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Mapping Research on Problem-Solving Skills in Physics Education: Bibliometric Analysis

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Abstract: This research aims to conduct a bibliometric analysis of literature related to problem-solving abilities in the context of physics learning. Through searching and analyzing relevant publications (articles, conference papers, reviews, and book chapters) using the Scopus database, research trends related to this topic were mapped. A total of 192 publications were obtained using Harzing's Publish or Perish application. Bibliometric analysis was carried out in this study. Search results from the Scopus database were extracted using VOSviewer software. The results of the analysis show that although there have been a number of studies conducted, problem-solving abilities in physics learning are still an interesting area for further research. There are great opportunities for further research involving the relationship between problem-solving abilities and various aspects, such as instrument development, STEM approaches, use of augmented reality technology, collaboration in problem solving, ability testing, student self-confidence, and learning materials. These findings show the importance of a deeper understanding of problem-solving abilities in the context of physics learning.

Keywords: Bibliometric Analysis, Problem-Solving Skills, Physics Education, Vosviewer

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INTRODUCTION

Problem-solving abilities are very important for understanding and applying physics concepts to solve real-world problems (Saiful, 2023). This is an important aspect in the construction of conceptual understanding and mastery of complex concepts (Amanda et al., 2023). As the curriculum develops and there is a shift in the educational paradigm, there is a growing focus on understanding students' abilities in solving contextual problems (Zakiah et al., 2022; Hayati et al., 2022). In the context of studying physics, problem-solving abilities play an important role in being able to understand physical phenomena and apply physics concepts to real-world scenarios (Pelobillo, 2022). The challenges students face in learning physics often require effective problem-solving abilities (Ginting, 2021). Therefore, many studies have explored the factors that influence and improve students' problem-solving abilities in physics education (Artinta and Fauziah, 2021; Hijriani and Hatibe, 2021; Lewa et al., 2018).

Strategies for solving problems have developed over the last 40 years. In the field of physics, there are many problem-solving strategies that can be used to help students improve their understanding and problem-solving abilities (Gok, 2010). One of the problem-solving steps that can be applied in physics learning is Heller's Theory (Aiyesi and Annisa, 2023). The problem-solving steps in Heller's theory consist of five steps: visualize the problem, describe the problem in physics terms (a physics description), plan a solution, execute the plan, and check and evaluate (Heller et al., 1992). Through the application of these problem-solving strategies, it is hoped that students will be able to train their problem-solving abilities.

Problem-solving ability is one of the most important abilities for students to have, especially in 21st-century learning. Previous research (Kulsum and Nugroho, 2014; Silaban, 2014; Handayani et al., 2018) has shown that students have good problem-solving abilities. Both have a higher probability of success in understanding and applying physics concepts. They tend to have the ability to analyze complex physics problems, formulate problem-solving strategies, and apply relevant physics concepts effectively. Therefore, problem-solving abilities are fundamental to understanding physics and preparing students to face future challenges (Sutarno et al., 2021).

Lestari (2015) and Amanah et al. (2017) revealed that problem-solving ability is a strong indicator in evaluating the effectiveness of physics teaching methods. The results of this research state the importance of teaching that focuses on developing problem-solving abilities in students. Active and interactive learning methods often allow students to practice solving physics problems, which can lead to improvements in their abilities. Therefore,

learning approaches that emphasize problem solving, such as inquiry methods, problem-based learning, and project-based learning, are often the recommended approach in the context of physics education (Arifin et al., 2021; Asuri et al., 2021; Dewi et al., 2017; Yuliati et al., 2020; Nurhidayah et al., 2021; Aristiani et al., 2018; Ananti & Anggraini, 2023) . So it is very important to have a comprehensive understanding of the scope, trends, and focus of research related to problem-solving abilities in students in the context of physics education. This understanding will be useful in developing curriculum, learning strategies, and evaluating the effectiveness of teaching methods. This emphasizes the importance of identifying specific problems related to problem solving in the context of physics learning.

Even though a lot of research has been conducted in the aspect of problem-solving abilities, it is necessary to provide an understanding of the focus, methods, and main findings from various previous research literature to determine the need for effective learning to improve problem-solving abilities in physics learning (Indasari et al., 2022; Susilawati et al., 2022; Qotrunnada, 2022). To obtain a clear and comprehensive understanding regarding the challenges faced in the current research literature, further studies need to be carried out to obtain and present a deeper understanding of the problems faced in developing problem-solving abilities in physics education. To gain this understanding, a detailed approach and strong methodology are needed to effectively show information related to the main focus and recommendations resulting from the analysis of existing literature. Thus providing significant practical implications for developing more effective curriculum and teaching strategies.

One way to find out the characteristics of a publication and understand trends in accordance with the study can be done through bibliometric analysis (Jetsadanuruk and Chansanam, 2023; Syafitri, 2023; Supriyadi et al., 2023). Bibliometric analysis in this context is considered important because it provides a strong foundation for an in-depth understanding of research trends and developments related to problem-solving abilities in physics learning. By exploring and analyzing data from previous studies, it can provide information regarding dominant research directions, significant citation trends, and the main contributions of various studies that have been conducted. Based on this, further research is needed to apply bibliometric analysis to previous research related to problem-solving abilities in physics learning.

This research was conducted through a systematic and comprehensive bibliometric approach to mapping trends, with a research focus related to problem-solving abilities in physics learning. Through the application of bibliometric methods and the use of analytical tools such as VOSviewer, this research can provide clear visualization and an in-depth

understanding of research networks, citation trends, and the relationships between relevant articles. Thus, it is hoped that this research can contribute to further understanding and development in the context of problem-solving abilities in physics learning, as well as pave the way for further research that is more innovative and useful for the practice of physics education. Therefore, the aim of this research is to conduct a comprehensive and systematic bibliometric analysis of related research literature to visualize research trends and identify further research opportunities that need to be carried out in the future. This research plays an important role in filling this gap by providing a deeper understanding of the focus and research trends related to problem-solving abilities in physics learning.

METHOD

This research design uses a bibliometric approach, which is a literature review method to analyze and summarize several articles on a particular topic. The search process for research articles was carried out using Harzing's Publish or Perish application on the Scopus database using the keyword "Problem Solving Skill in Physics Education" with a publication year range between 2019 and 2023. After getting the search results, a filter was carried out on the articles obtained to ensure they were suitable for their needs. data in this research. The collected data is then saved in.csv and.ris formats to facilitate further analysis.

Data analysis was carried out using the VOSviewer application, which is software used to produce visualizations in the form of bibliometric maps. In this research, the VOSviewer application is used to analyze and present relationships among articles related to problem-solving abilities in physics education. The resulting bibliometric map provides a clear visual representation of the relationships between articles, including citation patterns and interconnections between topics.

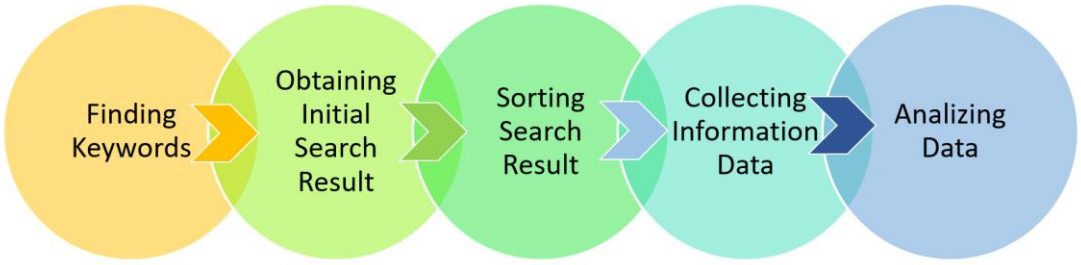


Figure 1. Bibliometric Analysis Method Stage

The articles taken as data sources come from various scientific journals and proceedings related to the field of physics education. By using this procedure, research can produce an in-depth understanding of the trends, focus, and contributions of research related to problem-

solving abilities in physics education. This research procedure is illustrated in more detail in **Figure 1**.

1. Finding keywords

   Search for literature using Harzing's Publish or Perish application using the keyword "Problem Solving Skill in Physics Education" in the Scopus database with a publication year range of 2019 to 2023.

2. Obtaining initial search results

   Based on initial search results using the keyword "Problem Solving Skill in Physics Education," there were 200 articles published.

3. Sorting search results

   The 200 articles obtained in the initial search were then sorted and filtered to select articles that were relevant to problem-solving abilities in physics education, resulting in a total of 192 articles. These results are then saved in.ris and.csv formats.

4. Collecting information and data

   For data in .csv format, a data collection process is carried out related to the type of publication (article, conference paper, review, or book chapter) according to the year of publication.

5. Analyzing data

   On data in .ris format, data analysis was carried out using the VOSviewer application to obtain data visualization in the form of a bibliometric map.

FINDING AND DISCUSSION

Annual publication related to the topic "Problem Solving Ability in Physics Education"

The publications analyzed in this research come from the Scopus data base and are limited to the last 5 years from 2019 to 2023. Details of the number of publications per year for the keyword problem solving skills in physics education are presented in **Table 1**.

Table 1. Number of Publications Each Year based on Keywords

Keywords	Publication Type	Year					Total
		2019	2020	2021	2022	2023	
Problem Solving Skill in Physics Education	Article	12	14	13	12	21	73
	Conference Paper	24	25	25	21	15	110
	Review	0	0	0	1	1	2
	Book Chapter	1	1	2	1	2	7
Total		37	40	40	36	39	192

Based on **Table 1**, it can be seen that there are four types of publications that appear based on searches using the keyword problem-solving skills in physics education, namely articles, conference papers, reviews, and book chapters. **Table 1** also explains that publications related to problem-solving abilities are still dominated by conference papers.

Visualization of the Research Trend Area "Problem Solving Abilities in Physics Education" Using VOSviewer

In bibliometric research, topic mapping plays an important role in identifying and visualizing relationships between topics related to certain keywords. **Figure 2** shows all topic areas related to problem-solving skills in physics education. In bibliometric analysis, analysis using VOSviewer will display three different types of mapping visualization, namely network visualization (Figure 2), overlay visualization (Figure 3), and density visualization (Figure 4). The minimum number of relationships between topics displayed is limited to two events or conditions**.**

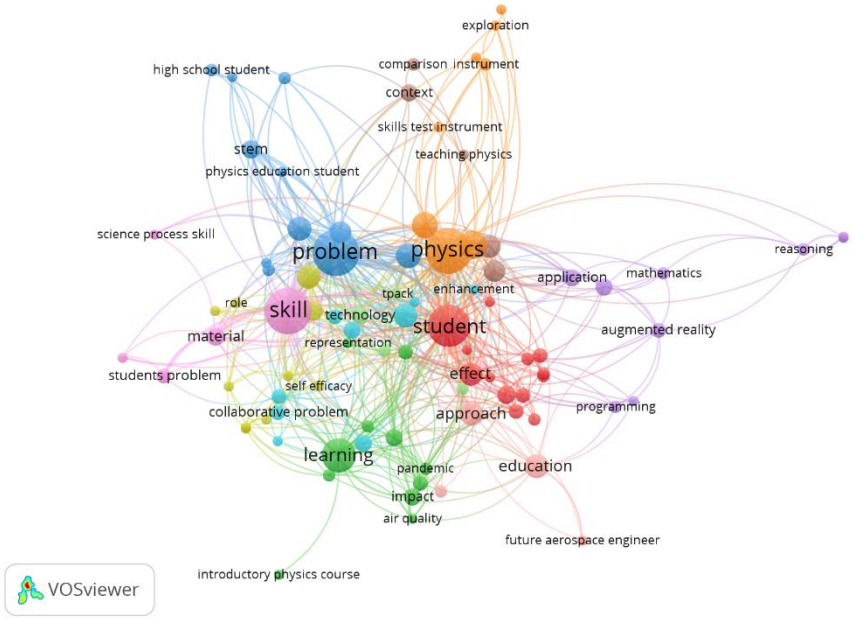


Figure 2. Network visualization of research trends related to problem-solving abilities in 2019–2023

Figure 2 displays research directions in the field of physics education related to problem-solving abilities. In the period 2019 to 2023, there are 192 international publication documents covering various countries on the topic of problem-solving abilities in physics education in Scopus data. After that, researchers visualized trends in research topics using the help of VOSviewer. **Figure 4** depicts a visualization of the entire Scopus data-based research

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regarding problem-solving abilities in physics education for that period. The analysis results show that 90 items appear and are divided into 11 different color clusters (orange, green, blue, dark yellow, purple, light blue, orange, brown, light purple, light brown, and light green) and are interconnected with 504 links. Each cluster shows a connection between one topic and other topics. The thickness of the connecting lines indicates the strength of the relationship between those topic areas or keywords. In addition, the size of the node indicates the frequency with which the keyword or topic appears. Based on **Figure 2**, it can be seen that the topics most frequently researched include physics, problems, students, skills, effects, learning, education, and approaches. Meanwhile, nodes that are located quite far compared to other groups have the potential to become a new topic in further research.

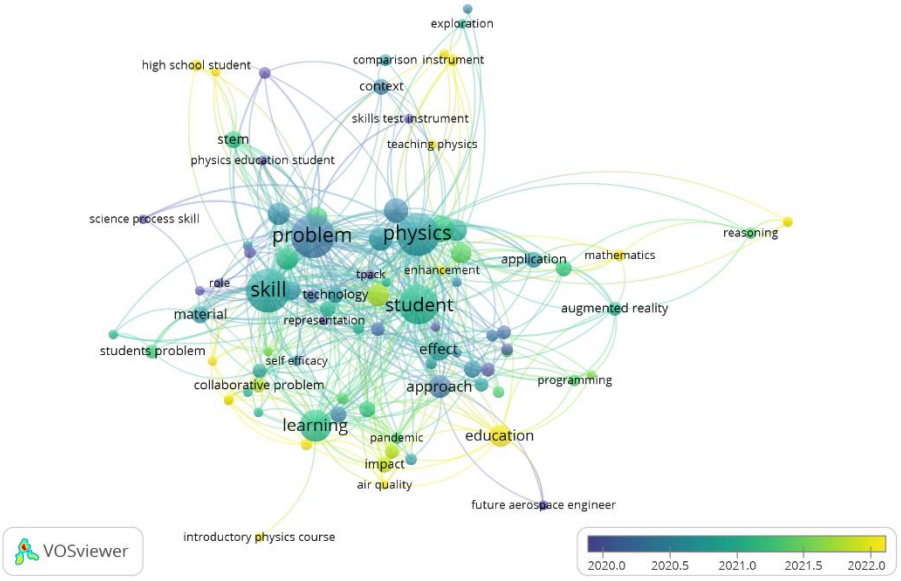


Figure 3. Overlay Visualization of research trends related to problem-solving abilities in 2019–2023

Figure 3 displays research trends from year to year related to research topic areas or keywords. The colors in the nodes indicate the research period. The darker the color of the node, the more research has been carried out, for example, research related to problems and approaches. On the other hand, the brighter the yellow color of the node indicates that research related to that topic has recently been carried out, for example, research related to instruments, high school students, and education.

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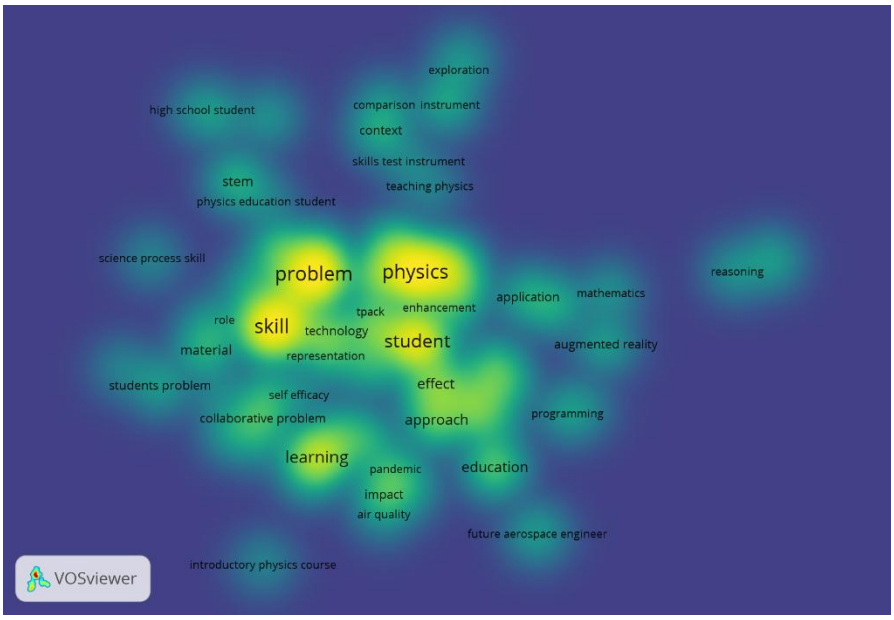


Figure 4. Density Visualization of research trends related to problem-solving abilities in 2019–2023

Figure 4 shows the depth of research related to the topic area studied. The darker the color, the more research has been conducted related to that topic area. Several topics, such as physics, problems, skills, students, and learning, have been widely discussed in previous research.

The results of this analysis indicate that research on problem-solving abilities in physics education is still limited, based on the number of articles found related to these topic areas or keywords in the 2019-2023 period. On the other hand, problem solving ability is one of the most important abilities in preparing future generations (Ismail et al, 2021; Wang, 2021). This capability is very important to achieve goals and its application in various industrial fields is very necessary (Aliu and Aigbavboa, 2021). The application of this ability also has an important impact in overcoming the challenges of living life in the 21st century (Szabo et al, 2020; Rahman, 2019). Therefore, problem solving ability is one of the key abilities to be successful in the future. So it is necessary to increase the amount of research in this field. This provides an opportunity for further research to explore related keywords, as well as create new research topics that are not connected to other keywords. In addition, Figure 4 shows that the current research trends for problem solving abilities in the context of physics education can be related to instruments, STEM, augmented reality, collaborative problems, skill test instruments, self-efficacy and materials. These results could be an interesting research subject, as research in this area is still relatively new.

CONCLUSION

Research related to problem-solving abilities in physics learning is still needed to deepen understanding and practical implementation. There is a great opportunity to conduct new research related to the relationship between problem-solving abilities and topics such as instruments, STEM, augmented reality, collaborative problems, skill test instruments, self-efficacy, and materials. Thus, further research in this area can provide deeper insights and support the development of more effective learning strategies for improving problem-solving abilities in the context of physics learning.

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