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Mathematical Reasoning Based on Gender: Mapping the Literature by Bibliometric Analysis

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ABSTRACT

This study aims to analyze the literature review based on the analytic database on google scholar about mathematical reasoning related to gender. A total of 200 papers on mathematical reasoning were published in the harzing data base from 1959 to 2021 and analyzed through a bibliometric analysis approach. Aggregation of bibliographies from sources, authors, countries, institutions, publications and co-occurrence of authors' keywords were analyzed and visualized through VOSViewer software. Mathematical reasoning is heavily influenced by other things, one of which is related to gender differences in it. The results from the bibliometric data of the Harzing Application and VOSViewer that there is a distribution related to mathematical reasoning is very closely related to the key words difference, mathematical reasoning ability, reasoning, reasoning ability, mathematical ability, boy, girl, female, and male. The journal that has a lot of research on mathematical reasoning based on gender is the Journal of Educational Psychology, an institution that researches a lot on mathematical reasoning based on gender is the American Psychological Association. And the country that has researched the most on mathematical reasoning is the United States.

Keywords: Difference, reasoning, mathematical reasoning ability, reasoning ability, mathematical ability, gender

ABSTRAK

Penelitian ini bertujuan untuk menganalisis literature review berdasarkan basis data analitik pada google scholar tentang penalaran matematis berkaitan dengan gender. Sebanyak 200 makalah tentang penalaran matematis diterbitkan dalam database harzing dari tahun 1959 hingga 2021 dan analisis melalui pendekatan analisis bibliometrik. Penggabungan bibliografi dari sumber, penulis, negara, institusi, publikasi dan kemunculan besama dari kata kunci penulis dianalisis dan divisualisasikan melalui perangkat lunak VOSViewer. Penalaran matematis banyak dipengaruhi oleh hal lain salah satunya terkait perbedaan gender di dalamnya. Hasil dari data bibliometrik Aplikasi Harzing dan VOSViewer bahwa terdapat sebaran terkait tentang penalaran matematis sangat erat kajiannya terkait kata kuncinya difference, mathematical reasoning ability, reasoning, reasoning ability, mathematical ability, boy, girl, female, and male. Jurnal yang benyak meneliti terkait penalaran matematis berdasarkan gender yaitu Journal of Educational Psychology, institusi yang banyak meneliti terkait penalaran matematis berdasarkan gender yaitu American Psychological Association. Dan negara yang paling banyak meneliti terkait penalaran matematis yaitu Amerika Serikat.

Kata kunci: Perbedaan, Penalaran, Kemampuan Penalaran Matematis, Kemampuan Penalaran, Kemampuan Matematika, Jenis Kelamin.

INTRODUCTION

Reasoning is drawing conclusions based on a statement that is known or considered true (Schünemann et al., 2019; Siti Rodiah 1, 2019). Reasoning itself is a way of drawing conclusions from cases that have been proven (Fischer et al., 2014; Mantere & Ketokivi, 2013). Reasoning is the adoption of thinking in order to produce a statement and to obtain conclusions about problem solving which is sometimes not based on formal logic so it is not limited to proof, mathematics has a close relationship with reasoning, reasoning is widely used in mathematics majors including the level of deductive reasoning, example-based reasoning and further education in mathematics (Evans & Over, 2013; Jäder et al., 2017; Mantere & Ketokivi, 2013; Sidenvall et al., 2015; Maarif et al., 2020). Indicators of mathematical reasoning ability a) There are logical conclusions b) Provide explanations using facts, properties, and relationships c) Estimate answers and process solutions d) Use relationships and patterns in analyzing mathematics, e) Prepare and review conjectures, f) Determine the opponent Following the rules of inference (Jäder et al., 2017; Kadarisma et al., 2019; Sidenvall et al., 2015; Sumpter, 2013). Reasoning in terms of constructing arguments is needed in every mathematics lesson as the foundation for developing a flow of thinking in proving a statement (Maarif et al., 2020). A person in planning and constructing evidence requires reasoning ability to analyze his ideas in compiling a valid argument, so that it can be accepted by others (Fischer et al., 2014; Osborne et al., 2013).

Mathematics is one of the most important disciplines in life, one of which is in the world of education. One of the subjects in education that is studied throughout the world is mathematics. NCTM suggests that there are 5 standard processes for students to use and acquire mathematical knowledge, connection, problem solving, representation, communication, reasoning and proof (Coronata & Alsina, 2014; Joung & Byun, 2021; Maoto et al., 2018; Widodo et al., 2020; Widodo et al., 2019). When viewed from the theory, reasoning is one of the important things in mathematical knowledge (Maarif, 2016), so students' mathematical reasoning must be improved (Hidayat et al., 2020; Widodo et al., 2020; Yuni & Suryana, 2020). Students will be more helpful in learning mathematics, because mathematical reasoning is an important aspect (Battey, 2013; Rahmat et al., 2019; Riccomini et al., 2015; Wheatley, 2013). From this statement that mathematical reasoning is very important, because with mathematical reasoning students will find it easier to deal with any kind of math problem. Mathematical reasoning is also very supportive of students in thinking creatively and independently. If a student's reasoning is high then, if students are faced with a question, the student can answer the question based on the student's creativity, one of which is by answering questions with their own formula.

With mathematical reasoning students can develop and understand mathematical material well. In fact, this reasoning ability is very low among students. In this case, the mathematical reasoning ability looks low from the previous research findings that as much as 49% of the mathematical reasoning ability score looks very low from the ideal category, which is 100 (Burais et al., 2016). So, students must have concepts in mathematical reasoning.

Gender according to the Studies Encyclopedia is the concept of emotional differences between men and women, both in terms of roles, behavior, mentality or characteristics that exist in society

(Salmina & Nisa, 2018). One's mathematics learning outcomes do not rule out the possibility that they can also be influenced by gender differences. Such as the statement which states that there are differences in brain hemispheres between men and women, the right hemisphere of the male brain is stronger than the female in the fields of logic and numeracy, while the left brain is more dominant in women who have advantages such as aesthetics and religion (Gurian, 2010; Salmina & Nisa, 2018). However, it cannot be one of the reasons for someone's low reasoning. External factors can also affect a person's reasoning. If you only look at the difference in brain hemispheres between men and women, then this will be an injustice to one party. Other influences such as: lack of practice questions or independent study can also affect, or a person's economic condition can also affect mathematical reasoning, environmental conditions and so on.

Analytical research related to bibliometrics is mostly done in the study of mathematical reasoning. Research related to mathematical reasoning with the research title Roles and Research Trends of Artificial Intelligence in Mathematics Education: A Bibliometric Mapping Analysis and Systematic Review conducted a bibliometric analysis of Web of Science data (WOS database) resulting that issues related to cognition were most investigated (34 articles), followed by learning behavior (22 articles) and affect (21 articles). It was also found that the research problems became more diverse from the first to the third period. For example, in the third period, problems related to skills and learning styles were included (Hwang & Tu, 2021).

In terms of cognition, most studies measured student learning performance (33 articles), while few considered students' high-level skills (2 articles) or collaboration or communication (1 article). In addition, there are no studies investigating students' cognitive load. In terms of influence, most studies investigated student attitudes or motivation (16 articles), followed by learning perceptions (9 articles), self-efficacy (5 articles) and satisfaction (4 articles). In the cognitive dimension, the initial study mainly focused on measuring student learning performance. In the third period, several studies began to investigate students' higher order thinking and their collaboration and communication competencies. For example, one study aimed to use ITS to facilitate the construction of students' mathematical ideas to help them understand the reasons behind mathematics to improve their mathematical problem solving, on the other hand, it was found that cognitive load was not addressed in the AIME study (Hwang & Tu, 2021).

Research related to mathematical reasoning with the research title Leveraging Mathematical Subject Information to Enhance Bibliometric Data carried out the same results on the zbMATH database. The first useful result is the systematic flaw detection in the current MSC2010 schema regarding “None of the above, but in this section”. A more detailed future analysis will be aimed at suggesting more adaptations. Mining of publication trends since 2010 will reveal new research areas, which are currently not adequately covered, and further discussion of commonalities is likely to provide structural insights that underpin the ongoing MSC2020 revision task (Koutraki et al., 2017). Based on the two articles, there are differences in data processing, namely with zbMATH and WOS (Web of Science). With the discussion more directed to the use of technology for learning mathematics. Some of the results of this study were carried out on articles from the last 10 years of

analysis from Google Schooler sources. Therefore, it is necessary to do further research related to mathematical reasoning based on gender.

METHOD

Bibliometrics is a discipline in which a research focuses on bibliography not only as a list of references, but also as a reflection of the development of other disciplines. Pritchard is someone who introduced bibliometrics for the first time in 1969 as the application of mathematical and statistical methods to books and other media of communication (Trisnawati, 2018; Rahayu et al., 2022).

Data Search and Extraction Strategy

In this study, on June 14, 2021, the study was based on the Harzing and VOSviewer databases. The Harzing and VOS viewer databases were chosen because they are considered impact reference sources for peer-reviewed scientific literature and interdisciplinary sources contributing to a broad view of scientific publications. This database is one of the most common sources in Indonesia among researchers and scientists. In addition, Scopus provides a wide range of content and provides very comprehensive citation analysis results. Searches were performed by subject area including article title, abstract, and keywords using the terms “Mathematical Reasoning” OR “Gender”. For the review, all references indexed and released from 1959 to 2021 were used. Search limitations for papers were limited to country (Indonesia) document type (articles, conference papers, reviews, and conference reviews), subject areas (social sciences and mathematics), source types (journals and conference proceedings), and language (English), and Harzing data for the period 1959 to 2021 produced 200 documents related to mathematical reasoning and gender. The *.ris* format, including citation information, bibliographic information, abstracts, and keywords is exported from the Harzing database.

Data Analysis and Visualization

Bibliometrics was performed with the Harzing application and VOSviewer (version 1.6.12). Documents presented in the form of years, documents by source, documents by author, documents by affiliation, and documents by type are analyzed by the Harzing Application. In addition, the VOSviewer program analyzes co-authored network visualizations using *.ris* files exported from Mendeley. To determine the main research subject, the VOSviewer software also analyzes the companion words of network visualization, overlay visualization, and density visualization. The most extensive set of related items consists of 200 items that have appeared on the Harzing app.

RESULTS AND DISCUSSION

Result

Harzing App Results

A total of 200 articles on Harzing's application published from 1959-2021 on mathematical reasoning based on gender were bibliometrically analyzed. However, we will present the top 10 articles from the 200 data that have been published in the Harzing app. Table. 1 shows data from the journals and 200 data related to mathematical reasoning by gender.

Table 1. Top 10 Journal Data

NO.	Journal Name	Number of Documents	Annual Citations	Score
1	Journal of Educational Psychology	60	5.93	2,506
2	Journal of Physics	10	6.5	1
3	Mathematical och mathematical statistics	50	1.83	2.37
4	Journal of Education and Practice	6389	2.75	7.15
5	The Development of Sex Differences and Similarities in Behavior	28	0.89	1
6	Journal for the Education of Gifted Young Scientists	650	1	1,171
7	International Journal of Science and Mathematics Education	216	3.2	0.460
8	Social forces	2706	15	1,953
9	Sage Journals	10	18.19	2
10	Journal of Educational Psychology	60	10.28	6.133

Based on Table 1. it can be seen that for the theme of mathematical reasoning the most published by the Journal of Education and Practice, then the Journal Social Forces, Journal for the Education of Gifted Young Scientists, International Journal of Science and Mathematics Education, Journal of Educational Psychology, Journal of mathematical statistics, The Development of Sex Differences and Similarities in Behavior, Journal of Physics, and the last of the top 10 journals, namely journal of sage journals.

VOSviewer Software Results

Mathematical reasoning based on gender VOSviewer analyzes the author's network scale Figure 1 below describes the network density can be seen the clarity of the distribution of keywords such as silhouettes.

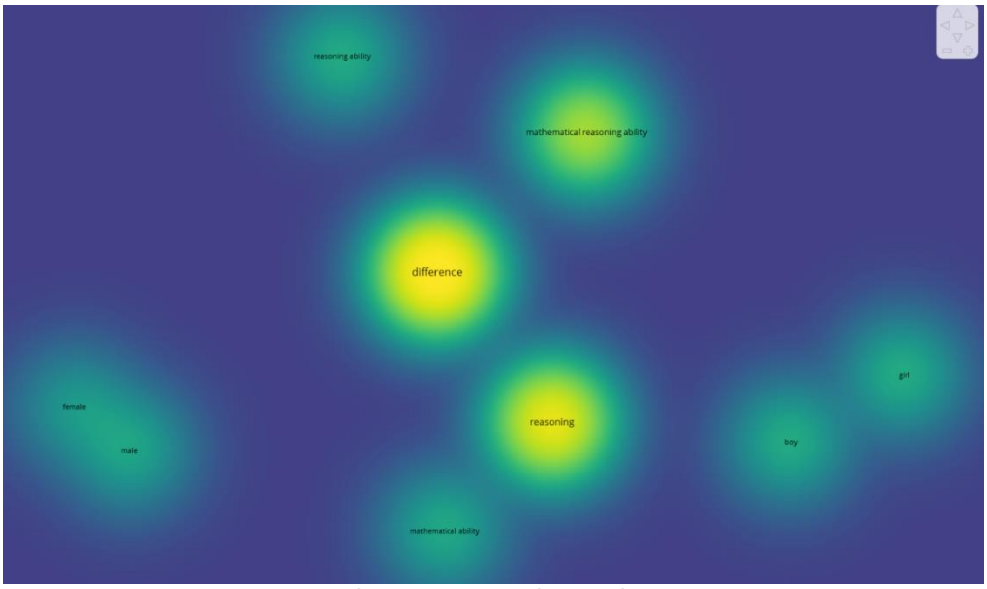

Figure 1. Network Density

Based on Figure 1. it can be seen that there are several keywords that are used related to mathematical reasoning based on gender. The distribution can be seen from the colors seen in the image. So, if sorted by color related to the most popular keywords, namely difference, reasoning,

mathematical reasoning ability, reasoning ability, mathematical ability, boy, girl, female and male. Then the overlay network shows the distribution by year, as in Figure 2.

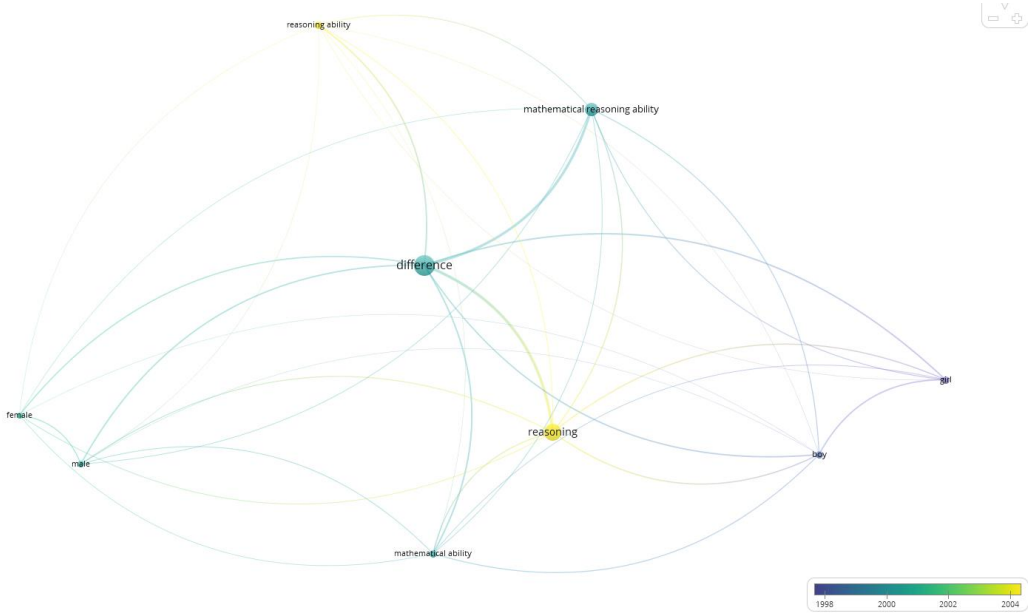

Figure 2. Network Overlay

Based on Figure 2. the overlay network shows the distribution followed by year. It can be seen that between 1959-2021 there is a distribution that likes mathematical reasoning based on gender with the keywords difference, reasoning, mathematical reasoning ability, reasoning ability, mathematical ability, boy, girl, female and male. In addition, Figure 2 also shows the relationships between these keywords.

Furthermore, in the use of the VOSviewer application, namely the network, it can be seen the clarity of the distribution of clusters related to mathematical reasoning based on gender. It can be seen in Figure 3.

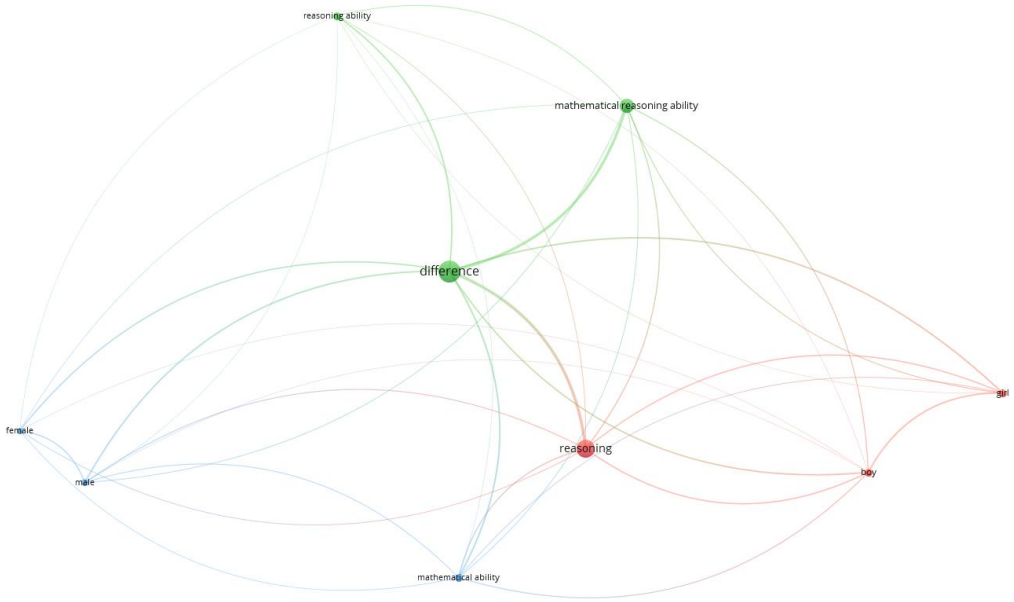

Figure 3. Network Network

Based on Figure 3, the network shows 3 clusters, namely the difference cluster, the reasoning cluster and the mathematical reasoning ability cluster. Where the 3 clusters are connected to each other. The first cluster is difference which is very closely connected with reasoning and mathematical reasoning ability, then close to reasoning ability, mathematical ability and boy, and connected but not too closely with girl, female and male. Furthermore, the second cluster is reasoning which is very closely connected to difference, mathematical ability and boy. After that, it is closely connected with mathematical reasoning ability and girl, but is far or not too closely connected with reasoning ability, famale and male. And the third or last cluster, namely mathematical reasoning ability, is very closely related to difference, reasoning and reasoning ability. And close to boy and girl, but not too close to mathematical ability, male and female.

Discussion

The findings in this study are related to students' mathematical reasoning based on gender using bibliometric analysis based on the google scholar database, namely there are 200 journal findings related to mathematical reasoning based on gender using the Harzing database and the top data obtained from 200 journals related to this research is entitled "Gender". Differences in academically talented young students' mathematical reasoning: Patterns across age and subskills from Journal of Educational Psychology and to make it easier for researchers to obtain data, the top 10 journals ranked on Harzing's data were selected from 200 journal findings. Another application to support this research is by using VOSViewer the keywords difference, reasoning, mathematical reasoning ability, reasoning ability, mathematical ability, boy, girl, female and male are obtained. From these keywords using VOSViewer it can be seen that there are 3 clusters related to mathematical reasoning based on gender, namely cluster difference, reasoning cluster and mathematical reasoning ability cluster.

When viewed from the results of this study, there are several differences from previous research related to mathematical reasoning based on gender. In the research entitled "Roles and Research Trends of Artificial Intelligence in Mathematics Education: A Bibliometric Mapping Analysis and Systematic Review" the database used is WOS (Web of Science) with the discussion of material more directed to the use of artificial intelligence (AI) for mathematical knowledge. someone and from the results of the study there is a weakness that is not supporting artificial intelligence (AI) against a person's cognitive problems only based on IT knowledge (Hwang & Tu, 2021). It can be said that a person's intelligence is not influenced by technology or IT, especially on the gender of each individual who has and is greater. In further research with the title "Leveraging Mathematical Subject Information to Enhance Bibliometric Data" with the database used, namely zbMATH with a discussion on the use of technology in mathematics. Where the technology is called MSC2010 which still has limitations in its scheme and has to do a lot of adaptations (Koutraki et al., 2017). So, from the two articles there are differences with this study, namely the database used in the study and what was discussed where the research raised the use of technology for understanding mathematics in a person, while in this study more emphasis was placed on intelligence in each gender, both male and female. Naturally, each individual has a big role in the process of understanding mathematics, one of which is related to mathematical reasoning.

CONCLUSION

This study shows that mathematical reasoning and gender are research subjects that get a lot of use in some time spans 1959-2021. Although the development of data in Harzing does not clearly show a significant and sequential increase. Then the use of VOSViewer further clarifies the distribution of data related to mathematical reasoning based on gender For further researchers, it is hoped that they can analyze other findings from the Harzing and VOSViewer data relating to mathematical reasoning and gender.

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