Teaching and Learning Fraction: A Systematic Literature Review

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Abstract
Fractions are one of the materials that have an important role in mathematics learning both domestically and abroad. Therefore, several articles discussing fractions published in several journals can be found in several sources, both national and international. This article aims to provide an overview of learning fractions, especially in context, activities, and learning outcomes based on relevant literature. This research uses the systematic literature review (SLR) method with Preferred Reporting Items for Systematic Review and Meta Analysis (PRISMA). This research focuses on three aspects, namely: 1) Activities and contexts used in learning fraction material, 2) Learning outcomes related to the application of these activities and contexts, and 3) Main findings in the research. A systematic literature review found that there were 10 contexts and activities implemented in learning fraction material. Apart from that, we also concluded that the holistic, interactive, and contextual learning approach, namely PMRI, had a positive impact on students' understanding of fraction material. Providing meaningful and relevant experiences can increase student interest and build a strong foundation for further mathematical understanding. The results of this research can provide a summary of existing literature and literature to identify weaknesses or gaps for further investigation in future research related to the topic of fractions.
Keywords: Fraction in Mathematics Education; PMRI; Systematic Literature Review.

Introduction

Fractions are an important part of mathematics subjects. One of the important roles of fractions is to develop algebraic reasoning abilities (Windria et al, 2020). Developing an understanding of fractions is one of the most challenging concepts in elementary mathematics and is a powerful predictor of future mathematics achievement (Rodríguez-Martínez, et al, 2022). Learning fractions involves more than just teaching mathematical ideas, methods and concepts, but also involves efforts to explain fractions as a process that includes their origins, emergence and gradual development (Prahantini et al., 2020). According to the National Council of Teachers of Mathematics (NCTM) for students aged 8 to 10 years how to develop an understanding of fractions should be taught as part of whole units, as part of a group, as placement on a number line, and as division of whole numbers (López-Martín, et al., 2022). The way teachers interpret and express fractions greatly influences students' teaching and knowledge about fractions (Afriansyah and

Turmudi, 2022; Alqahtani, et al., 2022). The difficulties experienced by students in learning fractions are that students still have initial knowledge that the denominator is considered the same as the natural number in fraction calculation operations (Supriadi, 2022).

There are four things that students often do when answering questions on the operation of adding and subtracting fractions, namely systematic errors, random errors, omission errors and not knowing how to answer fraction questions (Setambah, et al., 2021). Errors when working with fractions are caused because students do not yet understand the concept of fractions as part of a whole (Čadež, et al, 2018; Rodríguez-Martínez, et al, 2022). Understanding the concept and solving problems of fraction calculation operations in mathematics learning cannot go through an explicit or mechanical process, because elementary school age students are rapidly developing their memory and cognitive abilities, including metacognitive skills as the ability to think about their own thoughts and learn how to do it. to learn (Prahantini, et al, 2020).

Based on various kinds of student errors and misconceptions found in previous research findings (Čadež, et al, 2018; Prahantini, et al, 2020; Secepat, et al., 2021; Martínez, et al, 2022), several studies have been conducted to overcome this, such as using the context of the 2018 Asian Games, digital stories to reduce misconceptions about fractions, sharing pizza among students, using folded paper (Putri & Zulkardi, 2018; Fatma, 2018; Warsito, 2019; Yulia, et al., 2020). Then there is also research that uses the Putting Fractions Together (PFT) framework, props in the form of a board containing hidden words called fraction chipper, using videos and power point presentations, the traditional game Endog-endogan or the cultural egg game from Sundanese (Braithwaite, 2020; Setambah, 2021; Naido, et al, 2021; Supriadi, 2022).

From several studies described above, this research aims to describe learning at PMRI such as the context and activities used, learning outcomes from applying the context of the activities carried out and the main focus on the topic of fractions. To get the best knowledge of the results In this research, it is necessary to conduct a literature review (Xiao & Watson, 2019;). However, there is still a lack of comprehensive literature reviews that aim to identify, explore, evaluate, and integrate pertinent research topics related to teaching and learning about fraction. Since approximately 1990, there has been a growing trend in research that involves conducting literature reviews (Otten, et al, 2019; Kurniadi, et al, 2022).

This research analyzes existing literature related to teaching and learning fractions from 2018 to 2022. Therefore, this research aims to provide an overview learning fractions, especially in context, activities and learning outcomes based on relevant literature. In principle, systematic review is a research method which summarizes the main research results to present more comprehensive and balanced facts systematically (Kurniadi, et al, 2022). A Systematic Literature Review (SLR) was selected as an appropriate methodology which has three stages, namely: 1) Planing the review, 2) conducting the review, 3) reporting the review (Xiao & Watson, 2019).

Research Methods

This research is a systematic literature review (SLR) with Preferred Reporting Items for Systematic Review and Meta Analysis (PRISMA). According to this purpose, the following step of an SLR is conducted Xiao & Watson (2019).

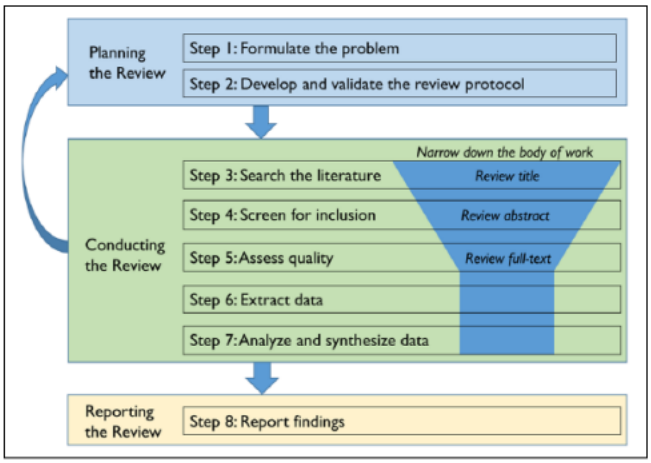

Figure 1. Proses *Systematic Literature Review*

Based on figure 1, the systematic literature review process is divided into eight stages according to three phases. Next, we will provide a detailed explanation of these stages.

1. *Planing The Review*

   Step 1: Formulate the problem

   The questions of this systematic literature review are that:

   - What are the activities and contexts used in learning fraction material?
   - How are the learning outcomes related to the application of these activities and contexts?
   - What were the findings in the research?

Step 2: Develop and validate the review protocol

The next step is to develop and validate the research protocol explains how fraction material is taught to students based on predetermined inclusion criteria.

2. *Conducting the review*

Step 3: Search the literature

Based on articles from the Scopus and Google Scholar databases using the Publish or Perish 8 application, the article search consists of the keywords Fraction in Mathematics Education*, Fraction Material Learning*, and PMRI*. One aspect that researchers consider when selecting articles is the year of publication, and we only reviewed articles that had been published within the last five years, namely from 2018 to 2022.

Step 4: Screen for inclution

At this step, the SLR that the researcher carried out used the help of a protocol, namely PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) to determine inclusion criteria. The selection process carried out refers to the four stages in PRISMA, namely identification, screening, eligibility, and inclusion (Otten, et al, 2019).

A data search carried out in October 2023 obtained 131 articles from Scopus and 200 articles from Google Scholar, which totaled 331 articles. The criteria determined at this stage are the journal index, relevance to mathematics education, use of English, and the contents of the title and abstract. Articles that were not in the field of mathematics education, did not touch the PMRI domain, did not discuss Fractions, or did not discuss the teaching or learning of Fractions, were excluded.

Step 5: Asses Quality

In the next step, the articles that have been found are filtered according to predetermined criteria. Researchers searched full-text articles to further evaluate their quality and appropriateness. Journal articles published by reputable publishers are considered high-quality research and are therefore included in the review. Most technical articles, reports and online presentations are excluded review due to lack of a peer-review process. Only U.S includes very few high-quality reports with well-referenced citations. Quality and feasibility assessment tasks are also carried out by researchers in parallel and independently. Any differences in their findings are discussed and resolved. After careful review, a total of two hundred and ninety-six

articles excluded: four were excluded because they had duplicate records; two hundred and thirty-eight excluded due to records being marked as ineligible by the automation tool; twenty-nine were excluded because incomplete text. In total, thirty-five articles from the initial search were included in the next step for analysis. So in the end only 35 articles remained from 26 journals that met these criteria (**see Figure 1**).

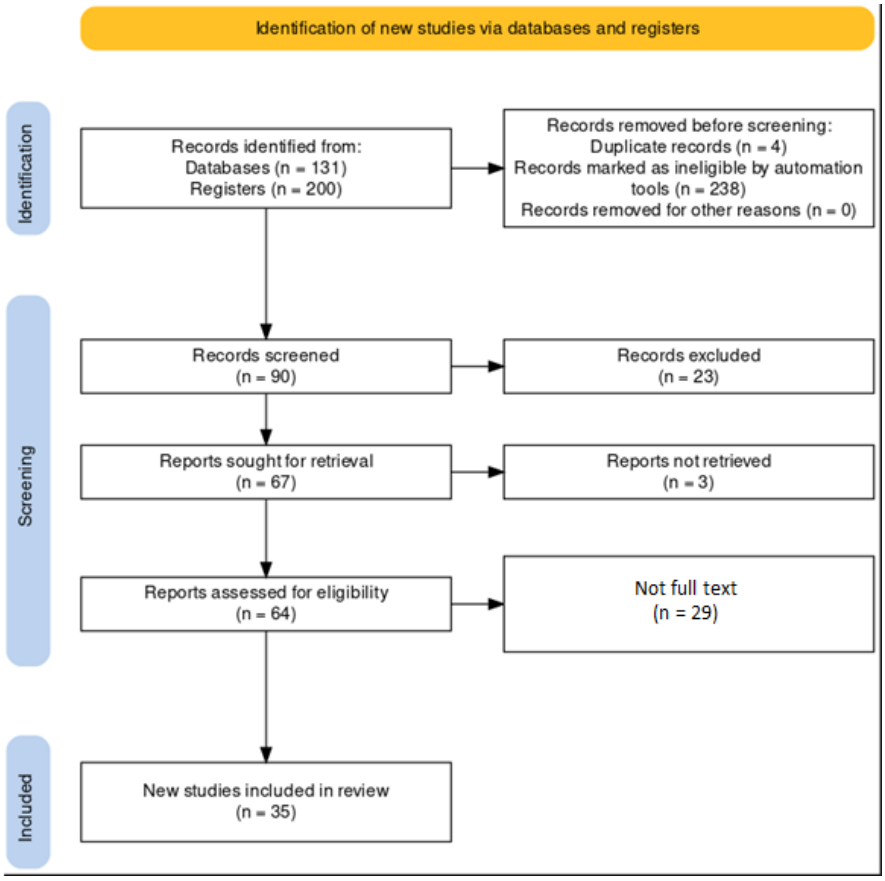

Figure 2. The flowchart in data Collection

Step 6: Extract data

Based on figure 2 for each of the 35 articles, information was extracted regarding the reasons and limitations of using context, learning activities, and learning outcomes that have been carried out. Information was extracted in case at least one sentence of the article was devoted to one of the three categories.

To describe the situations in which the learning and teaching of fractions material in the 35 articles, information was extracted regarding the students' grade level, duration of learning and types of activities the students did. So, from the systematic search process, 35 articles about learning and teaching about fractions will be included in the discussion, including 10 articles. Different aspects of these articles will be reviewed and summarized in Table 1.

Tabel 1. Learning Fraction with PMRI

No	Article	Journal	Research Method	Paper Code
1	Yilmas, et al. (2018)	International Journal of Mathematical Education in Science and Technology	Qualitative research	A1
2	Asep and Sobariah. (2018)	IOP Conference Series: Materials Science and Engineering	Classroom Action Research (CAR) of teacher researcher collaboration	A2
3	Putri and Zulkardi. (2018)	Journal of Physics: Conference Series	Design research type validation studeis	A3
4	Warsito, et al. (2019)	Journal of Physics: Conference Series	Design research type validation studies	A4
5	Flores, et al. (2020)	Remedial and Special Education	a comparison study	A5
6	Yulia, et al. (2020)	Journal of Physics: Conference Series	Design research type validation studies	A6
7	Setambah, et al. (2021)	Infinity Journal	Design research type validation studies	A7
8	Lovemore, et al. (2021)	South African Journal of Childhood Education	Qualitative action research	A8
9	Naidoo and Hajaree. (2021)	South African Journal of Childhood Education	Qualitative reseacrh	A9
10	Supriadi. (2022)	Pegem Journal of Education and Instruction	Qualitative and quantitative study applied the design of the didactic learning stage	A10

Step 7: analyze and systhesize data
Based on table 1, analysis has been carried out on the articles collected, which involves the process of documenting each article collected and then categorized according to year, Journal, and research method.

3. *Reporting the review*
   Stage 8: Report Findings
   The final stage that the researcher will carry out is to produce the results of a review of articles that meet the criteria and are in accordance with the problem formulation to provide an overview of opportunities and directions for further research.

Results and Discussion

1. Activities and contexts used in learning fraction material

   Based on data from the year of publication of the articles reviewed in this paper, there are 10 articles. The activities and context used to learn fractions are as tabel 1.

Tabel 2. Activities and contexts used in learning fraction material

No	Paper Code	Context
1.	A1	Digital stories
2.	A2	Drawing media
3.	A3	Asian Games 2018
4.	A4	The use of circle contexts and bar representations trigger
5.	A5	The concrete-representational-abstract (CRA)
6.	A6	Birthday event story
7.	A7	Fraction Chipper
8.	A8	Music (note values)
9.	A9	Video and Power Point presentations
10	A10	Traditional games "Endog-Endogan" or egg games from the Sundanese culture, West Java, Indonesia

Based on tabel 2 various contexts are implemented to support students to understand fraction learning. The context of digital stories is used to help students overcome mistakes and misconceptions about fractions of fourth graders in elementary school. In the preparation of activities related to digital storytelling, mistakes and misconceptions that students have regarding fractions are taken into account. As a data collection tool, a misconception determination form consisting of 30 open-ended questions about fractions prepared by researchers and observation records taken during the implementation process has been used. In addition, semi-structured interviews have been conducted to identify teacher and student views on activities designed with digital storytelling (Karaoglan et al, 2018).

The use of this image media context is used to bridge students' level of thinking who need concrete things for abstract mathematics learning. The activity carried out is to solve problems by coloring the pictures provided on the student worksheets, both individually and in groups (Asep dan Sobariah, 2018). The situation of the 2018 Asian Games, which consists of various sports, is used as a context for designing learning fraction material. The activities carried out are different for each fraction material. The sports context of the 2018 Asian Games is swimming, material on the concept of fractions, shot put, material on subtracting fractions, rowing, material on adding and subtracting fractions, running, material on dividing fractions, and hurdles, material on multiplication of fractions (Putri, 2018).

Understanding the concept of fraction addition operations is made easier through the application of circle and bar representations, which effectively guide students through the learning process by presenting a clearer learning trajectory. There are three activities implemented in this research, namely cutting pizza, placing parts of a circle in a full circle

and coloring the fraction values provided on the activity sheet (Warsito et al, 2019). The concrete-representational-abstract (CRA) teaching method has been proven to be effective in increasing students' conceptual understanding of fractions. The concrete and representational instructions present in CRA include model areas (circular shapes similar to Jordan et al.) and model sets (first, a group of objects/images is equipartitioned based on the denominator, and then one selects a certain number from the group based on the numerator). One example of an activity carried out by students is using model area fractions by filling the laminate circle with pieces and shading the image (Flores et al, 2020). The learning process carried out consists of seven activities using the context of a birthday story. Each activity is applied to achieve four specific goals that students must achieve, namely fractions as a relationship to whole parts, determining the value of fractions, comparing fractions and completing fraction operations (Yulia et al, 2020).

The activity that students carry out when using the fraction board context is to find words hidden on the fraction board in groups (Setambah et al, 2021). During the learning process regarding the operation of adding and subtracting fractions, the concept of "Sake Difference" is applied, where students are assessed based on the number of hidden words successfully identified and the accuracy in carrying out these operations. This intervention was carried out repeatedly over a four week period using the Control Function (FC). Music can be considered an ideal medium, where through an integrated teaching approach it can create opportunities for learning fractions which have the potential to help students understand the concept of fractions (Lovemore et al, 2021). The activity that students do is to use paper plates to represent different note values. A whole pitch plate represents one whole, a half pitch plate two halves, a quarter pitch plate four quarters, an eighth pitch plate eight eighths. The activities carried out by students are completing task-based worksheets followed by reflecting on videos and PowerPoint presentations that have been used to strengthen and support learning fractions (Naidoo and Hajaree, 2021). The activity carried out by students was to answer questions about subtracting fractions in groups by making fists like eggs singing the modified Endog-Endogan song (Supriadi, 2022).

2. Learning outcomes related to the application of these activities and contexts

Table 3. Learning outcomes related to the application of these activities and contexts

No	Paper Code	Learning Outcomes
1.	A1	As a result of the research, it has emerged that teaching implementations designed with digital stories have eliminated the mistakes and misconceptions that a large majority of students have about fractions.
2.	A2	The result of CAR implementation was that there was enhancement in students' learning outcome started from pre-cycle until cycle II. The enhancement of learning outcome is showed by the increase of Classical Absorption Capacity (CAC) score in which in pre-cycle was 23.3%, in cycle I was 60%, and in cycle II was increased to 83.3%. The recommendation of this study was that teacher can apply drawing media as alternative in enhancing mathematics learning outcome in the topic of fraction addition.
3.	A3	As the result, this research produces Local Instructional Theory (LIT) on fraction through the contexts of Asian Games 2018 sports namely swimming, shot put, rowing, running, and hurdles. The swimming context could stimulate students' informal knowledge about the meaning of fractions. By using shot-put context can assist students in learning the subtraction of fractions. Furthermore, running context can help students understand the division of fractions. Meanwhile, rowing context can help students understand addition and subtraction of fractions. Lastly, the context of hurdles can help students to realize their knowledge about the concept of multiplication of fractions with natural numbers.
4.	A4	The use of circle contexts and bar representations trigger the learning trajectory that students pass through in understanding fraction addition operations.
5.	A5	Concrete Representational Abstract (CRA) instructional sequence of instruction.
6.	A6	The result showed HLT for teaching fraction using RME that could be help all of levels students. This HLT helped students to reinvent fraction concepts through horizontal and vertical mathematical processes. Finally, the HLT facilitated students to make their own models from informal to formal and improved the interactions between students and teachers.
7.	A7	The results show that Fraction Cipher impacts students to understand and master the concept of fractional addition and fraction subtraction operations. This research also explains the "Sake-Beda" strategy to make it easier for students to solve fractional operation problems. Besides, this study also shows the change in students' attitudes from negative to more positive. Thus, students understand and are more motivated to learn the concept of fractions.
8.	A8	Findings highlighted the value of integrating music and mathematics as a teaching and learning strategy. Learning support materials and activities that promoted curriculum integration were designed. The discussion highlights benefits of these integrated lessons.
9.	A9	Based on the results of this study, it was evident that the participants valued the use of the technology-based tools during the teaching and learning of fractions. Based on an interpretive analysis of the data generated, two major themes emerged. Participants indicated that using videos and PowerPoint presentations inspired an appealing and fun way

		of learning fractions and inspired an encouraging atmosphere for learning fractions. These results may be of value to teachers, teacher educators, researchers, curriculum developers and learners of mathematics.
10	A10	The study results showed that the didactic design process in ethnomathematics learning teaching materials could be optimum with Endog-Endogan games because almost all teacher predictions were equal to elementary school students' responses. Besides, traditional games can be used as a solution to make learning mathematics easy and flexible with the mathematical concepts taught.

Based on table 3, it is found that the learning results from each of the 10 studies that have been carried out with various activities and the use of context refer to certain achievements or competencies to help students during fraction learning activities. These results are often interpreted to reveal the knowledge, skills and attitudes acquired by students such as demonstrating their understanding and expertise in the subject, especially fractions. These learning outcomes serve as determinants for assessing the effectiveness of educational programs and ensuring that students are ready to face challenges and opportunities in specific activities and contexts. This provides teachers with a clear framework for designing curriculum, teaching strategies, and assessments that meet desired educational goals.

3. Main findings in the research

Table 4. Main Findings in the research

No	Paper Code	Main Findings
1.	A1	✓ Teaching implementations designed with digital stories have eliminated the mistakes and misconceptions that a large majority of students have about fractions. ✓ Most of the students who had a limited perception about the concept of fraction before implementation have fully perceived the definition of fractions after the activities designed with digital stories. ✓ Most students expressed positive opinions on digital story use in lessons and found digital stories fun, instructive and constructive.
2.	A2	✓ The use of drawing media was effective in enhancing students' mathematics learning outcome in the topic of fraction addition. ✓ The Classical Absorption Capacity (CAC) score increased from 23.3% in the pre-cycle to 83.3% in the cycle II. ✓ Drawing media can be used as an alternative to enhance mathematics learning outcome in the topic of fraction addition.
3.	A3	✓ Swimming context can stimulate students' informal knowledge about the meaning of fractions. ✓ Shot-put context can assist students in learning the subtraction of fractions. ✓ Running, rowing, and hurdles contexts can help students understand addition, subtraction, and multiplication of fractions with natural

		numbers.
4.	A4	✓ Design research was conducted to provide an excellent consideration of learning process of fractional operations through the HLT framework. ✓ Results show that the use of circle contexts and bar representations trigger the learning trajectory that students pass through in understanding fraction addition operations. ✓ The stages of learning addition operations by HLT are designed, namely: understanding fraction values as part of the whole, comparing two fractions of value, looking for fractions of value, carrying out the same summing operations, and performing the summarized operations not the same.
5.	A5	✓ The CRA instructional sequence was found to be more effective than typical Tier 2 instruction for teaching fraction concepts. ✓ Significant differences in student performance were found between the CRA and Tier 2 groups. ✓ The CRA instructional sequence was found to be an effective means of teaching conceptual understanding of fractional numbers.
6.	A6	✓ Developed a hypothetical learning trajectory (HLT) for teaching fraction using realistic mathematics education (RME). ✓ HLT facilitated students to make their own models from informal to formal and improved the interactions between students and teachers. ✓ Data analysis technique used descriptive analysis techniques.
7.	A7	✓ Fraction Cipher has a significant impact on students' understanding and mastery of fractional addition and subtraction operations. ✓ The "Sake-Beda" strategy makes it easier for students to solve fractional operation problems. ✓ Students' attitudes towards fractions changed from negative to more positive.
8.	A8	✓ Integrating music and mathematics as a teaching and learning strategy is valuable. ✓ Learning support materials and activities that promote curriculum integration were designed. ✓ Benefits of these integrated lessons were highlighted.
9.	A9	✓ Participants valued the use of technology-based tools when learning fractions in mathematics. ✓ Two major themes emerged: videos and PowerPoint presentations inspired an appealing and fun way of learning fractions and an encouraging atmosphere for learning fractions. ✓ Research implications and recommendations for further research within this area are significant as there is a need for educational institutions globally to embrace the 4IR within teaching and learning.
10	A10	✓ The didactic design process in ethnomathematics learning teaching materials was found to be optimum with Endog-Endogan games. ✓ Traditional games can be used as a solution to make learning mathematics easy and flexible with the mathematical concepts taught. ✓ The study results showed that almost all teacher predictions were equal to elementary school students' responses.

From the table 4 it shows that the use of any context and activity almost has findings that are not significantly different from the 10 articles that have been analyzed. The learning process that has been implemented has found that whatever activities and context are used will be able to help teachers determine the right strategy and help students understand fraction material starting from students' attitudes when learning to being able to find solutions to the problems given.

Conclusion and Suggestion

Based on the systematic literature review that has been carried out, ten contexts and activities were found to be used in the learning process to help students understand fraction material. The contexts used are digital stories, image media, 2018 Asian Games, use of circle contexts and trigger bar representations, concrete-representational-abstract (CRA), birthday event stories, chipper fragments, music (tone value), video presentations and Power Point, Traditional game "Endog-Endogan" or egg game from Sundanese culture, West Java, Indonesia. While the ten activities in question can be seen in table 2. Apart from that, the researchers also concluded that in learning fraction material, the activities and context used had a significant impact on students' understanding and mastery of the concept. The holistic, interactive and contextual learning approach, namely PMRI, has a positive impact on students' understanding of fraction material. Providing meaningful and relevant experiences can increase student interest and build a strong foundation for further mathematical understanding. The use of context in PMRI learning helps students understand the concepts of the material being studied. Apart from that, learning mathematics becomes more meaningful in the classroom. The results of this research can provide a summary of existing literature and literature to identify weaknesses or gaps for further investigation in future research related to the topic of fractions.

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