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A Systematic Review of The Trends Research Problem Solving Ability in Physics Learning (2015-2024)

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Abstract─ 21st century learning encourages students to have the ability to solve problems in the learning process. This study aims to explore and assess the trends in research focusing on problem-solving abilities in physics learning. Employing descriptive and analytical methods, the data was sourced from documents indexed by Google Scholar between 2015 and 2024, using Publish or Perish and Dimensions.ai. The research followed PRISMA guidelines, analyzing publication types, sources, and frequently cited titles concerning problem-solving abilities in physics learning. Bibliometric analysis, supported by VOS viewer software, was utilized for data examination. The findings reveal a consistent increase in research on problem-solving abilities in physics education indexed by Google Scholar from 2015 to 2024. This trend indicates that such research has gained significant popularity among both new and experienced researchers. A substantial number of articles, proceedings, book chapters, and edited books address this topic. Common keywords in these studies include the STEM approach, critical thinking, creative thinking, physics problem-solving abilities, conventional learning, authentic assessment, etc.

Keywords─ Problem Solving Ability; Physics Learning; Review; VOSviewer; PRISMA.
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1. Introduction

In the 21st Century Partnership Learning Framework, students are encouraged to cultivate a range of essential 21st-century skills for modern education. These skills include: (1) critical thinking and problem-solving, (2) communication and teamwork, (3) creativity and innovation, (4) proficiency in information and communication technology, (5) contextual learning, and (6) information and media literacy skills [1]. 21st-century skills are essential for young people to thrive in today's competitive environment. These skills include fundamental literacy and numeracy, along with the ability to think logically and solve problems efficiently and independently [2].

Problem-solving skills are crucial for students in learning physics. This is because problem-solving activities can help students construct new knowledge and facilitate the learning of physics [3]. In facing the challenges of the 21st century, educators should focus on preparing students to be investigators, problem solvers, and critical and creative thinkers [4]. Indicators of students' problem-solving abilities include understanding, selecting, differentiating, determining, applying, and identifying [5, 6]. Additional indicators involve following Polya's stages, which offer a systematic framework to reduce errors in solving physics problems. Polya's stages consist of (1) understanding the problem, (2) devising a solution plan, (3) executing the plan, and (4) reviewing the solution [7].

Physics is a fundamental branch of natural science that helps students understand the natural phenomena around them. The introduction of Natural Science aims for students to grasp scientific concepts and apply scientific methods with a scientific mindset to solve problems [8]. Physics, as a body of knowledge, includes facts, concepts, theories, principles, and models. As a process, it encompasses the skills scientists use to develop this knowledge. As an attitude, it reflects the behavior and beliefs of scientists during their work. Effective physics education should integrate the Nature of Science as a process, product, and attitude [9].

Physics education aims to enhance students' awareness of the importance of physics by encouraging them to better understand its concepts and principles. However, the goals of physics education have not been fully achieved, as evidenced by low learning outcomes [10]. Data from the Educational Assessment Center (Puspendik) of the Ministry of Education and Culture show that the average national physics exam scores in 2018 and 2019 were 43.67 and 45.88, respectively, both classified as low. The low level of problem-solving skills is attributed to the perception of physics as a collection of facts and formulas to be memorized [11].

The results of Habellia's research show that there are misconceptions about GLBB material because students tend to memorize

formulas without understanding the concepts [12]. As for research conducted by Saomi's, the results obtained were that mathematical problem solving abilities were very low, causing students to have difficulty solving problems on GLBB material [13]. Based on these findings, the learning orientation that will be designed is directed at honing students' ability to master concepts and mathematical problem solving abilities. This is because conceptual and mathematical knowledge cannot be separated from physics learning [14]. Therefore, this research wants to know the research trend of the problem-solving ability. It is hoped that this research can become a reference in developing further research related to problem solving in students' physics learning.

2. Method

This study utilizes a descriptive and analytical approach to investigate and characterize research trends in problem-solving ability within physics education. Data for this study was obtained from sources indexed by Google Scholar, using analytical tools like Publish or Perish and Dimension.ai. Keywords related to research trends in problem-solving ability in physics learning were used to perform searches on Google Scholar. The study examined 500 documents indexed by Google Scholar from 2015 to 2024. Google Scholar was selected due to its reliable standards for document inclusion and its broader range of documents compared to other leading databases, especially in educational research [15, 16]. The researchers used the PRISMA guidelines to filter the data collected through Publish or Perish.

3. Result and Discussion

This study seeks to illustrate the research trends on problem-solving abilities from 2015 to 2024. The documents analyzed for trends in problem-solving abilities in physics education were sourced from publications between 2015 and 2024. Figure 1 below shows the research trends in problem-solving abilities within physics learning.

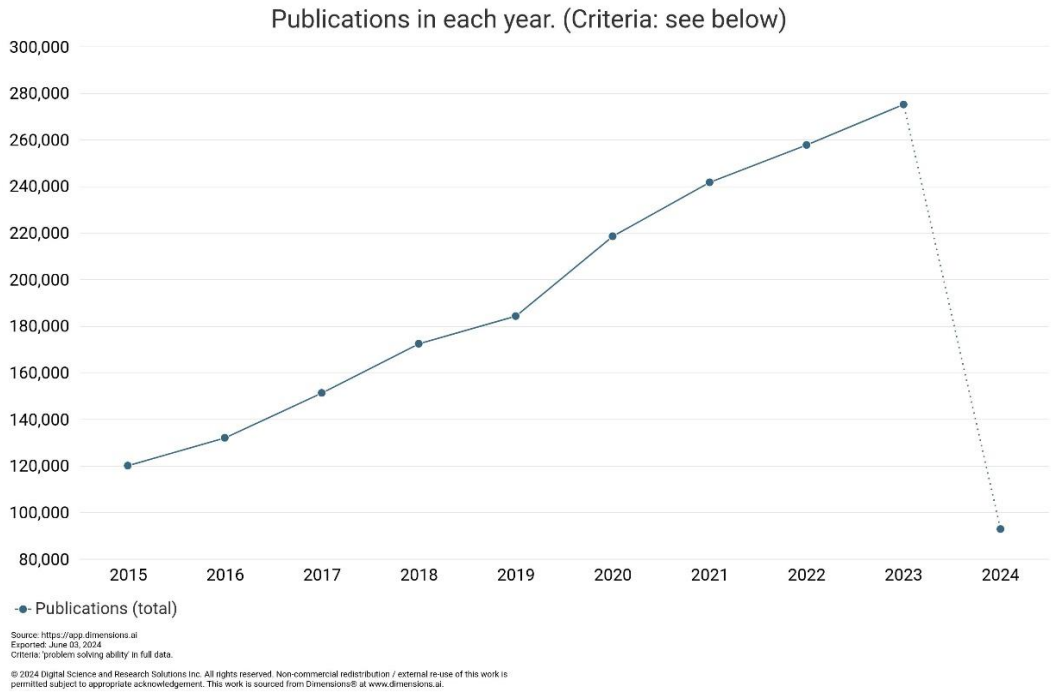

Figure 1. Research Trends in Problem Solving Ability in Physics Learning

Figure 1. shows that the trend in research on the problem solving ability in physics learning from 2015 to 2024 experiencing linear increases. Where the research trend with an increase in the number of publications from 2015 to 2024. The increasing trend in research on the problem solving ability in physics learning. Computational thinking, which involves digital era technology, is a way of thinking that refers to the ability to solve problems using concepts used in computing. These concepts include decomposition, pattern recognition, abstraction, and algorithms in solving mathematical problems. Computational thinking has become an important and essential skill for humans in the 21st century [17], but this is also due to the selection and application of appropriate learning strategies and models such as PBL, STEAM, and causalitic approaches. Results show that the scaffolding in causalitic approach that was implemented was effective in increasing problem-solving abilities [5].

Research is able to improve problem solving ability through various methods. Below are also presented research of problem-solving ability in physics learning based on the type of publication.

Table 1. Trends in Problem Solving Ability in Physics Learning Research Based on Publication Types

Publication Type	Publications
Article	1.991.279
Proceeding	282.568

Edited Book	158.874
Chapter	640.428
Monograph	143.842

Based on Table 1, it is known that problem solving ability in physics learning from 2015 to 2024 contained in 5 types of publications. Research trends problem solving ability in physics learning in article form is the type of publication that contains the most research about problem solving ability in physics learning compared to other types of publications.

Below are the top ten (10) most frequently cited sources in research on problem-solving abilities in physics education, as referenced by other researchers in this field.

Table 2. Top 10 Sources Title Trend of Problem Solving Ability in Physics Learning Research in 2015-2024

Name	Publications	Citations	Citations Mean
arXiv	125,026	24,016	0.19
SSRN Electronic Journal	51,950	236,941	4.56
Lecture Notes in Computer Science	49,339	574,367	11.64
IEEE Access	14,007	287,952	20.56
Behavioral and Brain Science	12,220	272,808	22.32
Proceeding of SPIE—The International Society For Optical Engineering	11,214	41,500	3.70
Advances In Social Science, Education and Humanities Research	11,071	6,382	0.58
Sustainability	11,052	158,541	14.35
Reseacrh Square	10,542	4,030	0.38
Journal Of Physics Conference Series	10,102	34,944	3.46

Table 2 shows that the most widely published source of research trends on the problem solving ability in physics learning is the arXiv namely 125,026 publications with 43 citations and an average citation of 0.19. Below are also presented top ten (10) article title trends in research on problem solving ability in physics learning which are often cited by other researchers related to this matter.

Table 3. Top 10 Citations on Trend of problem solving ability Research in 2015-2024

Cites/year	Year	Author	Title
7.50	2022	Susilawati, Fiki Rahmana, Kosim, Lalu Muliyadi	Practicality of Problem-Based Physics Learning Tools with Video Assistance to Improve Problem Solving Ability of Students
5.80	2019	N H D Retno, W Sunarno, A Marzuki	Influence of physics problem-solving ability through the project based learning towards vocational high school students' learning outcomes
5,40	2019	I W Suastra, N P Ristiati,, P P B Adnyana, and N Kanca	The effectiveness of Problem Based Learning - physics module with authentic assessment for enhancing senior high school students' physics problem solving ability and critical thinking ability
5.33	2021	E Susanti, R Maulidah and Y S Makiyah	Analysis of problem-solving ability of physics education students in STEM-based project based learning
5.00	2019	Awal Mulia Rejeki Tumanggor, Jumadi, Insih Wilujeng, Ernila Siringo Ringo	The Profile of Students' Physics Problem Solving Ability in Optical Instruments
3.50	2020	D A Gebze, Jumadi and S Perwati	Improving problem-solving ability in physics through android-based mobile learning application
3.00	20	Nicholus Gumisirizah, Charles M Muwonge and Joseph Nzabahimana	Effect of problem-based learning on students' problem-solving ability to learn physics
2.75	2020	Mardhiyyattin Naqiyah, Dadan Rosana, Sukardiyono, Ernasari.	Developing Instruments to Measure Physics Problem Solving Ability and Nationalism of High School Student
2.50	2022	Nova Allysa Qotrunnada	Analysis of the Difficulties of High School Students in Improving Problem Solving Ability in Physics Learning
2.20	2019	A Bahaudin, F Festiyed, D Djamas and N H Putri	Validity of physics learning module based on multirepresentation to improve the problem solving ability

Table 3 indicates that the research widely cited by other researchers focuses on "Practicality of Problem-Based Physics Learning Tools with Video Assistance to Improve Problem-Solving Ability of Students," with an average of 7.5 citations per year. This data aligns with the increasing trend of research on problem-solving abilities in physics education from 2015 to 2024. It suggests that during this period, research pertaining to problem-solving skills in physics learning consistently attracted citations from other researchers. The articles examined and authored by these researchers contain numerous terms and keywords associated with problem-solving abilities. Below, ten (10) popular keywords related to problem-solving abilities are presented.

Table 4. Keywords on Trend of Problem Solving Ability in Physics Learning Research in 2015-2024

Terms	Occurences	Relevence
Stem approach	9	1.94
Creative thinking	6	1.33
Critical thinking	7	1.24
Physics concept	9	1.15
Physics problem solving ability	13	0.76
Conventional learning	15	0.74
Student problem solving ability	21	0.58
Learning model	48	0.35
Problem solving ability	63	0.24
Authentic assessment	7	0.94

Table 4 shows that the keywords that often appear related to research on the problem solving ability in physics learning are Stem approach 9 times with a level of 1.94. This indicates that problem solving abilities in physics learning are often researched together with creative thinking abilities, for example, research conducted by Rahman's which examined Meta-Analysis: The influence of an ethnoscience-based STEM approach on students' problem-solving and creative thinking abilities [18]. Apart from that, research on problem solving abilities using a STEM approach has also been carried out by [19, 20]. Table 4 also shows that physics concept, physics problem solving, conventional learning, student problem solving are also a keyword that appears frequently in research trends on the problem solving ability in physics learning, which examined students' problem solving abilities on the topic of Archimedes' law using the STEM approach [21].

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of bibliometric mapping for the co-word network in articles related to the topic problem solving ability in physics learning are illustrated in Figure 2.

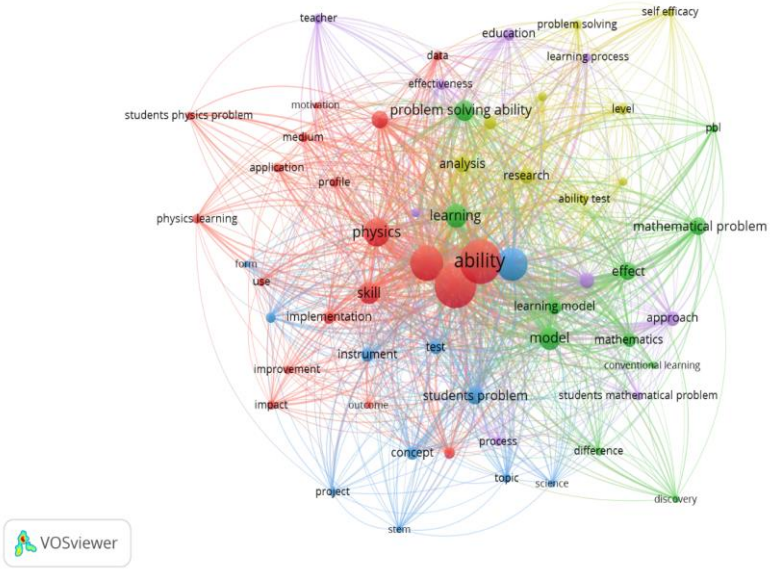

Figure 2. Network Visualization on Problem Solving Ability in Physics Learning Research

Figure 2 illustrates the outcomes of bibliometric keyword mapping concerning research trends in problem-solving abilities within physics learning. The figure delineates 5 clusters, with the first cluster depicted in red and comprising 19 keyword items such as physics learning, student physics problem, ability, and motivation. The second cluster, colored green, encompasses 11 keyword items including conventional learning, learning model, and PBL. The third cluster, shown in blue, consists of 11 keyword items such as indicator, instrument, and STEM. The fourth cluster in yellow encompasses 9 keyword items like ability test, analysis, and physics education. The fifth cluster in purple comprises 9 keyword items such as student problem-solving, effectiveness, and learning process.

Additionally, Figure 2 depicts network visualization revealing the connections between the terms being visualized. Keywords are categorized into five clusters and presented in a color chart indicating interconnected divisions/clusters. This analysis provides insights into keyword research trends in recent years, revealing commonly utilized keywords in research on problem-solving abilities in physics education. The visualization widens as more keywords appear. Furthermore, below are listed keywords related to problem-solving abilities in physics learning based on overlay visualization.

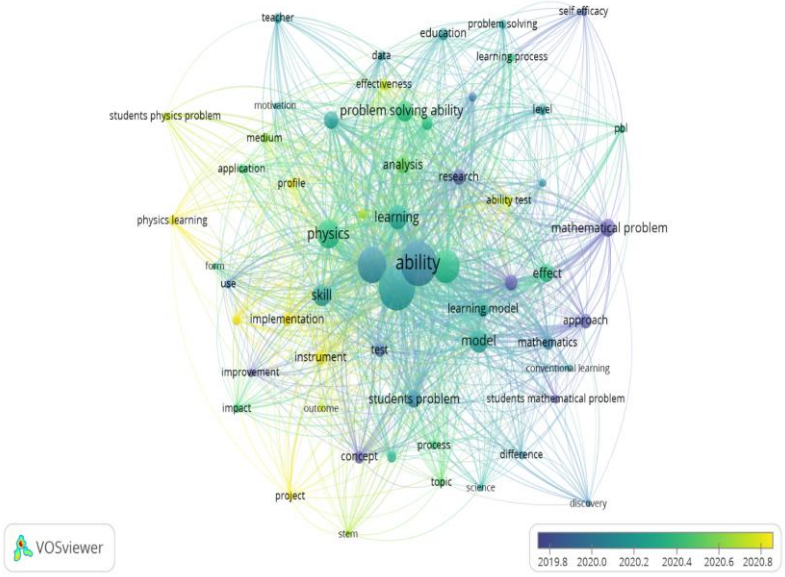

Figure 3. Overlay Visualization on Trend Problem Solving Ability in Physics Learning Research

Figure 3 shows the trend of keywords related to research on problem solving ability in physics learning in Google Scholar indexed journals from 2015 to 2024. The trends in article themes concerning problem-solving abilities in physics education, ranging from the earliest to the most recent years, are indicated by colors such as purple, blue, turquoise, dark green, light green, and yellow. In the illustration above, keywords like problem, problem-solving ability, teacher, and learning model are visible, indicating widespread usage by researchers in 2020. Similarly, in 2019, frequently appearing keywords included mathematical problem, research, and improvement.

Research on problem-solving abilities in physics education is a rapidly evolving field in recent years. Additionally, below are listed keywords for research on problem-solving abilities in physics education based on density visualization.

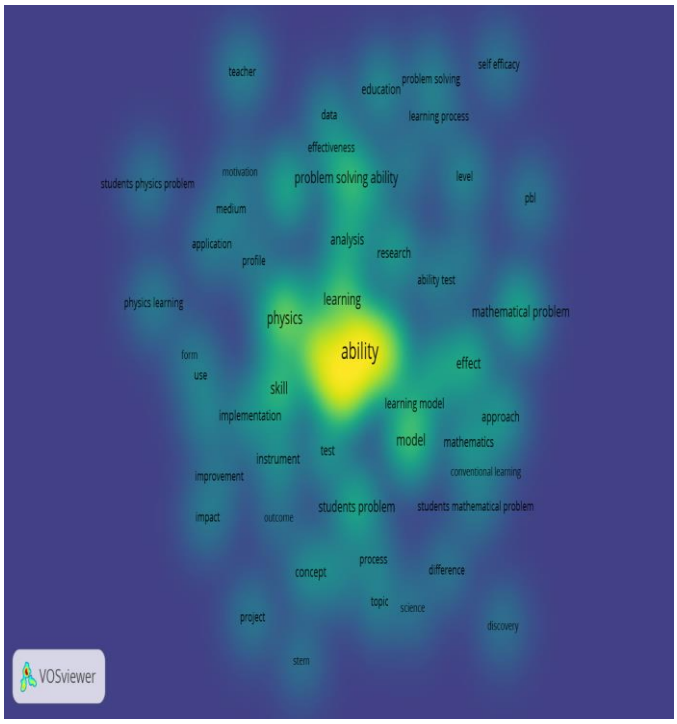

Figure 4. Density Visualization on Trend Problem Solving Ability in Physics Learning Research

Figure 4 exhibits density visualization, where the brightness of the colors indicates the density of research themes. Themes depicted in brighter yellow signify a higher volume of research, while fainter colors suggest themes that are less frequently researched [22, 23]. Dimly colored keywords like need, effort, term, and evaluation indicate areas that are less explored, potentially serving as avenues for further investigation. Yellow represents keywords currently and commonly utilized in research [24, 25].

In essence, research on problem-solving abilities in physics education holds significant importance as it contributes substantially to 21st-century education. Problem-solving skills are integral components of the skills students need in the modern era. These skills are crucial for students to process information and solve problems both within educational contexts and real-world situations.

The research trend in problem-solving abilities in physics education is anticipated to continue advancing in the coming years. This progression can be facilitated by developing new learning models, media, or tools to enhance students' problem-solving abilities, particularly in physics subjects.

4. Conclution

Studying the trends in problem-solving abilities within physics education is of utmost importance due to its potential to yield numerous benefits for 21st-century education. The research trajectory on problem-solving abilities in physics education, as indexed by Google Scholar from 2015 to 2024, has shown a fluctuating yet overall increasing pattern. There has been a notable rise in the number of publications on this topic during this period. Numerous documents in various formats, including articles, conference proceedings, book chapters, and edited volumes, delve into the research on problem-solving abilities in physics education. Commonly utilized keywords in this research include the STEM approach, critical thinking, creative thinking, and physics concepts, etc.

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