathematics teaching methodologies. Thus, this study has significant implications for the advancement of mathematical science while also offering tangible support for efforts to enhance the quality of mathematics education on a global scale.

Conclusion

The study provides a comprehensive analysis of literature trends, cross-border cooperation, and instructional content and activities utilized in teaching ratio and proportion. Recommendations for future research aim to address identified shortcomings and enhance the pedagogical landscape of mathematics, particularly concerning ratios and proportions. However, it is essential to recognize certain limitations inherent in this study. The literature review may have only captured a subset of global contributions, potentially overlooking publications beyond our analytical scope. Furthermore, the focus on lesson design may not have fully addressed all implementation facets, underscoring the necessity for further investigation in this domain.

Subsequent research endeavors should delve into the practical execution of identified instructional designs and their tangible impact in classroom settings, considering both challenges and opportunities. Additionally, fostering extensive cross-country collaborations is imperative to elucidate diverse perspectives from varied educational environments. Anticipated future research initiatives should strive to bridge existing knowledge lacunae and foster a more nuanced comprehension of mathematics lesson design. Such efforts would fortify both the practical and theoretical knowledge reservoirs, furnish precise guidelines for educators, and engender sustained advancements in the quality of mathematics education on a global scale.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the authors have completed the ethical issues, including plagiarism, misconduct, data fabrication and falsification, double publication and submission, and redundancies.

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Author Contributions

Irma Risdiyanti: Conceptualization, writing first draft, review & editing, formal analysis, and methodology; **Zulkardi:** Validation and supervision; **Ratu Ilma Indra Putri**: Validation and supervision; **Rully Charitas Indra Prahmana**: Conceptualization, review & editing, and visualization, validation, and supervision; **Duano Sapta Nusantara:** Conceptualization and validation.

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