



Analysis of students' mathematical reasoning between different genders: A systematic literature review

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Abstract: The main purpose of this study was to examine existing studies related to mathematical reasoning skills based on gender differences using Systematic Literature Review (SLR). The following studies identify reasoning abilities based on gender differences. The review was carried out by carrying out several stages, namely the process of identification, screening, feasibility, inclusion, and data analysis on two livelihood machines, namely SCOPUS and ERIC. In reporting this study, the guidelines used were PRISMA guidelines. The data used was sorted by the specified criteria and this resulted in a total of 8 articles. Our findings identify that the study was conducted in three places: Indonesia, Sweden, and Turkey. Based on the findings of the study using three research designs, namely qualitative, mixed method, and quasi-experimental. The topics of the material used in this study are topics of geometry, algebra, and other branches of mathematics. The SLR also includes characteristics of reasoning abilities found by gender as well as the distribution of studies in terms of trends and countries.

Keywords: ERIC; Gender; Mathematical reasoning ability; PRISMA; Scopus; Systematic literature review

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INTRODUCTION

Reasoning is one aspect of mathematical ability that is very important in the process of teaching and learning mathematics (Sukirwan et al., 2018). This ability is very important because it can build a mindset that is developed in mathematics requires and involves critical, systematic, logical, and creative thinking (Isnani et al., 2020). The National Council of Teachers of Mathematics (NCTM, 2000) revealed that reasoning skills need to be developed in a school. In Indonesia, this has been realized through Permendikbud Number 64 of 2013 (Kemdikbud, 2013) which states that one of the skills that need to be mastered is reasoning in the concrete realm and abstract realm related to the development learned in school independently and being able to use methods according to science.

Mafada et al. (2020)s revealed that reasoning is an ability used as a foundation in mathematical thinking, namely curricula in almost all parts of the world that want teachers to be able to facilitate reasoning. Reasoning is also defined as the adoption of thoughts to produce statements and to reach conclusions about solving problems that are not always based on formal logic so they are not limited to proof (Lithner, 2008). Meanwhile, Lee et al., (1999) stated that reasoning is basic in understanding, working on mathematics, and is a tool for understanding abstractions.



In the process of learning reasoning ability is the goal of education in Indonesia (Konita et al., 2019). In addition, reasoning skills are also very important to help students understand mathematical concepts better and assist students in solving problems in mathematics. Good reasoning abilities will encourage students to develop critical and creative thinking skills. Therefore, the learning process in the classroom must be encouraged so that students can have this ability.

Mathematical reasoning is divided into 3, namely inductive, abductive, and deductive (Jeannotte & Kieran, 2017; João Pedro da et al., 2020). Inductive reasoning (IR) and abductive reasoning (AR) involve conjecture, inductive reasoning by making assumptions, shadowing the discovery of rules or laws of formation and generalization, through observation, testing certain examples, and identifying patterns of regularity and abductive reasoning parts of unprecedented or unusual events and seeking explanations for their occurrence (Henriques & Martins, 2022). Meanwhile, deductive reasoning is logically recognized, involving the validation or invalidity of the resulting conclusion argumentation (Henriques & Martins, 2022). Meanwhile, indicators of reasoning ability consist of, namely: (1) formulating presumption; (2) performing mathematics manipulation; (3) checking the validity of an argument; (4) drawing conclusions or generalizing (Wahyuni et al., 2019). These indicators are used to analyze students' reasoning abilities.

The results of the analysis are then differentiated based on the characteristics between men and women which are expected to provide appropriate strategies to reduce the gap, especially in reasoning ability (Subekti et al., 2021). This is done because men and women have different learning performances influenced by goal orientation and mathematical content domains (Leder & Forgasz, 2018). This ability is influenced by various factors, namely: learning interaction, gender, essential competence, and self-efficacy (Alghadari et al., 2020).

Research on students' abilities in mathematical reasoning in terms of gender differences has been found a lot. Therefore, a comprehensive review is needed related to the description of the research on mathematical reasoning abilities based on gender. This review can use the Systematics Literature Review (SLR) method. This review using SLRs helps to synthesize the literature. The results of this SLR are expected to help researchers who want to deepen this gender-based reasoning ability.

Research on students' ability in mathematical reasoning in terms of gender differences has been widely encountered. Therefore, researchers want to the mathematical ability of gender differences using the Systematics Literature Review (SLR) method. Systematics Literature Review is one of the methods used by researchers to identify, review, evaluate, and interpret all available research in the topic area of interesting phenomena, with research questions relevant to the topic under study (Kitchenham & Charters, 2007; Triandini et al., 2019). By conducting a literature review, it is hoped that it can identify gaps that can be explored by future researchers (Paré et al., 2015).

The purpose of this research is to describe and synthesize research results related to reasoning abilities in terms of gender. The description in this study will be reviewed based on the year of publication, journal index, methods used, level of education, and material used to measure students' reasoning ability.

1. Where was the research conducted?
2. What methodology is used to analyze mathematical reasoning abilities by gender?
3. What are the characteristics of differences in mathematical reasoning abilities based on gender?
4. What are the math topics used to measure mathematical reasoning abilities based on gender?

METHOD

Systematic Literature Review

Systematics Literature Review (SLR) is the method used in this research using a quantitative descriptive survey approach (Little et al., 2008). The survey was conducted on secondary data regarding the results of basic research on students' mathematical reasoning abilities of different genders. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach which includes identification, screening, eligibility, and include select review articles obtained by References, clearly the acquisition of review articles is presented in Figure 1. Only articles that are relevant and meet the criteria were carried out in the analysis phase (Jesson et al., 2011; Juandi, 2021; Juandi & Tamur, 2020).

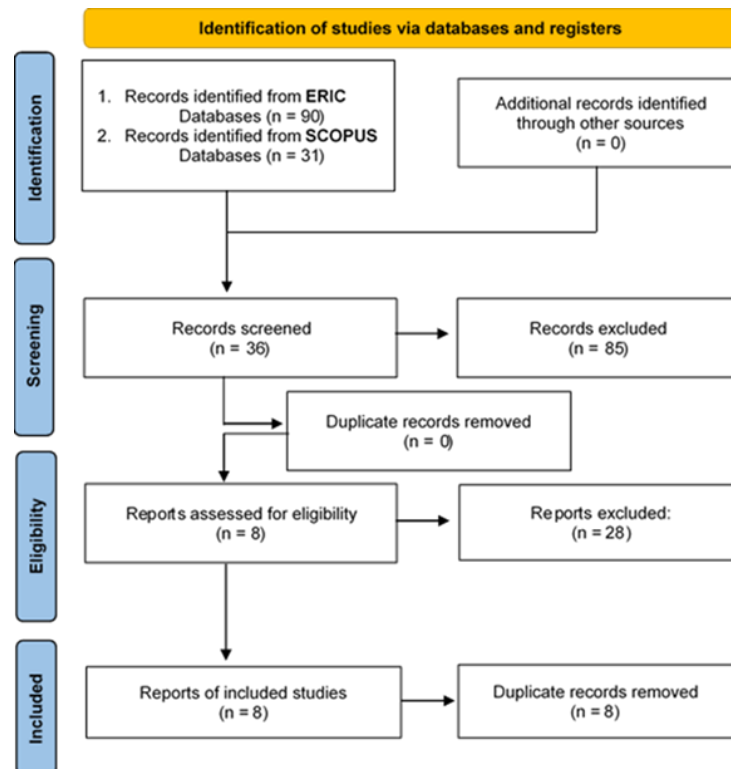


Figure 1. PRISMA flowchart

Screening

In this identification stage, the primary data is in the SCOPUS database, and ERIC because these databases are very relevant to this research. This screening stage is carried out by reviewing and selecting articles based on the following criteria: (1) The study was conducted within 1 decade; (2) Studies published in a journal; and (3) Study using English. The data found is then extracted. Of the 121 articles obtained at the identification stage, 36 articles were obtained after the screening process and 85 articles were omitted because they did not meet the criteria at the screening stage.

Eligibility

Articles obtained at the screening stage are then subjected to a feasibility process by reviewing articles and selecting articles based on the following criteria: (1) research relevant to keywords; (2) relevant research with research questions; and (3) research relevant to the researcher's field of study. Of the 36 articles at the screening stage, 8 articles were obtained after the feasibility process and 28 articles were omitted because they did not meet the criteria at the eligibility stage according to Figure 1.

Include

From the previous stage, 8 studies were selected for inclusion in this review based on the inclusion criteria for this systematic literature review as shown in [Table 1](#).

Table 1. Inclusion and Exclusion Criteria

| Criteria | Inclusion | Exclusion |
|---------------------------|--|--|
| Article title and content | Appropriate title and meet the research requirements | Appropriate title and meet the research requirements |
| Year of Publication | Publications from 2012-2022 | Publications other than the specified range |
| Publication Type | Original study and journal-type articles only | Reviews, editorials, and non-empirical studies |
| Language | English | Other |
| Field of Study | Mathematics education | Others that are not math education |
| Articles | | |
| Sample size | Primary school - College | Beyond the specified sample size |

The validity and reliability of the research depended on the quality of the included articles and the techniques used to conduct the review. The strict flow outline of the PRISMA protocol followed by inclusion criteria is a method for increasing the validity and reliability of data by reducing the risk of bias.

RESULTS AND DISCUSSION

Studies by Year of Publication

In this systematic review, we screened 121 articles from two search engines namely SCOPUS and ERIC with selected eight articles related to mathematical reasoning abilities based on gender. The data used in this systematic review study were published between 2012 and 2022 or within the last decade. The distribution of the number of articles from 2012 to 2022 is presented in [Figure 2](#).

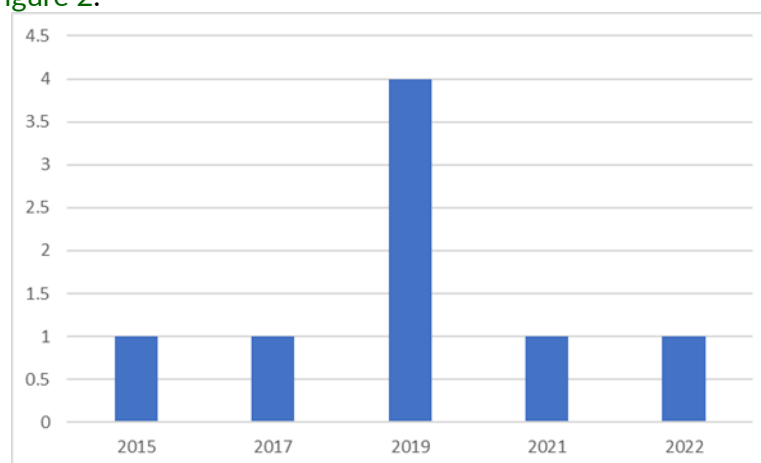


Figure 2. The distribution of research on mathematical reasoning abilities in terms of gender differences by year of publication

Based on [Figure 2](#), it can be concluded that the development of research on mathematical reasoning abilities in terms of gender differences from the SCOPUS and ERIC databases has fluctuated every year. It was recorded that 2019 was the year that had the most published articles with 4 articles. The increase in research trends in 2019 was based on a decrease in Indonesia's PISA results in 2018 when compared to 2015 so many researchers were interested

in conducting this study (Hewi & Shaleh, 2020; Tohir, 2019). Figure 2 also shows that there is still very little research on this research between 2012–2015.

Studies Based on Research Sites

The first research question relates to the location of the research conducted in the study. Based on Figure 3, it was obtained that Turkey and Sweden each published 1 article, while Indonesia published 6 articles relating to the study of mathematical reasoning abilities based on gender differences.

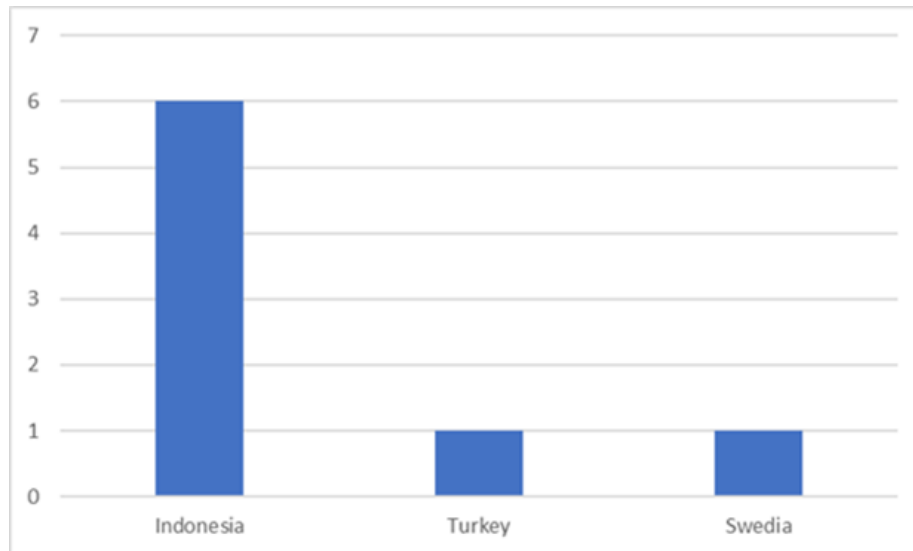


Figure 3. Distribution of studies based on research locations

Indonesia is the country with the most research locations related to this theme, this is also inseparable from the decline in Indonesia's PISA results in 2018 (Hewi & Shaleh, 2020; Tohir, 2019) which prompted researchers from Indonesia to conduct this research.

Conducted Research Design

The second research question relates to the research design related to the analysis of mathematical reasoning abilities in terms of gender differences. Based on Table 2, information was obtained that 4 studies focused on qualitative analysis (Erdem & Soylu, 2017; Karunika et al., 2019; Rokhima et al., 2019; Rosdiana et al., 2019), 3 studies focused on mixed methods (Ramadhani et al., 2022; Subekti et al., 2021; Sumpter, 2015), and 1 study focused on quasi-experimental (Kadarisma et al., 2019).

Table 2. Research Design Used

| Authors (Year) | Research Design |
|-------------------------|--------------------|
| Rosdiana et al. (2019) | Qualitative |
| Kadarisma et al. (2019) | Quasi-experimental |
| Rokhima et al. (2019) | Qualitative |
| Subekti et al. (2021) | Mixed Methods |
| Karunika et al. (2019) | Qualitative |
| Ramadhani et al. (2022) | Mixed Methods |
| Erdem and Soylu (2017) | Qualitative |
| Sumpter (2015) | Mixed Methods |
| Total | 8 |

The research design used is tailored to the needs of researchers. For example, research by Rosdiana et al., (2019) uses a qualitative research design because the data is collected and presented in the form of words arranged in sentences, in depth the subject matter concerned, does not generalize and with a reasonable background so that what is revealed by the real

conditions that occur. In line with this, the use of this research design is also intended to describe the problem and the situation that occurred at that time (Rokhima et al., 2019).

The use of a mixed methods research design also has aims and objectives. Subekti et al. (2021) use mixed methods because in their research quantitative analysis is used to present the analysis of reasoning abilities based on gender, is qualitative analysis to describe the findings of the characteristics of reasoning abilities in a sentence. This is in line with what was expressed by Ramadhani et al. (2022) who explained that the use of mixed methods was carried out to gain a clearer understanding of exploring students' statistical reasoning abilities and triangulating findings (Creswell & Clark, 2018).

Furthermore, the use of a quasi-experimental research design also serves a purpose. Kadarisma et al. (2019) explained that the use of this method was because there was manipulation of treatment in one class which involved 44 grade 8 students of SMP Negeri in Cimahi consisting of 20 male students and 24 female students.

Characteristics

The third research question relates to the characteristics of reasoning abilities based on gender. Based on research by Rosdiana et al. (2019) revealed that there were differences between male and female students related to reasoning abilities, namely at the stage of understanding the questions, the answers given by male students were more detailed than the answers given by female students. In contrast, the results by the study of Kadarisma et al. (2019) revealed that there was no significant difference in mathematical reasoning abilities between male and female students.

Research by Rokhima et al. (2019) revealed that male and female students can analyze problems by starting the right strategy and they can both choose mathematical concepts that might be applicable. Male students think flexibly while female students tend to follow sequential strategies. However, research by Subekti et al. (2021) said something different because in their research it was revealed that the percentage of women's abilities, 64.71%, was better than men's abilities, 54.19%. It was further explained that men tend to think it is more practical to do it even though sometimes it is wrong, on the other hand, women tend to do it step by step.

Furthermore, Karunika et al. (2019) research revealed that female students who have high self-efficacy in mathematical reasoning abilities explain the use of models, facts, traits, and relations to use patterns and relations to analyze mathematical situations; provide an explanation of existing models, pictures, facts, characteristics, relationships or patterns; and perform mathematical manipulations. Ramadhani et al. (2022) research revealed that students have different levels of statistical reasoning abilities which are related to students' initial mathematical abilities. Students with low initial mathematical abilities are at special level 1, while students with high initial mathematical abilities are at procedural level 4.

Then Erdem and Soylu (2017) research revealed that with age, mathematical reasoning develops and male students perform significantly better than female students in mathematical reasoning. This was also expressed by Sumpter (2015) who revealed that boys were significantly more often associated with rote reasoning and limited algorithmic reasoning. Girls are connected to familiar algorithmic reasoning, the type of reasoning where you use standard methods when solving math tasks.

Material Topic Used

The fourth research question relates to the topic of material used in the related research. The results of the analysis show that 4 branches of mathematics are used as material topics, namely: geometry, algebra, arithmetic, and other branches of mathematics. More clearly the distribution of the materials used is presented in Table 3.

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the Results. The Discussion should be an interpretation of the results rather than a repetition of the Results.

Table 3. The distribution of topics used

| Author (Year) | Geometry | Algebra | Arithmetic | Other |
|-------------------------|----------|---------|------------|-------|
| Rosdiana et al. (2019) | ✓ | | | |
| Kadarisma et al. (2019) | | | ✓ | |
| Rokhima et al. (2019) | | | | ✓ |
| Subekti et al. (2021) | | | ✓ | |
| Karunika et al. (2019) | | ✓ | | |
| Ramadhani et al. (2022) | | | | ✓ |
| Erdem and Soylu (2017) | | | | ✓ |
| Sumpter (2015) | | ✓ | | |
| Total | 1 | 2 | 2 | 3 |

Based on Table 3, 1 article was obtained in the branch of mathematical geometry, namely in the research of Rosdiana et al. (2019) using geometric material, 2 articles in the algebraic branch of mathematics, namely in the research of Karunika et al. (2019) and Sumpter (2015) by using the material of each linear program and linear and quadratic equations. 2 articles also on the branch of arithmetic mathematics, namely in the research of Ramadhani et al. (2022) and Erdem and Soylu (2017), especially on the matter of number patterns and sequences and series respectively. Meanwhile, 3 other articles in other branches of mathematics were not listed, namely in the research by Rokhima et al. (2019), who used trigonometry in their research, Ramadhani et al. (2022), who used statistics in their research, and Erdem and Soylu (2017) who in his research used mathematical reasoning questions in general.

The choice of geometry topics was based on the weak ability of students to solve questions Programme for International Student Assessment (PISA) mostly measures the level of reasoning, problem-solving, and argumentation abilities (Asdarina & Ridha, 2020). Accordingly, the National Council of Teachers of Mathematics (NCTM, 2000) revealed that spatial reasoning ability is one of the basic abilities that students need to have. The topic of algebra and arithmetic is also used in the application of standard PISA questions because these two topics contain indicators of higher-order thinking skills (HOTs), including logic and reasoning, analysis, evaluation, and creation (Kurniati et al., 2016) so that it is also relevant to analyze their reasoning abilities based on gender.

CONCLUSION

To recap, this review has answered all the research questions posed. The research theme regarding mathematical reasoning abilities is most often carried out in Indonesia based on the analysis of studies conducted. Of the eight articles analyzed, 6 articles were conducted in Indonesia. Then 1 article each was conducted in Sweden and Turkey.

The theme of this research is based on findings using 3 research designs, including: qualitative, mixed methods, and quasi-experimental research designs. The results of the analysis obtained information that 4 studies focused on qualitative analysis (Erdem & Soylu, 2017; Karunika et al. 2019; Rokhima et al. 2019; Rosdiana et al. 2019), 3 studies focused on mixed methods (Ramadhani et al., 2022; Subekti et al., 2021; Sumpter, 2015), and 1 study focused on quasi-experimental (Kadarisma et al., 2019). The characteristics of reasoning abilities based on gender differences focus on whether or not there are differences in mathematical reasoning abilities based on gender. The results show that there are significant differences in mathematical reasoning abilities based on gender differences (Erdem & Soylu, 2017; Karunika et al., 2019; Ramadhani et al., 2022; Rokhima et al., 2019; Rosdiana et al., 2019; Subekti et al. al., 2021; Sumpter, 2015) and some say that there is no significant difference in mathematical reasoning abilities based on gender differences (Kadarisma et al., 2019).

The use of this theme is considered important because it analyzes students' reasoning based on gender differences. This is interesting to study to get an idea that gender can more or less affect students' reasoning abilities which can be seen from a biological aspect. In this study, the topic of the material used relates to the 4 branches of mathematics, namely: geometry, algebra, arithmetic, and other branches of mathematics. These topics were chosen because they have characteristics that can measure students' mathematical reasoning abilities.

This research has limitations, namely that only articles containing gender differences are included in the analysis so that for future researchers to obtain comprehensive and generalizable information, the use of the term gender difference should be removed from the keywords. Then, the database used is only 2 databases, so it is recommended for further researchers to use another database so that it is possible to get quality articles from other databases.

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