

Mapping teacher problem-solving research: A bibliometric review of the literature in two decades and the trend to support the SDGs

Albrian Fiky Prakoso^{1*}, Waspodo Tjipto Subroto², Eka Hendi Andriansyah³, Vina Budiarti Mustika Sari⁴, Muhammad Abdul Ghofur⁵, Ardhita Eko Ginanjar⁶ and Prattana Srisuk⁷

^{1,2,3,5,6}Surabaya State University, Indonesia

⁴KIP Widya Darma, Indonesia

⁷Thai Global Business Administration Technological College, Thailand

Abstract. This research aims to use bibliometric methods to explore Problem-Solving by Teachers over the last twenty years. Furthermore, this research also wants to understand how problem-solving can develop and achieve conceptual and practical understanding in accordance with the quality education points in Sustainable Development Goals (SDGs). This study utilized the Scopus database as a source of literature metadata and then analyzed it using Bibliometrix software with Biboshiny tools. 562 articles were initially identified, with 115 meeting specific inclusion criteria. This research reveals important themes in problem-solving by teachers, providing information that is easy to understand through pictures, tables, and maps. This research also analyzes the productivity of articles, journals, authors, and countries. This research also provides information on crucial research directions regarding problem-solving, including its application to teachers and students. The findings are valuable for future researchers as they inform practical implications for educators and policymakers. Thus, the contribution of this article specifically is that teachers can analyze problem-solving trends that are suitable to be presented in the learning process so that they remain in line with existing developments, while in general, this article helps develop strategies for implementing problem-solving according to 21st-century education.

1 Introduction

There have been many studies that have raised the theme of problem-solving [1, 2]. however, most of this research focuses on various fields and has not focused on teachers. Problem-solving in general science focuses on problem-solving strategies and behavior in the workplace as a team. Meanwhile, problem-solving for teachers focuses on how they give problems to students in the form of assignments, projects, or exams so that they can solve them. Teaching through problem-solving ensures active and interactive involvement of

* Corresponding author: albrianprakoso@unesa.ac.id

students in the teaching process, with the teacher acting as a facilitator to stimulate learning [3].

Problem-solving in the context of education is essential for advancing Sustainable Development Goal number 4, which is quality education [4], with teachers at its forefront. Quality education is not just about mastering academic subjects, but also about shaping students' independent character, enabling them to confidently and effectively tackle various challenges in their future.

In more detail, problem-solving plays a big role in education. It can become an opportunity for learning development for teachers and prospective teachers to understand student characteristics [5]. However, the teacher must still act as a facilitator so students do not go in the wrong direction. In addition, problem-solving abilities can be further developed through structured assessments and implementing more varied learning models [6, 7]. Teachers' research on problem-solving has recently experienced significant development. The proof is that many researchers develop problem-solving-based assessments [8], the Influence of Cognitive Abilities on Problem-Solving [9], and Gender Differences in Problem-Solving [10]. The role of research in developing problem-solving is manifested in developing problem skills, information, communication technology, planning, and continuous improvement for SDGs [11]. Bibliometric analysis is needed to integrate the findings from these research results and find directions in which research should be developed [12].

Bibliometric research is useful for teachers to find information about problem-solving and providing connections between one article and another. Several Scopus-indexed articles about bibliometrics discuss problem-solving, [13] Analyzing problem-solving and decision-making concerning Education for Sustainable Development (ESD). [14], who analyze bibliometric problem-solving articles related to remote learning. On the other hand, [15] discusses bibliometric problem-solving related to STEM and uses project-based learning about the greenhouse effect. Even though the three articles have focused on problem-solving, this article focuses on higher education and still uses VosViewer software. From this, the research gap that emerges is the significant lack of specific research on the development of teacher problem-solving worldwide. Therefore, the novelty of this research is to focus on studying the development of teacher problem-solving research globally using the latest data from 2002 to June 2024.

Thus, this study carries out bibliometric analysis. The aim is to obtain visualization and map the research profile followed by trends that emerged in teachers' problem-solving themes. This research also aims to expand problem-solving knowledge for teachers, lecturers, students, educational institutions, leaders in the Ministry of Education, and researchers in general. Of course, related parties can use the results of this research as recommendations for research themes and policy-making related to improving the world of education because they have obtained important information and recommendations from these researches, so they can carry out research and make educational policies appropriately and in accordance with the latest developments. The research questions are below:

1. What are the primary pieces of information and progress of teacher problem-solving literature?
2. What are the main profiles and source titles of teacher problem-solving literature sources?
3. What are the knowledge structures of teachers' problem-solving literature? s

2 Methods

This research uses a bibliometric approach to determine and map problem-solving research trends. Research trends can be defined as the collective behavior of a cluster of researchers beginning to show interest in a specific scientific research theme. These conditions reflect

the urgency of the problems and needs of people in various parts of the world in the form of dynamic scientific research. Bibliometric mapping can be done to carry out this analysis. Bibliometric research can help other researchers find relevant research directions. In practice, access to bibliographic databases is needed to help researchers determine scientific publications' identity, from the title, author's name, and abstract to references. One credible bibliographic database is Scopus. In Scopus, various scientific works are available, including journals, conference proceedings, and books that meet international standards. This is because Scopus only indexes scientific works and high-quality data.

2.1 Article selection process and methods

The bibliographic data search mechanism in Scopus was implemented on June 5, 2024, with initial findings of 562 documents based on searches related to "TITLE (Problem-solving AND Teacher)." The selection process begins with screening a certain period, namely 2002-2024, to obtain the final data of 502 documents. Then proceed with the "Document Type" filter, namely "Article," and get 365 related article titles. Next, filtering was repeated using the "English Language" category, and 337 articles were obtained. The articles were narrowed down again until we got 115 with filter keywords, namely "Problem-solving" and "Problem-solving". The overall selection process can be depicted in Figure 1.

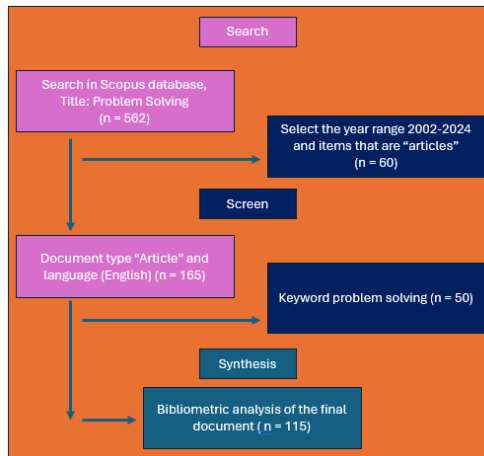


Fig. 1. Article Selection Process and Methods.

2.2 Data analysis

Filtered documents were extracted using the comma-separated variable (.csv) Microsoft Excel files containing affiliation, author name, title, country, journal name, and keywords. Then, the file is analyzed to provide a descriptive response aligned with the research query. To visualize bibliographic data, this research uses bibliometrix software. This software provides many functions for comprehensive bibliographic analysis of scientific works, such as the number of publications, citations, co-occurrence networks, and keywords. Moreover, this software enables standardized and consistent bibliometric measurements and indicators, ensuring that data analysis is reliable and comparable with other literature about problem-solving. Quantitative descriptive analysis is used to obtain important information in problem-solving research, such as the title, sources/journals that publish the most, top countries that publish, and affiliates that publish the most. This research also examines how pairs of authors are referenced in quotations using co-authorship analysis. In the end, co-occurrence

knowledge mapping was carried out to illustrate development path trends as an effort to support the SDGs, keywords, and teacher problem-solving research themes. The use of common keywords can reflect the popularity of themes in a particular research area. As a result, keyword co-occurrence mapping is used to assess how frequently the term appears in research and how central it is in the co-occurrence knowledge map.

3 Result and Discussion

3.1 Main information

Table 1. Main information of bibliometric.

Description	Results
Main Information About Data	
Timespan	2002: 2024
Sources (Journals, Books, Etc)	88
Documents	115
Annual Growth Rate %	-5.34
Document Average Age	6.89
Average Citations Per Doc	9.261
References	5124
Document Contents	
Keywords Plus (Id)	181
Author's Keywords (De)	348
Authors	
Authors	312
Authors Of Single-Authored Docs	21
Authors Collaboration	
Single-Authored Docs	22
Co-Authors Per Doc	2.94
International Co-Authorships %	14.78
Document Types	
Article	115

Table 1 shows that the main information in problem-solving studies taught by teachers during the period in question comes from the Scopus database. This research shows changes from year to year and has a significant impact. This result is proven by the average citation per document related to the theme of 9,261. The subject of inquiry encompasses both domestic and international collaboration, as indicated by patterns of co-authorship. The proportion of international co-authorship suggests a potentially high collaboration index within this field. With various keywords and interdisciplinary themes, problem-solving research continues to evolve according to developments in education and research worldwide.

The trend in problem-solving publications experienced high fluctuations, as depicted in Figure 2. From 2004 to 2008, the number of publications experienced a decline. Meanwhile, in 2009, there began to increase about 5 publications until 2010. However, in 2011, there was another decline. The fluctuating increase began to occur from 2016 to 2023, with the highest peak being 18 publications. Unfortunately, it is still showing a negative trend in the current year, which is indicated by the number of publications, which was only 1 at the beginning of June 2024.

3.2 Publication trends

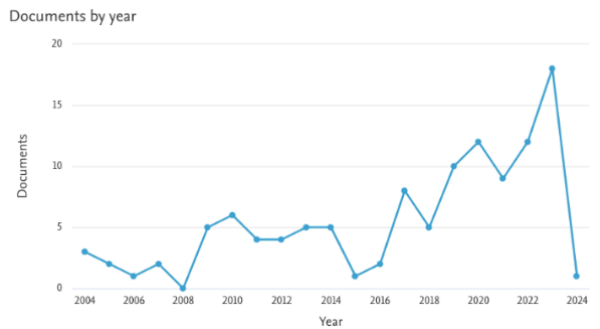


Fig. 2. Annual Scientific Production of Teacher Problem-Solving

If examined in depth, the progress of discussion of problem-solving topics is in line with the development of education in the 21st century [16, 17]. In this era, educational inclusion and the skills needed to adapt have been integrated into the curriculum, thus requiring teachers to teach students good problem-solving skills. Moreover, during this period, follow-up skills for critical thinking are very necessary, namely problem-solving skills that can be implemented contextually. This is the main provision for students to face competition with AI artificial intelligence in the world of work in the future. With AI, students are greatly helped in searching for information [18], This must be optimized with problem-solving abilities so that they have complex skills. On the other hand, skill development through problem-solving is a form of improving the quality of education in the SDGs. For this reason, it is not surprising that there is a lot of research on problem-solving in schools.

Meanwhile, the extreme decline that will occur in 2024, according to Figure 2, is indicated to occur because the data collection in this research was carried out in the middle of the year. The number will likely increase by the end of 2024. This could happen because many articles are still in the process of "Submission" and "Scanning" in the Scopus database.

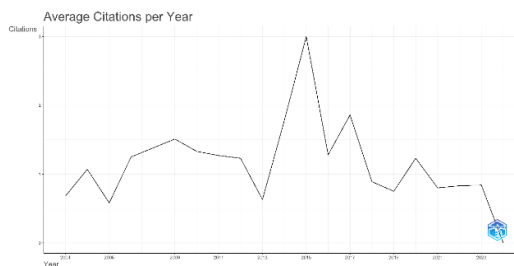


Fig. 3. Average Citations Per Year in The Teacher Problem-Solving Literature

The Figure 3, illustrates the mean citation rate per annum for scholarly research. on the problem-solving theme applied by teachers in the learning process. The graph above explains that the topic of teacher problem-solving has been vulnerable from 2004 to 2015, and it has experienced increasing fluctuations. In this vulnerable year, the need for in-depth knowledge about topics is very high, especially in 2015. Apart from that, some of the decline could be caused by trends in the need for different topics in the world of education. Meanwhile, there was a fluctuating decline in the vulnerable years from 2015 to June 2024. It is indicated that the decline in the number of statistics per document could occur due to the abundance of scientific information related to the topic being discussed, so researchers will only look for topics that directly address their research.

Overall, scientific publications in problem-solving by teachers have attracted massive interest among academics and are predicted to experience substantial growth in times to come [18]. This can occur due to the urgency of 21st-century students' skills requiring high problem-solving abilities in the work process. They can take advantage of it through various artificial intelligence technologies in the next few years. Several studies recognize that cultivating problem-solving skills is very important to overcoming complex challenges in Industry 5.0. Many industries emphasize problem-solving as the main soft skill [19]. In the realm of SDGs, citing elements of teacher problem-solving in various related research can better develop skills to face global challenges.

3.3 Researcher profile and source title

3.3.1 Top writer

Table 2. List of top authors and their impact on teacher problem-solving.

Authors	Articles	Articles Fractionalized	h-index	Total Citation
Perdomo-Diaz J	3	0.75	5	70
Siswono Tye	3	0.70	12	469
Verschaffel L	3	0.92	51	8652

The eminent authors offer valuable perspectives on the advancement of research in teacher problem-solving, encompassing productivity, patterns of collaboration, and the impact of their research. Table 2 lists the top 3 authors in the literature. The top three rankings are occupied by Perdomo-Diaz J, Siswono TYE, and Verschaffel L. The "Fractionated Articles" metric shows that their contributions are distributed across various publications, possibly collaborating with other researchers. Perdomo Diaz's article, "Problem-solving as a Professional Development Strategy for Teachers: A Case Study with Fractions," comes from Chile [20]. Meanwhile, if you refer to the Scopus ID profile, the author comes from Spain. The topics discussed most are social science, mathematics, and psychology.

Meanwhile, Siswono TYE, a researcher from Indonesia, in his article entitled "Examining teacher mathematics-related beliefs and problem-solving knowledge for teaching: Evidence from Indonesian primary and secondary teachers" [21], discusses Physics and Astronomy, Social Sciences, and Mathematics. On the other hand, a researcher who also made a major contribution, Verschaffel L, with his main article titled "Pedagogical content knowledge: A systematic review of how the concept has pervaded Mathematics educational research" most discusses Social Sciences, Psychology, and Mathematics [22]

3.3.2 Top sources

Table 3. Top sources and their local impact

Source Name	N	Cite Score	H_Index	G_Index	M_Index	TC	Py_Start
Teaching and Teacher Education	4	6.5	4	4	0.19	200	2004

Source Name	N	Cite Score	H_Index	G_Index	M_Index	TC	Py_Start
Eurasia Journal of Mathematics, Science, and Technology Education	4	4.3	3	4	0.214	37	2011
Journal of Mathematics Teacher Education	3	5.4	3	3	0.15	32	2005

Table 3 shows that "Teaching and Teacher Education" received the top ranking by producing 4 articles about problem-solving by teachers, with an h-index of 4 from 200 citations. This journal was published in 2004. Furthermore, the journal has a high Cite Score of 6.5 and a G-index of 4, which shows its significant effect and impact on the academic sphere. Please note that the H index helps us determine the number of articles and citations from the author. In the following year [23], refining the h index with the name g index informs us about the worldwide citation impact of a collection of articles. This indicates that the "Teaching and Teacher Education" journal is suitable for use as a place to search for problem-solving topics by qualified teachers.

3.4 Knowledge structures analysis

3.4.1 Conceptual structure

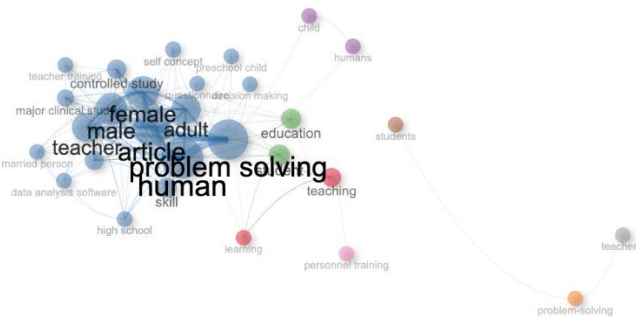


Fig. 4. Co-occurrence Network

Figure 13 presents a network of concurrent problem-solving publications by teachers, creating a visual depiction illustrating the connections between keywords across a series of publications. The co-occurrence network consists of several thematic groups, each representing a group of related terms, suggesting common themes and research directions. The following are several prominent and powerful groups in teacher problem-solving research, as indicated by the strength of the links.

Cluster 1 (blue): Problem-solving. This cluster revolves around discussing problem-solving and related topics that are most widely discussed. This includes related terms such as "Human," "Gender," "Teacher," "Controlled study", and many more. This indicates that the majority of problem-solving discussions in scientific work are related to human abilities, the influence on gender to the teacher profession in the learning context.

Cluster 2 (Green): Education and students. This cluster discusses terms that still have a significant relationship with problem-solving when viewed from the discussion of all

publications. The two terms above refer to the role and implementation of problem-solving in education, especially in the school environment. This indicates that school education and teaching have much to do with problem-solving.

Cluster 3 (Red): Learning and Teaching. This cluster also has a sufficient correlation with the term problem-solving. The two subjects above indicate that many academics are studying the role and contribution of problem-solving to teaching and learning in the current era. The instruments used can also include teaching media, the curriculum, and the teaching materials that reflect problem-solving elements.

Overall, it can be concluded that problem-solving topics that tend to be discussed relate to abilities humans need in the current era. This includes its implementation in the world of education and learning. The role of teachers is also widely discussed as the party responsible for teaching problem-solving to students so that they have an output that meets the demands of this century.

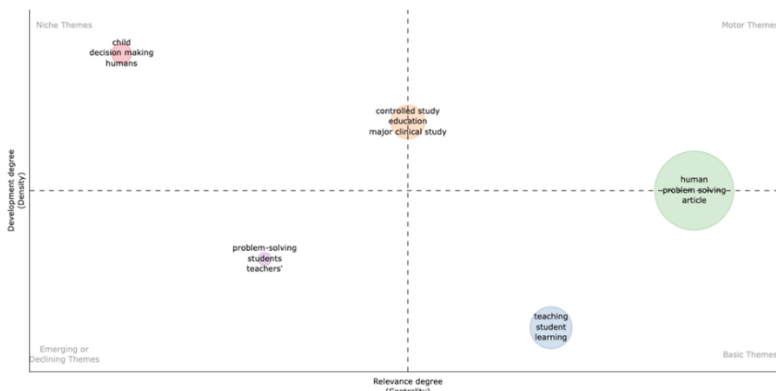


Fig. 5. Thematic Map

Another method of analysis that elucidates the conceptual framework is the thematic map with various themes from a particular domain above (Figure 5). A research area's relevance level is represented by centrality, while a theme's development level is represented by density. In the niche theme, several terms that appear are "child," "decision making," and "humans." At the intersection between niche and motor themes are "Controlled study," "Education," and major clinical study. These terms are what best reflect the level of relevance. Furthermore, to support the smooth running of the SDGs, future research should be able to focus more on emerging areas. "Problem-solving, student, and teacher" terms are used in emerging or declining themes [24]. This means that "students" are the main object of the problem-solving abilities brought by teachers. Meanwhile, in the basic theme quadrant, the terms are teaching, student, and learning.

3.4.2 Social structure



Fig. 6. Countries Collaboration Map

Regarding cooperation between countries, Figure 5 shows a map illustrating cooperation among countries in publishing the teacher problem-solving literature represented by the brown line. The data shows a notable degree of collaboration between America and Europe, especially between Canada, Spain, and Chile, which shows the strongest strength of the relationship. Then, the collaborative network was followed by a relatively strong relationship in Southeast Asia, namely collaboration between Indonesia and Malaysia.

4 Conclusion

This bibliometric study offers important information. The past teacher problem-solving research trend showed a decline of -5.34%. This is because the metadata retrieval process in the Scopus database was carried out in mid-2024, so there may still be many articles that have not been indexed. The expansion of the teacher problem-solving topic has been dominated by the United States and Indonesia, which only differ in the frequency of one article. Based on the most cited research, namely from the author, who observed teachers' behavior when given problem-solving online. Teaching, students, and learning are the most important themes that significantly influence the topic. So, it can be concluded that the theme that still has the potential to be cited is problem-solving for students and teachers. The topics above highlight the conditions most relevant to current problem-solving developments that lead to education and are aimed at students. Students become the most interesting subject as objects for implementing problem-solving skills by teachers.

The findings of this research underline the need to include research objects, namely teachers or students, in problem-solving contexts at all levels of education. This is crucial, considering that problem-solving is an important element in the current and future era of education. Teachers who want to remain relevant to current developments must look at trends related to problem-solving to support SDGs in education. As explained in this article the knowledge and learning skills they teach can be in line with developments in the world of education.

The ultimate weakness of this research is data limitations. Therefore, it is highly recommended that future researchers choose various other credible databases, such as combining the Scopus database with the Web of Science, so that a more in-depth and broader comparative analysis can be carried out. Nevertheless, the practical applications of this research offer numerous advantages. Educators can combine various other learning models with problem-solving concepts according to students and their needs to make them more effective. Meanwhile, policymakers should continue integrating problem-solving in the latest curriculum at all levels of education. Eventually, this research helps make it easier for future writers when they research problem-solving to refer to important themes, authors, and journals with the most teachers' problem-solving topics and articles with the highest number of citations identified in this paper.

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