

Exploring Research Trends on PISA in Mathematics: A Systematic Review Using Bibliometric Analysis

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ABSTRACT

Research on the development of PISA studies in the mathematics domain has not been widely or specifically reported in scientific publications. Although the emphasis on PISA research has been evident in recent years. PISA data and reports in the mathematics domain are not readily available. Meanwhile, these reports are needed by many researchers to increase mathematics outcomes. Therefore, a bibliometric analyses is needed to report the results. This study aims to review PISA studies in the mathematics domain with bibliometric and bibliographic analysis. The analysis in this study used documents from the Scopus database published from 2013 - 2023. The analysis includes performance, citation, co-word, and co-authorship supported by VOSviewer and Rstudio applications. The results of the analysis show that publication and citation trends fluctuate down, up, and static in a certain range of years. Analysis of documents, sources, authors, organizations, and countries is also reported. The top five documents with the most citations focused on factors affecting PISA results, problem-solving difficulties, problem development, and student achievement. The documents also discussed analysis of student errors, development of PISA item contexts, and other variabels. The most productive authors focused on the keywords of mathematics problem design and student answer analysis. The keywords that appeared the most were factors that influence PISA in content, process and context components. Based on the top documents and keywords that often appear, teachers and policy makers can make evaluation and analysis materials to improve the learning process so that they can achieve the expected PISA scores.

Keywords: mathematics; PISA; Rstudio; trend analysis; VOSviewer

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INTRODUCTION

International Large-Scale Assessments (ILSA) are international assessments of education. ILSA results are of interest to policy makers and stakeholders involved in education. One of the largest international student assessments from the ILSA program is the Program for International Students (PISA) which has been widely implemented (Martens & Niemann, 2013; Meyer & Benavot, 2013). In the last ten years, international research on PISA has increased rapidly (Addey et al., 2017; Hernández-Torrano & Courtney, 2021). PISA was organized in 32 countries in 2000 and is held every three years. International involvement has increased to 85 countries in organizing PISA in 2022 based on OECD report, and it is estimated that by 2030 there will be 170 countries involved in organizing PISA (Xiaomin & Auld, 2020).

Knowledge and skills described in real-life situations are applied to assess 15-year-old students nearing the end of compulsory education with the PISA program (Hopfenbeck &



Görge, 2017; OECD, 2022). The three main cognitive domains in each PISA assessment including reading, mathematics and science are evaluated with subject-specific tests. In 2022, math will be the focus. PISA has effects that cannot be ignored. In these reports, there are references to improving education systems as well as contributions to policy making in participating countries (Baird et al., 2016; Hastedt & Rocher, 2020; Thompson et al., 2015).

OECD's implementation of PISA data endorses the need for data-driven national policy (Meyer, 2014). The PISA assessment in the mathematics domain is very important as it determines the overall results. The importance of PISA studies in the mathematics domain for education is that they can help stakeholders such as teachers, practitioners, and lecturers in providing better quality education, especially in terms of learning methods. It can also help policy makers in understanding PISA trends, especially those related to mathematics.

Until now, research on the development of PISA studies in the mathematics domain has not been widely or specifically reported in scientific publications in internationally indexed journals (Hopfenbeck et al., 2018). Although the emphasis on PISA research has been evident in recent years, PISA data and reports in the mathematics domain are not available (Teig et al., 2022). Meanwhile, reports on the development of PISA studies in the mathematics domain are needed by many researchers who focus on improving mathematics education outcomes. Therefore, a systematic review based on bibliometric analysis is needed in this study to report the results of research on the development of PISA studies in the mathematics domain.

Bibliometric analysis is a systematic technique for examining and analyzing large amounts of scientific data to show emerging research trends (Aria & Cuccurullo, 2017; Donthu et al., 2021). Bibliometric analysis can help get a one-step overview, find knowledge gaps, lay out contributions to a particular field, and get new ideas for research (Donthu et al., 2021). Bibliometric analysis examines and analyzes scientific publication citations using a number of frameworks, instruments, and techniques (Hodonu & Lazarus, 2018). Bibliometric analysis establishes the connection between researchers and their work through a variety of citation analysis techniques (Koo, 2017). Bibliometric analysis is used to categorize authors, institutions, primary journals released, indexing, research formulating strategies, comparative evaluation, bibliographic control, and library management (Gasparyan et al., 2016; Perrier et al., 2016).

Until now, no one has examined the bibliometric analysis of PISA in the mathematics domain using the Scopus search engine. There are 2 literatures that examine PISA in Scopus using bibliometric analysis but not specifically in the mathematics domain. The analysis of the 2 literatures is only on PISA as a whole which includes literacy and science domains.

In this study, word searches were used on the 3 main components of PISA, the main keywords and other keywords that are closely related to PISA studies in the Mathematics domain. The three main components including process, content and context are tested in PISA based on OECD (Sälzer & Roczen, 2018). PISA Framework The PISA Mathematics Framework is based on three dimensions: (i) mathematical content; (ii) the process that students need to do when observing a phenomenon, relating the phenomenon to mathematics, then solving the problem they observe; and (iii) situation and context. As shown in the following Figure 1.

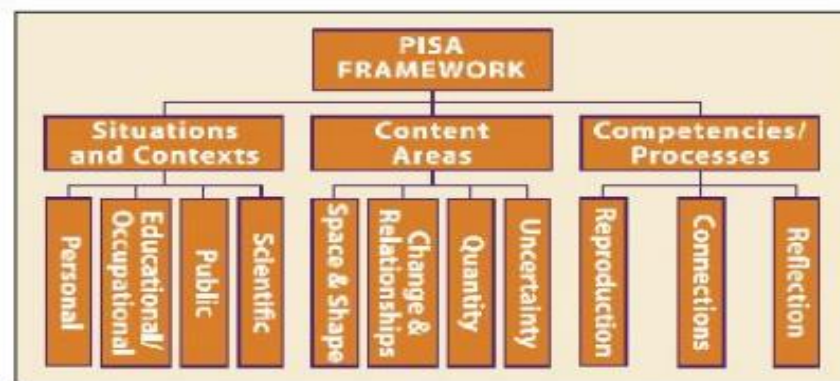


Figure 1 PISA framework in mathematics

Mathematics Content

According to Hayat (2010), the content is divided into four parts:

- The topic of space and shape in geometry. In this topic, problems are presented that test students' understanding of shapes, characteristics of objects and their positions, recognizing similarities and differences from representations of shapes.
- The topic of change and relationships in algebra. Mathematical equations and relationships such as addition, subtraction, and division. This topic also covers symbols including tables, graphs, geometric shape changes. Each symbol has a unique representation and characteristics. Therefore, the process of interpreting symbols is very important and adjusted to the objectives carried out.
- The topic of number (quantity) on the relationship between numbers and number patterns. This topic presents questions to test understanding related to the calculation of number patterns, measurement of objects, and everything related to numbers in everyday life. Number topics include understanding mathematical procedures, quantitative reasoning skills, representing in numerical form, and making estimates.
- The topic of probability and uncertainty deals with statistics and probability.

These four math topics are the content that serves as the foundation for learning math in everyday life.

Mathematical Process

According to Hayat (2010), PISA divides this process component into three groups:

- Reproduction process component. Students are asked to copy or repeat information they have previously acquired. For example, students can repeat mathematical definitions. Students are able to complete simple calculations that may require common and less complex solutions. Such skills are of course often observed in traditional assessments.
- Connection process component. Students make connections between different mathematical concepts, and relate to real situations in their environment. They can solve problems that are simple but related to everyday problem solving. Students can directly engage in mathematical decision-making using simple mathematical reasoning.
- Reflection process component. This component is the highest competency measured in PISA, covering the ability to reason using mathematical concepts. Students are faced with situations where they can use their mathematical thinking in depth to solve problems. Students analyze the situation, identify and find the 'mathematics' behind the situation. This mathematization process includes students' competence in

recognizing and formulating situations in mathematical concepts, making their own models of these situations, analyzing, thinking critically, and reflecting on these models, as well as solving problems and connecting them back to the original situation.

Mathematical Context

The mathematical context in PISA is divided into four situations, according to Hayat (2010):

- Personal context. Directly related to students' personal daily activities or problems and solved with mathematical concepts.
- Educational and work contexts that relate to students' lives at school and/or at work. Students' knowledge of mathematics will help them in formulating, classifying, and solving problems in general related to education and work.
- General contexts relating to the use of mathematical knowledge in social life and the wider environment of everyday life. Students can contribute their understanding of mathematical knowledge and concepts to evaluate various relevant situations in life in society.
- Scientific context. Relates to scientific activities that are more abstract in nature and require understanding and mastery of theory in solving mathematical problems. This context is known as the intra-mathematical context.

Each question in PISA covers three dimensions above, namely content, process and context dimensions. The three components in PISA based on OECD can be seen in the Figure 2 (Ahyar et al., 2014).

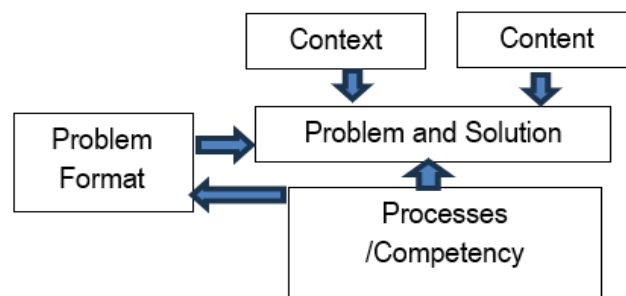


Figure 2 PISA Components in Mathematics

The purpose of this study is to provide a bibliographic and bibliometric analysis of various studies found in the Scopus database related to PISA in the mathematics domain. The research questions are as follows:

1. What are the publication and citation trends of PISA-related research in the mathematics domain from 2013 to 2023?
2. In relation to PISA research in the mathematics domain, which documents, authors, countries, institutions and sources are most productive and influential?
3. What are the most dominant keywords related to PISA research in the mathematics domain?
4. What is the distribution of dominant keywords related to PISA in the mathematics domain in 2013–2023?
5. In mathematics, how do authors and countries relate to PISA?

METHOD

A bibliometric and bibliographic review of PISA research in the mathematics domain is presented in a systematic review using bibliometric analysis. The bibliometric analysis was conducted in five steps (Fuad et al., 2022), as shown in Figure 3.

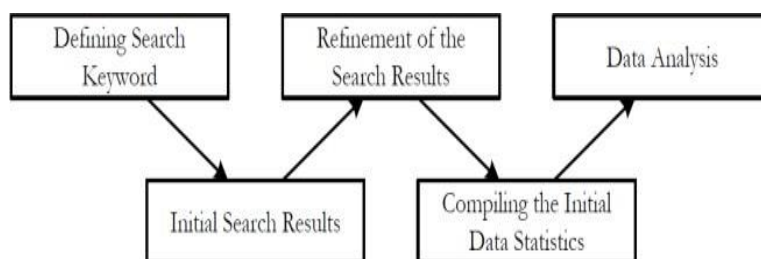


Figure 3 Steps of Bibliometric Analysis

A more detailed explanation of each step of the bibliometric analysis is as follows.

Defining Search Keyword

Scopus was used to search and find documents relevant to PISA in the mathematics domain. Scopus is one of the best scientific databases that provides many high-quality documents, so it was chosen to help search for high-quality documents related to PISA in the mathematics domain. The documents were investigated with specific keywords, such as "PISA" in the mathematics domain. In addition, PISA documents in the math domain have been searched in November 2023.

Initial Search Results

Using the keywords "PISA" and "mathematics", an initial search found 1,346 documents published from 1991 to 2023. Many documents have already been published, but some are still in the process of being published. The following languages were used: English, Chinese, Turkish, German, Russian, Czech, Croatian, French, Slovenian, Norwegian, Spanish, Portuguese, Swedish, Serbian, Polish, Lithuanian, Japanese, Dutch, Bulgarian, and Bosnia-Herzegovina. In addition, the types of source documents are journals, conference proceedings, books, and book series, as well as articles, papers, book chapters, reviews, commentaries, notes, short surveys, and erratums. In addition, the keywords "PISA" and "mathematics" were not found in most document titles.

Refinement of the Search Results

The systematic document selection process consists of four stages: 1) identification, 2) screening, 3) eligibility, and 4) inclusion. Inclusion criteria were set to find documents relevant to "PISA" and "mathematics". First, the keywords "PISA" and "mathematics" should be included in the title of the document. Second, determine whether the document has been published or has reached the publication stage. Third, specify that the document is only written in English; fourth, specify that the source document is only a journal; and fifth, specify that the document is only an article. Finally, the document was published from 2013 to 2023. Figure 4 shows how the documents for this bibliometric analysis study were selected. One exception was that the titles did not contain the keywords "PISA" and "mathematics".

Compiling the Initial Data Statistics & Data Analysis

Bibliometric information, bibliographic information, abstracts and keywords were included in Comma Separated Values (CSV) format downloaded from the Scopus

database. Performance analysis showed the trend of mathematical publications and citations related to PISA. Meanwhile, relationships between research constituents were examined through analysis of science mappings such as citations, co-words, and co-authorship. Citation analysis was used in detail to display the most prolific and influential documents, authors, countries, affiliations and sources of mathematics related to PISA. Co-word analysis was used to show the most frequently occurring mathematics keywords related to PISA in 2013-2023. Co-authorship analysis showed the social relationships between authors and countries in PISA studies in the mathematics domain. Rstudio application can assist in Performance analysis, citations, co-word, and co-authorship. Network analysis was also conducted, which included hierarchical clustering, overlay and network visualization to enhance the science mapping analysis. VOSviewer can perform both science mapping and network analysis (Eck and Waltman, 2010). Steps in Conducting Bibliometric Analysis can be seen in Figure 4.

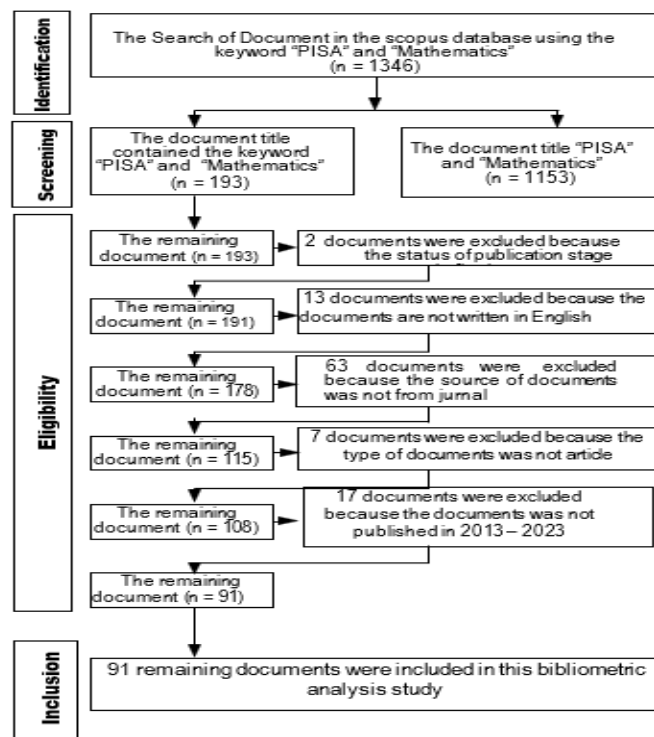


Figure 4 Steps in conducting bibliometric analysis

RESULT AND DISCUSSION

Performance Analysis

The development of the number of publications and citations related to PISA in the mathematics domain from 2013 to 2023 is presented through performance analysis (See Figure 5).

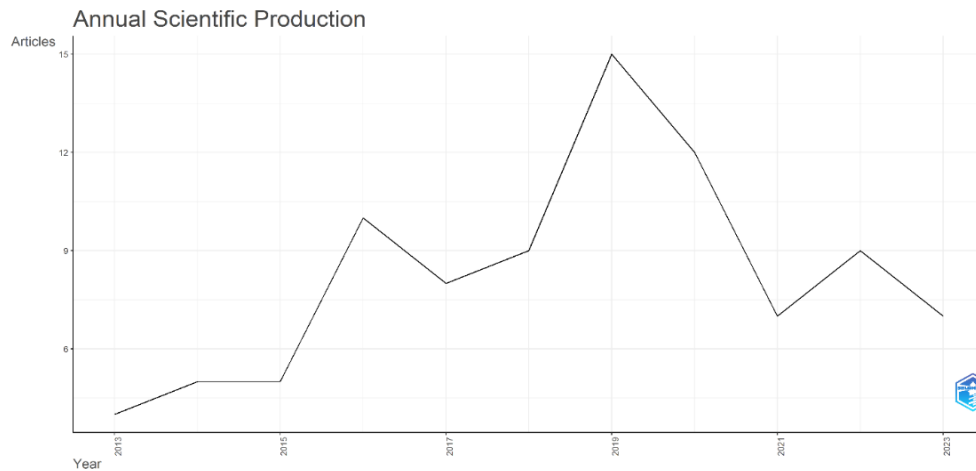


Figure 5 Annual scientific production

Figure 5 shows that from 2013 to 2019, publications related to PISA research in the mathematics domain increased relatively. However, from 2019 to 2021, they experienced a considerable decline, then experienced a slight increase in 2022, and again experienced a decline in 2023. Of the total 91 documents published during the period, four were published in 2013, five were published in 2014, five were published in 2015, ten were published in 2016, eight were published in 2017, nine were published in 2018, fifteen were published in 2019, twelve were published in 2020, seven were published in 2021, nine were published in 2022, and seven were published in 2023. In Figure 5, it can be seen that publications in Scopus in 2013 were the lowest regarding PISA study keywords in the mathematics domain. This may be because PISA was only released one year earlier. Article distribution trends fluctuate up and down. However, the peak of publications occurred in the 2018-2019 range, this may have happened because the 6th PISA results were released in 2018. From 2019 to 2021, publications experienced a very sharp decline compared to other years. This is due to the Covid-19 pandemic which limits the implementation of the 7th PISA.

Figure 6 shows that the development of PISA study citations in the mathematics domain has decreased on average from 2013 to 2023. The average index of citations per year in 2013 was 8.2, in 2014 was 3.8, in 2015 was 1.6, in 2016 was 2.1, in 2017 was 1.4, in 2018 was 2.2, in 2019 was 1.9, in 2020 was 1.8, in 2021 was 3.3, in 2022 was 1.3, and in 2023 was 1.3 (See Figure 6).

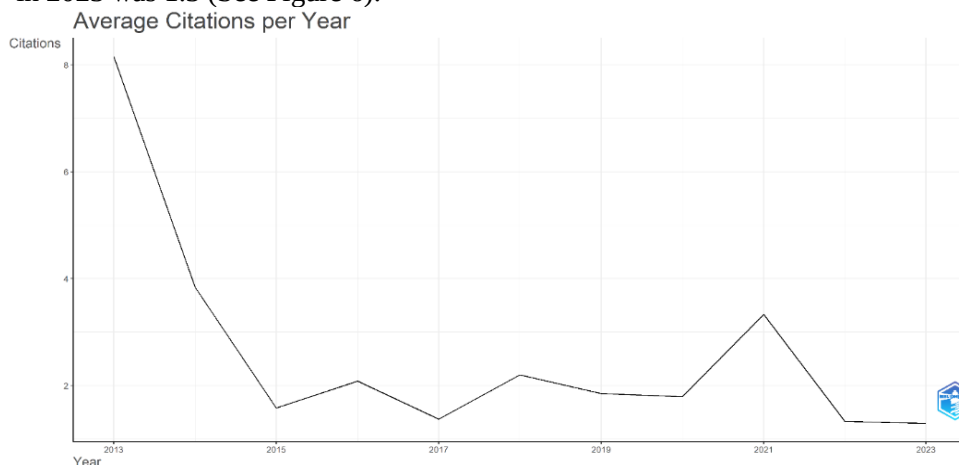


Figure 6 Average citations per year

Figure 6 shows that from 2013 to 2023 there are ups and downs in the number of citations of PISA study publications in the mathematics domain. The most significant decrease is from 2013 to 2014 and the highest increase is from 2020 to 2021.

Science Mapping and Network Analysis

Citation Analysis

Citation analysis highlights the most fruitful and significant document, authors, countries, organizations, and sources associated with PISA research in the field of mathematics. The authors, countries, organizations, and sources with the highest productivity were identified based on total publications (TP). Rather, the most influential document, authors, countries, organizations, and sources are identified using total citations (Fuad et al, 2022). The top five articles with the most citations (refer to Table 1) contain the most influential papers pertaining to the PISA research in the mathematics domain. Table 1 shows the most influential documents related to the PISA study in the mathematics domain, sorted from first to fifth place.

Table 1 The five highest citation documents

Document Title	Authors	Source	Citation Source	Year
Sex Differences in Mathematics and Reading Achievement Are Inversely Related: Within- and Across-Nation Assessment of 10 Years of PISA	Stoet & Geary	PLOS ONE	252	2013
Difficulties in solving context-based PISA mathematics tasks: An analysis of students' errors	Wijaya A, van den Heuvel-Panhuizen M, Doorman M, Robitzsch A	Mathematics Enthusiast	99	2014
Higher-order structure of noncognitive constructs and prediction of PISA 2003 mathematics achievement	Lee J & Stankov L	Learning and Individual Differences	62	2013
Developing PISA-like mathematics task with Indonesia natural and cultural heritage as context to assess students' mathematical literacy	Oktiningrum W, Zulkardi, Hartono Y	Journal on Mathematics Education	40	2016
Examining students' achievement in mathematics: A multilevel analysis of the Programme for International Student Assessment (PISA) 2012 data for Greece	Karakolidis A, Pitsia V, Emvalotis A.	International Journal of Educational Research	39	2016

As can be seen in Table 2, the most productive countries are the highest five with the highest publications, and the most influential countries with the highest citations. According to Table 2, Indonesia is the country with the most productivity, having published 67 papers about PISA research in the mathematics domain. Meanwhile, the most influential country is United Kingdom. In other related documents, the PISA study publications in the mathematics domain have been cited 303 times. (See Table 2).

Table 2 The highest five countries in the publications and citations

Countries with the most publications		Countries with the most citations	
Country	Total Publications	Country	Total Citations
Indonesia	67	United Kingdom	303
Turkey	26	Indonesia	155
USA	20	Australia	62
Jerman	12	Turkey	50
Kanada	10	Malaysia	45

Furthermore, The three most productive organizations are indicated by the highest number of publications from 2013 to 2023 in the PISA study in the mathematics domain. Only the top three organizations were taken because there are several organizations that have the same publications. (See Table 3).

Table 3 Top three document of organization

Five institutions with the highest production		
Organization	Country	Document
Sriwijaya University	Indonesia	23
Tilburg University	Belanda	6
University Of Tartu	Estonia	6

We can see in Table 3 that Sriwijaya University is the top organization in PISA study publications in the mathematics domain, followed by the other top three organizations.

The top journal, Journal on Mathematics Education, has 16 papers pertaining to PISA research in the mathematics domain. Given that other relevant publications have cited it 282 times, it is the most influential source, followed by the other top 4 journals (See Table 4).

Table 4 The five highest production

Five sources with the highest production		
Source	Number Publication	Total Citation
Journal on Mathematics Education	16	282
European Journal of Psychology of Education	3	30
Frontiers in Psychology	3	37
International Journal of Science and Mathematics Education	3	38
Studies in Educational Evaluation	3	19

Co-word analysis

Hierarchical clustering analysis is added to network and overlay visualizations to create co-word analysis (Fuad et al., 2022). Initially, network visualization aided by hierarchical clustering analysis was done to display the most often occurring terms in each of the three PISA components for mathematics: content, process, and context. Only 71 keywords are chosen, and the fewest instances of a chosen term are 1 occurrence with 332 keywords present. According to Figure 7, the chosen keywords are the most pertinent to PISA in mathematics (See Figure 7).

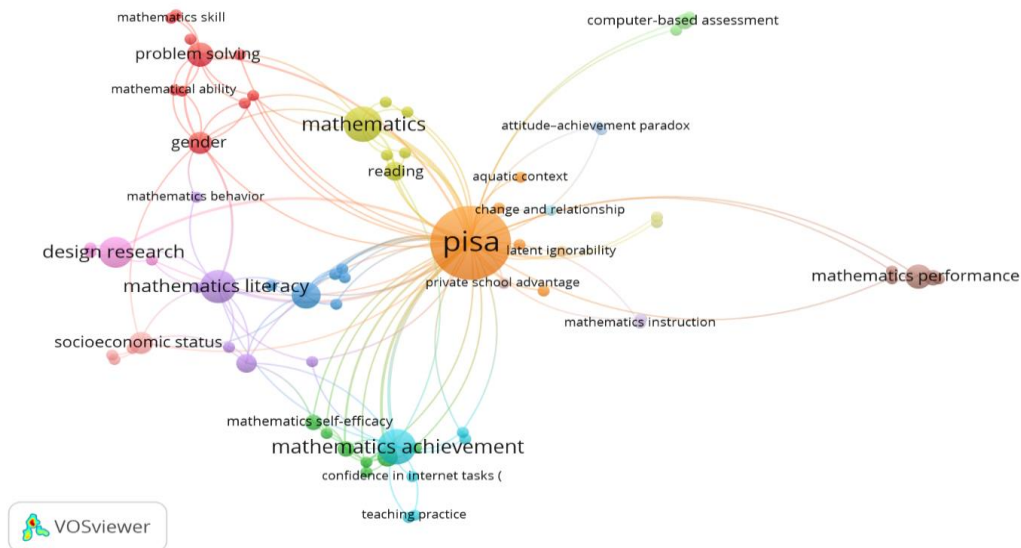


Figure 7 Network visualization

Refer to Tabel 5, there are 4 main keywords that are selected with the number of 71 occurrences included 5 different clusters regardless of color in the network visualization. This is because there are special criteria in the PISA component in the mathematics domain which must be grouped based on type. These 5 clusters were created based on the following components in the PISA framework (See Table 5 below).

Table 5 Kluster Main Keyword

Cluster	Keyword	Occurance	Total link strength
Main Keyword	PISA	45	78
	Mathematics	10	20
	Mathematics Education	6	14

There are other keywords related to PISA in the mathematics domain and are presented in Table 6.

Table 6 Others keyword that related to PISA in mathematics domain

Cluster	Keywords
Others Variabel Related to PISA in Mathematics Domain	Mathematics achievement, Mathematics literacy, Gender, Mathematics performance, Socioeconomic status, Mathematics Self-efficacy, school climate, opportunity to learn, computer- based assesment, Mathematics-self concept, affective characteristics, perseverance, student evaluation, educational inequality, latent ignorability, Student achievement, curriculum, ICT, Immigrants, Multicultural policies, test anxiety, attitudes toward school, classroom environment, educational governance, language minority student, learning strategies, Mathematics behavior, Mathematics pedagogy, Mathematics teachers, motivation, noncognitive factor, self -beliefs, student attitudes, time on task, word problems, cognitiv diagnosis, internet confidence, cross-cultural comparability, educational equality, educational evaluation, enrichment program, growth mindset, international comparison, mathematics anxiety, mathematics burden, primary school students, policy development, school characteristic, school-effectiveness, school- level factory, students difficulties, teacher-student relationship, teaching practice, technology, fundamental mathematical capabilities, mathematics problems, Mathematics curricula, Mathematics skill, Mathematics task, numeracy task,

Cluster	Keywords
	private advantage school, problem of pisa, teacher -classroom behaviour, statistical literacy proses, junior high school.

The appearance of keywords in cluster 3 of the PISA components, namely content, process/competition, and context, is in the following table (See Table 7)

Tabel 7 Cluster 3 PISA components in mathematics

Cluster	Keyword
Conten	Model uncertainty, Specification curve analysis, mathematics content, process data, change and realtionship.
Procces /Competency	Model uncertainty, Specification curve analysis, mathematics content, process data, change and realtionship.
Context	Realistic Mathematics educations, contextual problems, bangka context, covid-19 context, local wisdom, real life situation, sailing context, aquatic context,

The next analysis is an overlay visualization analysis. In this analysis, the most recent year of keyword research on the net is shown in light to yellow color, while darker colors indicate that the research year related to the keyword is quite old. The latest year regarding PISA is 2020 and above, related to several words, one of which is mathematics performance, mathematics self-efficacy, computer-based assessment. Meanwhile, quite old years, namely 2016 and below, include the keywords problem solving and student achievement. The keywords are more clearly presented in Figure 8.

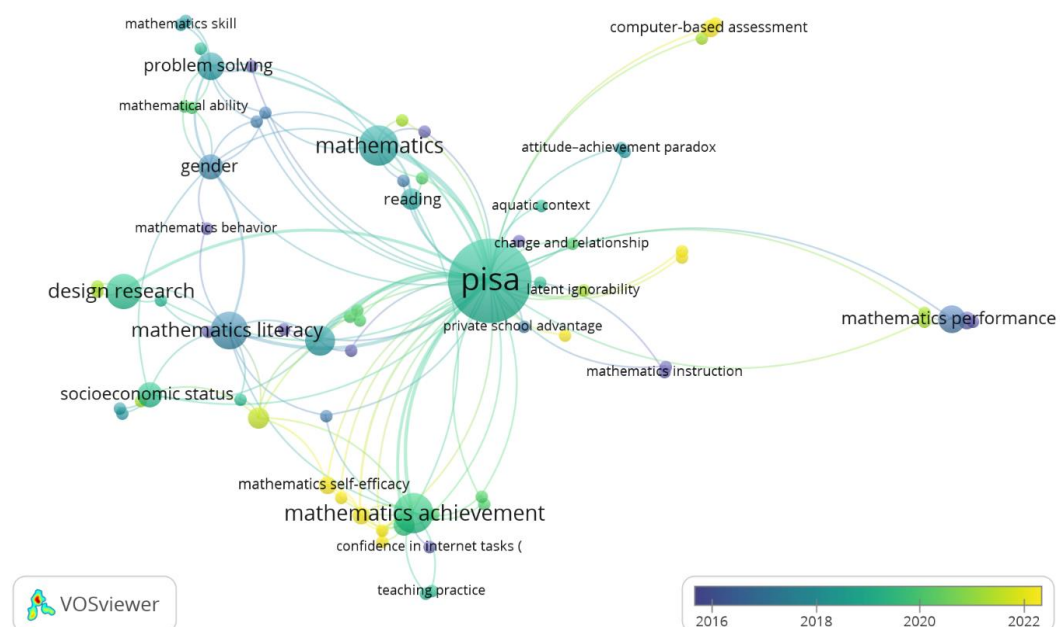


Figure 8 Overlay visualization

Density Visualization

Another part of network analysis besides overlay visualization is density visualization using VOSviewer. Density visualization related to PISA research in the mathematics domain can be seen in Figure 9.

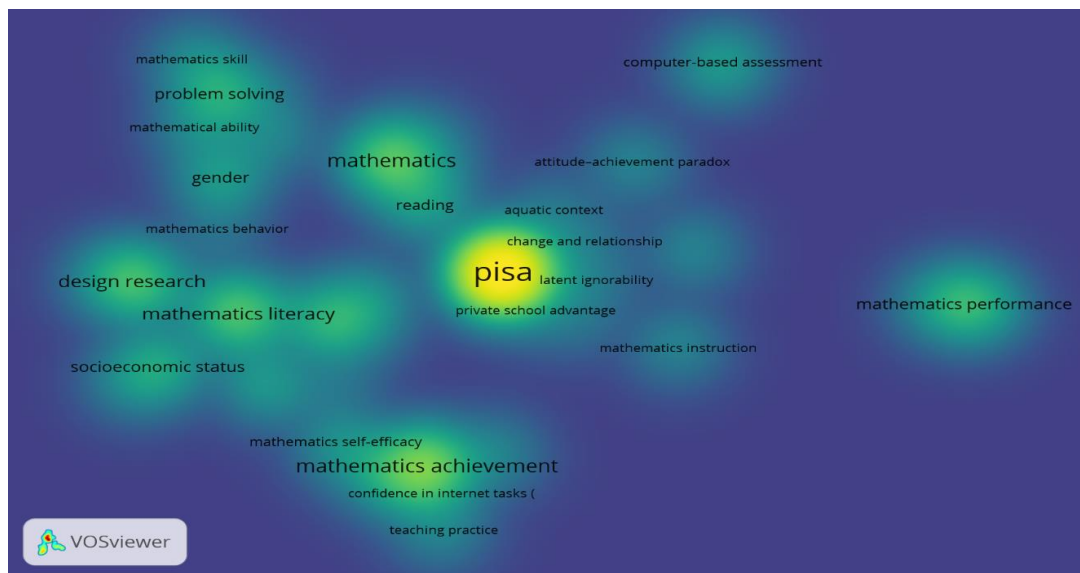


Figure 9 Density visualization

The brighter the yellow light, it means that many people have done research on that keyword. On the other hand, the fainter it means there are still fewer people researching it. In the picture you can see the colors are dim. One of the keywords is mathematics instructions and mathematics behavior. There are still few who research PISA in the mathematics domain. By looking at identifying colors in the density visualization analysis, researchers can find gaps in novelty or research ideas by utilizing what variables are rarely investigated or not interconnected, so that researchers can find new relationships from these variables.

Co-author analysis

The author unit and the country unit make up the co-authorship analysis in this study. The author's social relationships associated to PISA studies in the mathematics domain are first shown using co-authorship analysis in the author's unit. The author's minimal number of documents is chosen, one document with 23 appearances from authors who are typically related (See Figure 10).

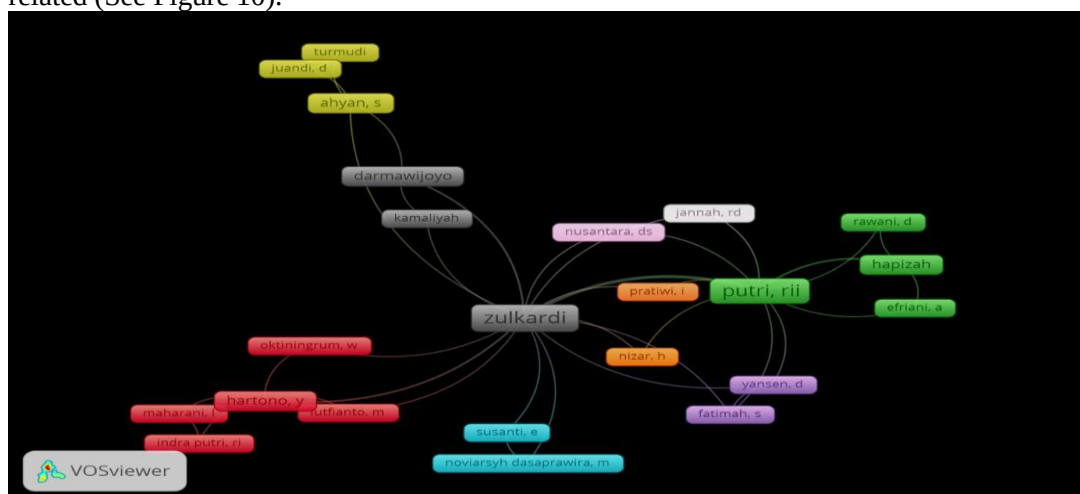


Figure 10 Social interactions between authors in PISA studies in the mathematics domain

Figure 10 shows that there are 9 clusters such as, blue, gray, yellow, orange, red, green, purple, pink, white. where each author is generally connected to each other. There are three writers in the gray group: Zulkardi, Kamaliyah, Darmawijoyo. There are five writers in the red cluster: Oktiningrum, Hartono, Lutfianto, Maharani, Indra Putri. Writers in the blue cluster include Susanti and Noviansyah. There are three writers in the yellow cluster: Turmudi, Juandi, Ahyani. There are two authors in the orange cluster: Pratiwi and Nizar. Writers in the green cluster: Putri, Rawani, Hapizah, Efriani. There are 2 authors in the purple cluster: Yansen and Fatimah. There is one writer in the pink cluster, namely Nusantara. There is one writer in the white cluster, namely Jannah.

Additionally, social contacts between country relevant to PISA research in the mathematics domain are presented using co-authorship analysis in country units. One document with five authors who are generally related to one another is chosen as the author's least number of documents (See Figure 11).

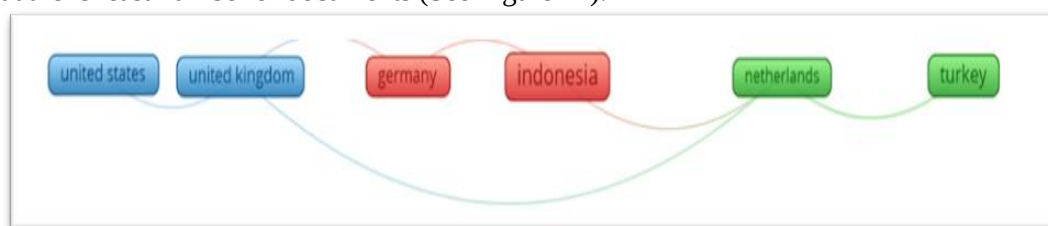


Figure 11 Social interactions between countries in the PISA study in the mathematics domain

Publication and Citation Trends of PISA Studies in the mathematics domain

Publication and Citation Trends for PISA studies in the mathematics domain from 2013 to 2023 in the Scopus database experienced fluctuations of ups and downs, static, significant decreases and significant increases in certain years. From 2013 - 2014 there was a slight increase of 1 document from before, in 2014 - 2015 it was static because there was no increase or decrease, in 2015 - 2016 it increased quite high by 5 documents from before, in 2016 - 2017 there was a decrease of 2 documents, in 2017 - 2018 there was a decrease of 1 document, in 2018 - 2019 there was an increase of 6 documents, in 2019 - 2020 there was a decrease of 3 documents, in 2020 - 2021 it decreased by 6 documents, in 2021 - 2022 it increased by 2 documents, in 2022 - 2023 it decreased by 2 document. A significant decline occurred in the period 2020 - 2021, this occurred due to the occurrence of Covid-19 which resulted in the postponement of the implementation of the 7th PISA since 2000. Furthermore, the development of citations to sources pertaining to PISA in the mathematics domain also experienced fluctuations, in 2013 saw the highest citations in the last 10 years. This is because in the previous year, namely 2012, the PISA test was carried out, so the citations in the following year, namely 2013, were extremely high with average annual citations was 8.2. Moreover, there was a notable decline in citations between 2014 and 2015; in 2014, the average annual citation was 3.8, whereas in 2015, it was only 1.6. Citations increased in 2016, with an average of 2.1 citations annually. Then, in 2017, it dropped once more, averaging 1.4 citations annually. Grew little in 2018, with an average of 2.2 citations annually. The average annual citation fell little to 1.9 in 2019. In 2020 saw a comparatively stable 1.8 citations each year on average. An average citation per year of 3.3 in 2021, it grew the most compared to prior years, and dropped dramatically the following year in 2022, to an average citation per year of 1.3. Finally in 2023 it will be static because the number of citations remains the same from the previous year.

The Countries, Organizations, Documents, and Sources that Have Contributed the Most to PISA to PISA Studies in the Mathematics Domain

Based on the highest citations, the document concentrate on variables or relationships among several variables that affect PISA scores in mathematics domain, difficulties in solving PISA questions in mathematics, development of mathematics questions such as questions in PISA, and testing student achievement in mathematics. These documents also study the category of variables related to PISA results such as prediction of students' mathematics achievement in PISA, analysis of students' errors, development of the context of PISA questions, and other abilities that influence PISA results in the mathematics domain such as reading achievement.

The most productive writer is Zulkardi who is affiliated with Sriwijaya University. Zulkardi published 11 articles in the period 2013 – 2022 related to PISA studies in the mathematics domain. Almost all of the articles he produced on PISA studies in the mathematics domain focused on designing Pisa-like mathematics tasks, developing mathematics questions of Pisa, and analyzing student answers. The development of the PISA questions that he produced in his research used various contexts such as the Asian Games context, Covid-19 context, sailing context and several other contexts.

The most productive institution in publishing PISA studies in the mathematics domain is Sriwijaya University with a total publication of 23 documents. The most productive source publishing PISA studies in the mathematics domain is the journal on mathematics education with 16 total publications in the last 10 years. Citations overall (282), h-index (12), g-index (16), and m-index (1,019). Indonesia produces the most, with 67 documents produced.

CONCLUSION

The information provided by this bibliometric study pertains to the development of PISA studies in the mathematics domain from 2013 to 2023. The development of publications related to PISA studies in the mathematics domain relatively increased from 2013 to 2019, but experienced a significant decline from 2019 to 2021, and experienced a slight increase in 2022 and decrease again in 2023. This shows that the development of PISA study citations in the mathematics domain experienced an average decline from 2013 to 2023. The highest average citation was in 2013 from 2013 to 2023, after 2013 the number of citations per year relatively fluctuates up and down, which is not very significant, and is static from 2022 to 2023. Based on the highest citations, the document concentrate on variables or relationships among several variables that affect PISA scores in mathematics domain, difficulties in solving PISA questions in mathematics, developing mathematics questions such as questions on PISA, and testing student achievement in mathematics. These documents also study the category of variables related to PISA results such as prediction of students' mathematics achievement in PISA, analysis of students' errors, development of the context of PISA questions, and other abilities that influence PISA results in the mathematics domain such as reading achievement. Based on this main document that has emerged, classroom teachers and policy makers in the world of education can use it as evaluation material to improve students' PISA results. The most productive country in publishing 67 documents regarding PISA studies in the mathematics domain is Indonesia. Meanwhile, The most influential country with the highest number of citations is United Kingdom. The organization with the highest publications in the PISA study in the mathematics domain for the period 2013 – 2023 is Sriwijaya University with the most productive author being Zulkardi who is affiliated with Sriwijaya University. Almost all articles by the most productive authors on PISA studies in the mathematics domain focus on the keywords designing Pisa-like mathematics tasks, developing

mathematics questions of Pisa, and analyzing student answers. The development of the PISA questions that he produced in his research used various contexts such as the Asian Games context, Covid-19 context, sailing context and several other contexts. Likewise, the keywords that appear most often relate to factors that influence PISA in the content, process and context components as in the previous discussion section. Based on the focus of the top documents and keywords that often appear, teachers and policy makers in the world of education can make evaluation and analysis materials to improve the learning process so that they can achieve the expected PISA scores.

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