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DEVELOPMENT PROPORTIONAL REASONING IN MATHEMATICS LEARNING ENVIRONMENT: SYSTEMATIC LITERATURE REVIEW

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Abstract

Proportional reasoning is closely related to everyday life. Conditions in schools show that there are still many students who still have difficulty in mastering proportional reasoning. Many studies have been conducted to overcome this. The purpose of this study is to provide an overview of research related to environmental mathematics learning interventions in developing students' proportional reasoning abilities. The method used is a systematic literature review (SLR) using the PRISMA protocol. The databases used are Google Scholar, Scopus, and ERIC in the 2018-2023 year of publication. There are several interventions carried out and discussed in the research results. Research related to interventions in the mathematics learning environment in developing students' proportional reasoning abilities has fluctuated in the 2018-2023 range, most were carried out in 2018 as many as 14 studies, most were carried out in junior high school demonstrations, namely 23 studies, the most widely used research method was quantitative method, namely 20 studies, Indonesia being the country that conducted the most research, namely 14 studies, and sample sizes in the range of 30-99 samples were the most widely used samples..

Kata Kunci: Proportional Reasoning, Mathematics, Systematic Literature Review

A. Introduction

Reasoning cannot be separated in human daily life (Permatasari et al., 2017). Reasoning is one of the important aspects that must be involved in learning and of course must be owned by students (Izzah & Azizah, 2019). Reasoning skills are very important for students to be able to know the meaning of mathematical material not only procedurally and following examples (Basir et al., 2020). Reasoning is defined as an activity or thought process to draw new conclusions based on statements that have been proven true (Marfu'ah et al., 2022). The definition of reasoning is also put forward by Ardhiyanti et al. (2019) which states that reasoning is a person's thinking process in formulating conclusions based on facts. Firmanti (2017) defines reasoning as a thought process in drawing

conclusions in the form of knowledge and has certain characteristics in finding the truth. Meanwhile, Agustyaningrum et al. (2019) state that reasoning is a thinking activity to understand conclusions and determine statements resulting from the thinking process that are true from relevant theories. Because reasoning is directly related to everyday life which functions in determining the right conclusion based on true facts and knowledge, reasoning skills are very important for students to have.

Because reasoning is directly related to everyday life which functions in determining the right conclusion based on true facts and knowledge, reasoning skills are very important for students to have (Konita et al., 2019; Hjelte et al., 2020). This is emphasized by NCTM (2000) which states that reasoning is one of the five process standards in mathematics learning. In learning mathematics there are various kinds of reasoning that are developed. One of them is proportional reasoning. Interpreting proportional reasoning can be done through an understanding of reasoning and proportion. This is in line with Misnasanti et al. (2017) which states that proportional reasoning is mathematical reasoning related to proportions and ratios. If the definition of reasoning has been explained at the beginning which is a thinking process in drawing the right conclusions based on true facts and knowledge. Proportion is the statement of the equality of two ratios, i.e: a/b = c/d (Tourniaire & Pulos, 1985; Nugraha et al., 2016). Proportionality is a key concept in elementary through college math education (Ahl, 2016).

Proportional reasoning is a mental activity that is able to understand the relationship of changes in one quantity to another through multiplicative relationships (Risdianti, 2016). Proportional reasoning is reasoning that focuses on understanding values, and understanding what happens when values change through multiplicative relationships. (Lutfi et al., 2022). Proportional reasoning is formed from the word reasoning which means the process of thinking logically and proportional which means a comparison situation, so proportional reasoning is defined as the process of thinking logically in a comparison situation. (Nugraha et al., 2016). Meanwhile, Norton (2005) defines proportional reasoning is used to describe the concepts and thinking needed to understand rate, ratio and proportionality including scale. The definition of reasoning in this study is the

thinking process used in drawing the right conclusions in proportionality problems through multiplicative relationships.

Research on proportional reasoning should receive great attention in mathematics education. Research conducted by Zulkarnaen (2017) shows that the achievement of proportional reasoning ability of 10th grade high school students is still low. Another study, namely Yuliani et al. (2021) showed that the proportional reasoning ability of junior high school students was still classified as moderate with an average of 48.46%. Research by Zulfikar et al. (2018) stated that the proportional reasoning ability of junior high school students is still low.

There are still many students who have difficulty in understanding the concept of proportionality. Vysotskaya et al. (2021) explained the factors that make the concept of proportionality very complicated for students, namely the multiplicative relationship behind the proportionality-based concept, and the didactical obstacles posed by the teaching process (intervention with prior knowledge). Mardika & Mahmudi (2021) shows that students have difficulty in finding multiplicative relationships contained in proportional reasoning problems, difficulty in understanding the value of inverse comparisons, and difficulty in explaining the solutions obtained from problems.

The low achievement of students' proportional reasoning skills is not in line with the importance of proportional reasoning skills. Of course, this is a serious problem that requires a solution. Several studies have been conducted that aim to develop students' proportional reasoning skills Scheibling-Sève et al. (2022); Gündoğdu & Tunç, (2022); Begolli et al., (2021); Lestari et al., (2019; Fauzi, (2018) and other studies. Furthermore, a further review is needed related to proportional reasoning ability, especially how the mathematics learning environment develops it so that complete and comprehensive information is obtained. Like the research conducted by Agusantia & Juandi (2022) who conducted systematic literature review research focusing on analogy reasoning skills. The absence of research related to systematic literature review on proportional reasoning ability is the reason for researchers. Systematic literature review is a literature review method that identifies, reviews, evaluates, and interprets all available research (Afsari et al., 2021). With a systematic literature review of mathematics learning environment

intervention studies on proportional reasoning ability can provide important insights to improve the quality of mathematics education in the future.

The purpose of this study is to systematically review the literature related to proportional reasoning in mathematics by paying attention to several things, namely interventions carried out in developing students' reasoning skills, year of publication, level of education, research methods, and sample size. Therefore, the problem formulation in this study is as follows: (1) How is the result of mathematics learning environment intervention research in developing students' proportional reasoning ability based on co-occurrence of author's keywords (2) How is the intervention of mathematics learning environment in developing students' proportional reasoning ability? (3) How is the result of mathematics learning environment intervention research in developing students' proportional reasoning ability based on publication year? (4) How is the result of mathematics learning environment intervention research in developing students' proportional reasoning ability based on education level? (5) What are the results of mathematics learning environment intervention research in developing students' proportional reasoning ability based on research methods? (6) What are the results of mathematics learning environment intervention research in developing students' proportional reasoning ability based on country demographics? (7) What are the results of mathematics learning environment intervention research in developing students' proportional reasoning ability based on sample size?

B. Method

Research Design

The method used in this research is a systematic literature review (SLR) which is a survey-based quantitative descriptive approach (Juandi, 2020). We conducted a systematic structured literature review on a comprehensive digital database that is widely used for relevant information on mathematics learning environment interventions on students' proportional reasoning ability. To conduct our review, we used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Grimshaw et al., 2021; Juandi & Tamur, 2020).

The steps used are (1) identifying topics and searching for relevant studies; (2) screening documents to identify important studies; (3) checking the feasibility of studies; (4) including analysis documents, synthesizing, and describing studies.

Inclusion Criteria

To select papers that fit the topic, the researchers applied the inclusion criteria. The inclusion criteria used to obtain research data are in accordance with the research objectives (Ariati & Juandi, 2022). The inclusion criteria in this study are: (1) Research on learning environment interventions in developing students' proportional reasoning skills, including bachelor, master, and doctor theses; (2) Publication in the range of 2018 to 2023 (3) The research sample must consist of elementary to college levels. (4) Research indexed by Google Scholar, Scopus, and ERIC. Figure 1 shows PRISMA's steps in reviewing articles on mathematics learning environment interventions in developing students' proportional reasoning skills.

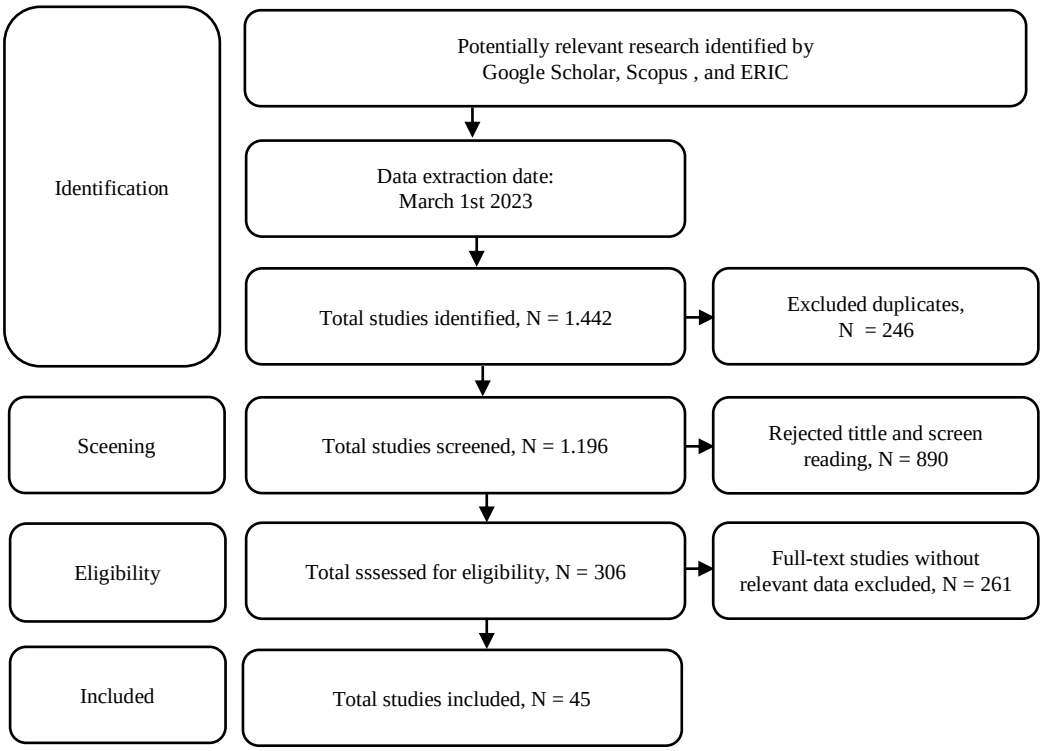


Figure 1. Stages of Systematic Literature Review

To collect studies about the intervention of mathematics learning environment on students' proportional reasoning ability, the research conducted a search on the search platform using the help of Publish or Perish 8 (PoP 8) software with Google Scholar, Scopus, and ERIC databases. In the Google Scholar database, two searches were conducted with different keywords, namely in English with the keywords "proportional reasoning" AND "mathematics" and in Indonesian with the keywords "proportional reasoning" AND "mathematics" while in Scopus and ERIC using the same keywords, namely "proportional reasoning" AND "matehamtics". Researchers found 45 research papers. Next, the researcher downloaded the selected and investigated papers, then the researcher analyzed the information presented in the research papers. To show an overview of the co-occurance of keyword authors, the VOSViewer software is used.

C. Results and Discussion

The results of the study are presented in seven sections including co-occurance of keyword author, mathematics learning environment intervention, year of publication, education level, research methods used, research demographics, and sample size. The results of the analysis based on year of publication, education level, research methods used, research demographics, and sample size are presented in the table below:

Table 1. Research of Article Analysis Based on Inclusion Criteria

Characteristic Study	Criteria	Frequency
Year of Publication	2018	14
	2019	8
	2020	3
	2021	9
	2022	9
	2023	1
Education Level	Elementary school	11
	Junior high school	23
	Senior high school	3
	College	5
Research Method	Quantitative	20
	Qualitative	14
	Mix-Method	3
	Research Design	4
	Research & Development	3
Country Demographics	Indonesia	14

Characteristic Study	Criteria	Frequency
	United States	12
	Belgium	1
	Italy	1
	Japan	1
	Israel	1
	Germany	1
	Yordania	1
	Korea	1
	South Africa	1
	Turkey	7
	Spain	2
	France	1
Sample Size	x <30	12
	30-99	19
	$x \geq 100$	8
	Unknown	5

Study Based on Co-Occurrence of Author Keywords

The following presents co-occurrence based on the author's keywords which can be seen in the figure below.

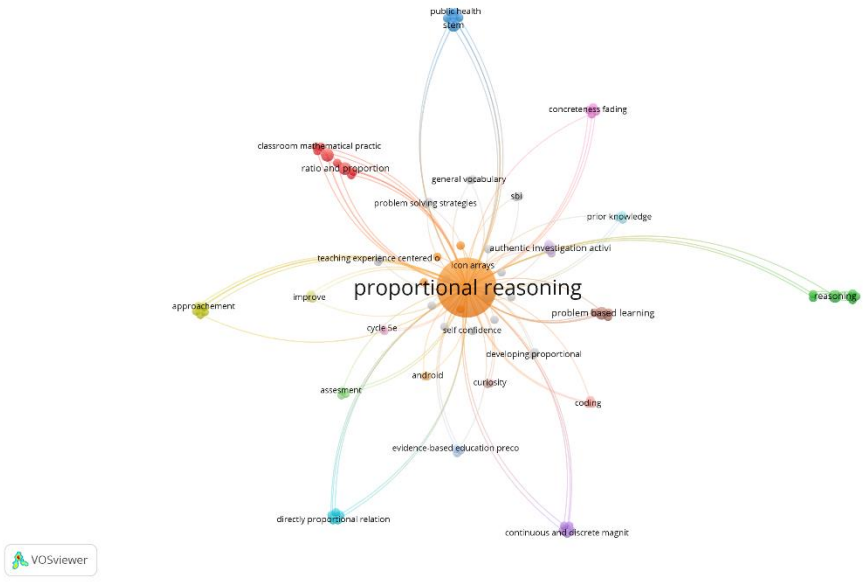


Figure 2. Co-Occurrence of Author Keyword

Figure 2 shows that there are several keywords used by the authors of the 45 selected articles. These keywords can facilitate and help readers who put a big focus on research on mathematics learning environment interventions in developing students' proportional reasoning skills.

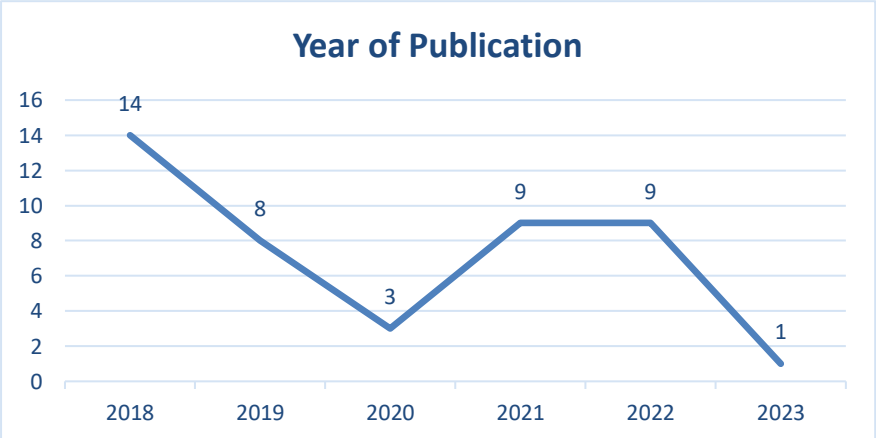
Mathematics Learning Environment Intervention in Developing students' proportional reasoning ability

Some of the interventions carried out in developing students' proportional reasoning skills are multimedia interactive, training based on multiple categorization, Science Technology Engineering, Mathematics, and Art (STEAM), Realistic Mathematics Education (RME), learning trajectory and lesson, error analysis-based learning, metacognitive improve technique, assessment-assisted discovery learning, specific mathematical language, self-explanation and example-based practice, augmented reality activities, problem based learning, mathematical modeling, learning cycle 5e nuanced ethnomatematics, hands-on activities, social constructivist, continuous representations, authentic investigation activities, iconic representations, instructional mixed model, instruction of problem-solving strategies, situated simulation-based learning environment, preceding stimuli formats, schema-based instruction, Meaningful Instructional Design (MID), metacognitive apprroach, diskursusmulty reprecentacy, and model Knisley. Of course, these interventions can be used by teachers who want to develop students' proportional reasoning skills.

Study Based on Year of Publication

The research sampled in this study is from 2018 to 2023. Several studies have been conducted on proportional reasoning of mathematics learning environment interventions in developing students' proportional reasoning skills. The following is presented the distribution of research that has been conducted based on the year of publication as follows:

Figure 3. Study Distribution Based on Year of Publication



In Figure 3, it can be seen that research on mathematics learning environment interventions in developing students' proportional reasoning skills fluctuates from

year to year. Research on the intervention of the mathematics learning environment in developing students' proportional reasoning skills was mostly conducted in 2018, namely 14 studies, then experienced a decrease in the number of publications in 2019 and 2020, namely 8 articles and 3 articles respectively, and experienced an increase in 2021, namely 9 studies, while in 2022 it was still stagnant or the same as in 2021. Meanwhile, in 2023, there was only 1 study. Regarding the importance of proportional reasoning skills for students to have as stated, reasoning is the basis for several mathematical concepts as well as a major component of the secondary school mathematics curriculum (Vanluydt et al., 2021) and proportional reasoning is one part of mathematics that is very difficult for students to understand. (Vanluydt et al., 2021), It is necessary to conduct other research on mathematics learning interventions in developing students' proportional reasoning skills.

Study Based on Education Level

Research on the intervention of mathematics learning environment in developing students' proportional reasoning ability was conducted at various levels of education. The frequency of research in terms of education level can be seen in the figure below.

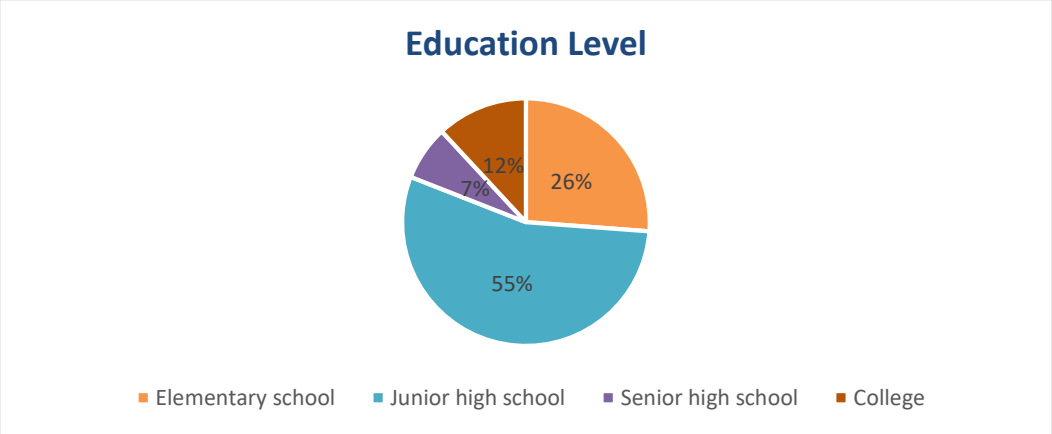


Figure 4. Study Distribution Based on Educational Level

Based on Figure 4, it can be seen that most of the research on the intervention of mathematics learning environment in developing students' proportional reasoning ability was conducted at the junior high school level where there were 23 studies with a percentage of 55%. Meanwhile, at the elementary school and university levels, each has 11 studies with a percentage of 26% of research and 5

studies with a percentage of 12%, and the least research was conducted at the high school level, namely 3 articles with a percentage of 7%. This is in accordance with research conducted by that proportional reasoning is developed from the age of children to junior high school. (Kahraman et al., 2019).

Study Based on Research Method

Furthermore, research on the intervention of mathematics learning environment in developing students' proportional reasoning ability has been conducted using various methods. The number of studies, based on the research methods used, can be seen in Figure 5 below:

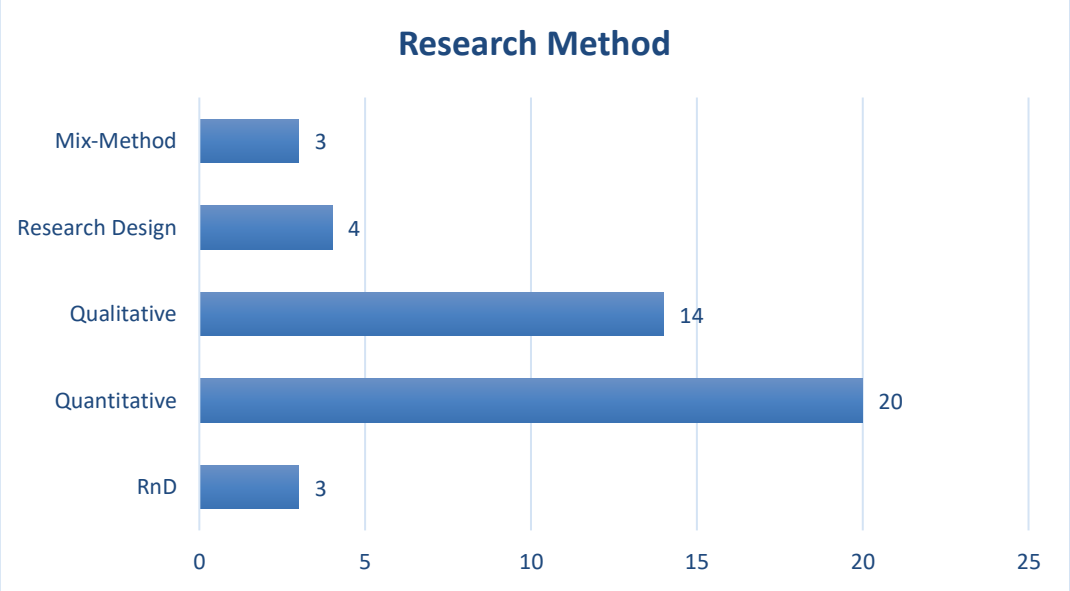


Figure 5. Study Based on Research Method

Based on Figure 5, the research method that is often used in learning intervention research in developing students' proportional reasoning skills is quantitative research methods, there are 20 studies that use quantitative methods. This is because the research on the intervention of mathematics learning environment in developing students' proportional reasoning ability will be more visible with quantitative methods that are stronger on statistics. In many of these quantitative studies using a quasi-experimental approach, to see the causal relationship between treatment and results (Khasawneh et al., 2022). Meanwhile, there were 14 studies that used qualitative methods, 4 studies used design research methods, and 3 studies each used RnD and mixed-method methods. This dominating quantitative research can make opportunities for future follow-up

research on metaanalysis of proportional reasoning skills, such as research conducted by Juandi et al., (2022) conducted a meta-analysis of critical thinking skills and problem-based learning.

Study Based on Research Location

Research on the intervention of mathematics learning environment in developing students' proportional reasoning ability has also been conducted in various countries in the world. The following is the distribution of countries that have conducted research on the intervention of the mathematics learning environment in developing students' proportional reasoning skills.

Figure 6. Study Based on Research Location

Based on Figure 6, it can be seen that research on the intervention of mathematics learning environment in developing students' proportional reasoning ability is mostly conducted in Indonesia, namely 14 studies. There are 12 studies in the United States, 7 studies in Turkey, 2 studies in Spain, and several countries with 1 study, namely Belgium, Israel, Italy, Japan, Germany, Jordan, Korea, France, and South Africa.

Study Based on Sample Size

Research on the intervention of the mathematics learning environment in developing students' proportional reasoning skills was carried out using various methods and different sample sizes according to the research objectives to be achieved. The following presents the distribution of research based on sample size.

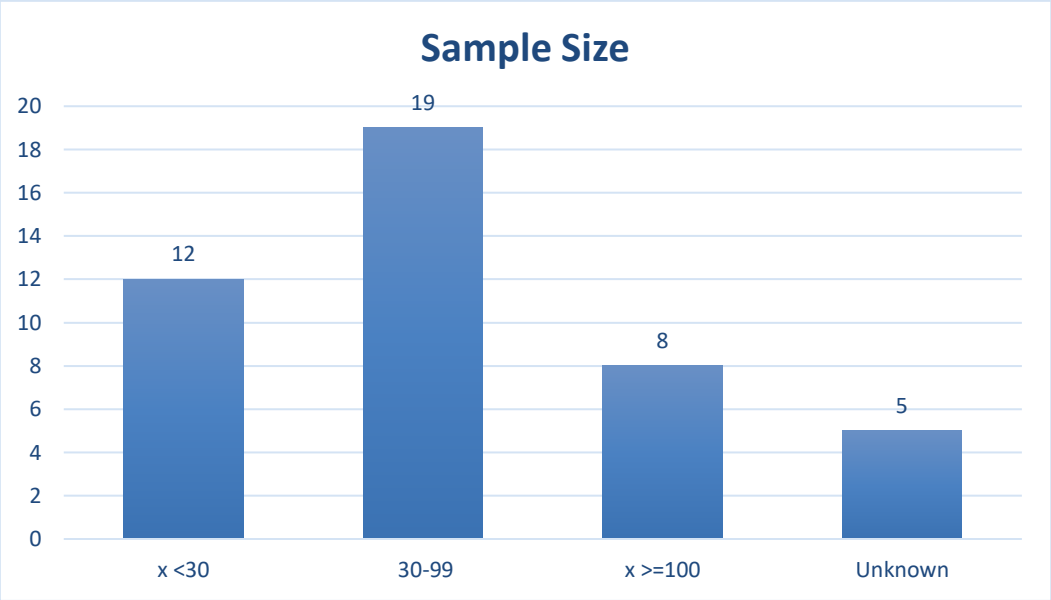


Figure 7. Study Based on Sample Size

Based on Figure 7, it shows that the research on interventions in the mathematics learning environment in developing students' proportional reasoning skills is mostly carried out using a sample size in the range of 30-99 students as many as 19 studies. Meanwhile, 12 studies used sample sizes below 30 students, and 8 studies with sample sizes above 100 students. Some studies found also did not write the sample size used in the proportional reasoning research conducted, namely as many as 5 studies.

D. Conclusion

Based on the presentation of the results and discussion, it is concluded that mathematics learning interventions in developing students' proportional reasoning skills. Some of the interventions are multimedia interactive, training based on multiple categorization, Science Technology Engineering, Mathematics, and Art (STEAM), Realistic Mathematics Education (RME), learning trajectory and lesson, error analysis-based learning, metacognitive improve technique, assessment-assisted discovery learning, specific mathematical language, self-explanation and example-based practice, augmented reality activities, problem based learning, mathematical modeling, learning cycle 5e nuanced ethnomatematics, hands-on activities, social constructivist, continuous representations, authentic investigation activities, iconic representations, instructional mixed model, instruction of

problem-solving strategies, situated simulation-based learning environment, preceding stimuli formats, schema-based instruction, Meaningful Instructional Design (MID), metacognitive apprroach, diskursusmulty reprecentacy, and model Knisley.

Research related to the intervention of the mathematics learning environment in developing students' proportional reasoning skills fluctuated in the range of 2018-2023, while the most in 2018 was 14 studies, most of them were conducted at the junior high school level, namely 23 studies, the most used research method was quantitative method, namely 20 studies, Indonesia became the most countries in conducting research, namely 14 studies, and the sample size in the range of 30-99 samples was the most widely used sample. Of course, this research can provide benefits for many parties, especially for teachers who encounter difficulties in students regarding proportional reasoning and want to develop it. Suggestions for further research, of course, there are still many things that need to be done, for example a systematic literature review that focuses more on indicators and how to measure students' proportional reasoning skills and meta-analysis research such as Juandi et al. (2022) can also be done in the future.

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