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Systematic Literature Review: Problem-Solving Skills in Physics Learning

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Abstract: This study explores problem-solving skills in physics education by systematically reviewing literature from articles published between 2015 and 2024. The review adhered to the PRISMA-P guidelines and analyzed 18 relevant studies sourced from the Scopus database. The findings reveal that the majority of research focuses on enhancing students' problem-solving abilities, particularly in terms of improving critical thinking, reasoning, and creativity in physics instruction. The integration of technology into teaching methods also emerged as a prominent trend in supporting the development of these skills. High school students were the most common research subjects, followed by college students, underscoring the importance of fostering problem-solving abilities early in education. Furthermore, the study highlights a predominance of quantitative and mixed-methods approaches, suggesting the need for more research into practical classroom applications. The study recommends further investigation into adaptive learning models and calls for more qualitative research to deepen the understanding of problem-solving skills in physics education.

Keywords: Physics learning; Problem-solving skills; Systematic literature review

Introduction

The 21st century is marked by globalization influenced by the Industrial Revolution 4.0. This period is known for technological advances, the internet, and global competition that pose new challenges in various areas of life (Eristya & Aznam, 2019; van Laar et al., 2019). Currently, the Industrial Revolution 4.0 has developed into Society 5.0. This shift has an impact on many areas, including education (Mursyidah & Muhammad, 2023). Society 5.0 is built on the Industrial Revolution 4.0, which presents significant challenges and opportunities in education (Astini, 2022). Current education is 4C skills: Creativity, Critical Thinking, Communication, and Collaboration. In this era, students are expected to have six essential literacy skills and competencies, which include critical thinking, reasoning, creativity, communication, collaboration, and problem solving (Kim, 2019; Dakhi et al., 2020). These skills are important for developing and advancing in the 21st century (da Silva et al., 2019; Priyatni & Martutik, 2020). Furthermore, the integration of digital literacy and technological proficiency is crucial to adapt to the dynamic demands of Society 5.0. By mastering these skills, students can become active contributors to solving complex global challenges.

Problem-solving is the model for an activity that relies on a regulated procedure (Gunawan et al., 2018). The automatic production procedures and production have not been studied, and the controlling process enables one to confront a novel situation. Furthermore, effective problem-solving necessitates that individuals develop knowledge to address challenges and may involve employing various strategies to eliminate unfavorable circumstances (Ince, 2018). The process of problem-solving, which can also be characterized as the

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organization of cognitive and emotional behavioral processes aimed at a particular objective, is intricately linked to creativity.

In education problem-solving skills are essential competencies that every student should develop. It is essential to enhance this aspect to effectively equip students for success in academic, professional, and personal settings (Yanto et al., 2019; Maryani et al., 2020). Utilizing problem-solving abilities in daily life enhances an individual's capacity to confront the challenges of the 21st century (Graesser et al., 2020; Suryanti et al., 2020). Numerous learning challenges exits, particularly in the study of physics, including students' inadequate problem-solving abilities, struggles with understanding abstract concept, and difficulties in recognizing quantities and establishing connections between variables (Fathiah et al., 2015). The development of problem-solving skills in physics education should be grounded in constructivist theory, which posits that students must actively construct their own knowledge (Wati et al., 2020). To address these challenges, teachers must adopt innovative teaching strategies that engage students in active learning. Effective instructional designs, such as problem-based learning or inquiry-based learning, can help students apply theoretical knowledge to practical scenarios. This approach fosters critical thinking and enables learners to develop a deeper understanding of physics concepts.

The engagement of student in the study of physics within the classroom is characterized by two key components, hand-on activities ang cognitive engagement. Student who are able to associate new information with their existing knowledge are better equipped to formulate ideas that assist in problem-solving (Stefanou et al., 2013). Nevertheless, many students continue to struggle with integrating these two aspects. This challenge arises from the fact that educators often do not provide adequate support in facilitating this integration. Consequently, students frequently find it difficult to relate scientific concepts to real-word contexts (Widowati et al., 2017). Students who struggle with problem-solving skills may be hindered by insufficient practical experience in the laboratory, difficulties in performing unit conversions, and a scarcity of physics textbooks utilized as references.

In particular, there is a need to improve the teaching of problem-solving skills (Fiore et al., 2018). Teachers should focus on creating a conducive learning environment that allows students to understand and express ideas and concepts of the scientific method. Improvements in the education system can be achieved through improving the quality of education, implementing context-specific teaching practices (Kim et al., 2019), and adapting curriculum materials, assessments, and professional development. Furthermore, integrating technology into the learning process can provide students with interactive and engaging tools to enhance their problem-solving abilities. Collaboration between educators, policymakers, and researchers is crucial to ensure that these improvements align with the evolving needs of students. Ultimately, a holistic approach to teaching problem-solving skills will prepare students to tackle complex challenges in their academic and professional lives.

Based on the description above, the researcher wants to research problem-solving skills in physics learning. The purpose of this study is to determine the research trends on problem-solving skills in physics learning from year to year, and which grade students are most often used as samples for research on problem-solving skills in physics learning. Similar research conducted by Susetyarini et al. (2020) focused on critical thinking, while this study specifically examines problem-solving skills in the context of physics learning.State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Method

This research conducts a systematic literature review to explore problem-solving skill in physics education. The literature was sourced from the Scopus database of articles. The articles analyzed in this study were published online between 2017 and 2024. Of the 153 articles collected, there were 18 articles examining problem-solving skills in physics education. This study used the PRISMA-P 4-step systematic review rule. The research process includes the following stages: identification, screening, classification, and inclusion (Moher et al., 2009).

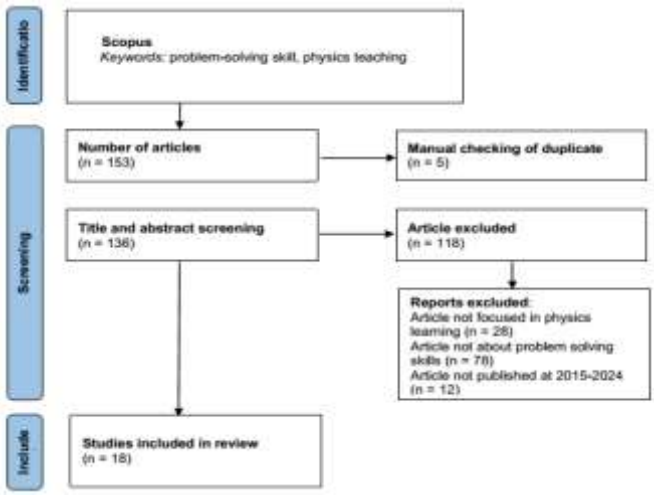

Figure 1. Prism model graph

Identification: Search for articles using several terms, namely problem-solving skills to find articles with various topics when used in the initial search database for articles. The search for these article was limited to certain years by selecting only articles that fit the criteria. The relevance of the article was determined by examining the title, abstract, and results. Any articles that did not meet the screening criteria were excluded from this study. Inclusion: The terms, phrases, or sentences "problem solving skills," were included in the title, abstract, or keywords of the chosen papers, which were restricted to articles published between January 2017 and December 2024. The papers to be reviewed were chosen using all of these steps, and the related graphs are shown in PRISMA, as shown in figure 1.

Result and Discussion

Prism-P

An initial database search identified 153 articles related to physics problem-solving ability. Articles were selected based on the year of publication between January 2016 and December 2024 so the number of articles found was 153 articles. Following the aspects and categories of article retrieval made by the author, 17 articles were obtained as shown in table 1.

Table 1. Synthesized Articles

Author	Journal
Gibson et al. (2015)	European Journal of Physics
Argaw et al. (2017)	EURASIA Journal of Mathematics Science and Technology Education
Aşiksoy (2019)	Sustainability Journal
Balta & Asikainen (2019)	Journal of Technology and Science Education.
Abdulfattah & Supahar (2019)	Journal for Education of Gifted Young.
Haviz & Maris (2020)	Journal for the Education of Gifted Young Scientists
Manurung & Panggabean (2020)	Educational Horizon
Pullicino & Bonello (2020)	Journal Information
Astuti et al. (2020)	Journal of Physics: Conference Series.
Naqiyah et al. (2020)	International Journal of Instruction
Carvalho et al. (2021)	Atmosphere Journal
Munfaridah et al. (2021)	EURASIA Journal of Mathematics, Science and Technology Education
Poveda (2022)	Investigações em Ensino de Ciências
Siddiqui (2022)	Education Sciences
Prahani et al. (2022)	Journal of Technology and Science Education.
Šarlah & Planinšič (2023)	European Journal of Physics
Ngo (2024)	Journal of Research in Innovative Teaching & Learning
Weissman et al. (2024)	EPJ Quantum Technology

Table 1 presents a list of articles synthesized in this study. The articles were selected based on their relevance to the study topics, namely physics education, mathematics, science, technology, and innovation in learning. The sources of the articles came from various reputable scientific journals with a publication range from 2015 to 2024, reflecting research developments for almost a decade. The variety of journals and article topics came from multidisciplinary journals such as the European Journal of Physics, Sustainability Journal, Journal of Technology and Science Education, to more specific journals such as the Journal for the Education of Gifted Young Scientists. This shows the breadth of the theme, ranging from physics education, technology-based learning, to education for gifted students. The more recent publication years of the articles (2020–2024) indicate recent developments, such as those discussed by Van Thien Ngo in teaching innovation or by Weissman et al. in quantum technology. These articles can provide insight into the latest trends in educational research.

The European Journal of Physics (Gibson et al., 2015; Šarlah & Planinšič, 2023) focuses on innovations in physics teaching, with new approaches to make physics concepts more understandable to students. The EURASIA Journal of Mathematics, Science and Technology Education (Argaw et al., 2017; Munfaridah et al., 2021) shows consistency in publishing STEM (Science, Technology, Engineering, Mathematics) based research, which includes innovative learning methods to improve students' skills in science and technology. Other studies provide additional insights into the field of gifted student courses and education. The Sustainability Journal (Aşiksoy, 2019) discusses the integration of continuity in learning, while the Journal for Education of Gifted Young Scientists (Abdulfattah & Supahar, 2019; Haviz & Maris, 2020) discusses educational strategies for gifted students in the modern era. Based on data obtained by researchers, the number of keywords is 1044. There are 20 relevant keywords which can be seen in figure 2.

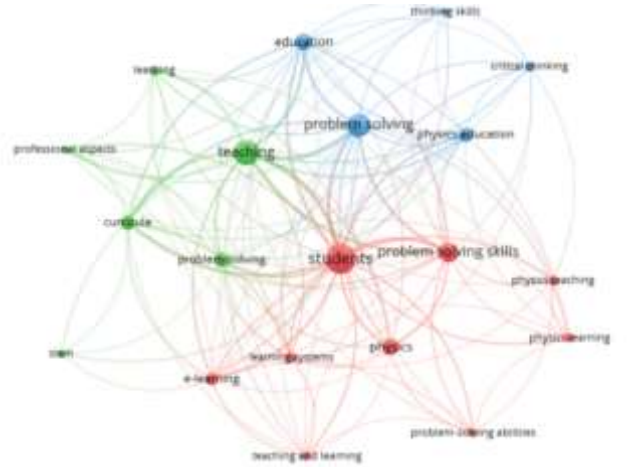

Figure 2. Network visualization results

The results of the keyword network visualization using Vosviewer show the main focus of this study on students, learning, and problem-solving skills. Words such as "students" and "problem-solving" stand out as key elements in physics education. This shows the importance of critical thinking and problem-solving skills in helping students understand physics concepts. The emphasis on the interaction between students and the learning process illustrates that this study seeks to improve higher-order thinking skills among students through innovative approaches.

The keyword network analysis reveals a strong correlation between students' learning processes and the development of problem-solving skills, underscoring the pivotal role these skills play in mastering physics concepts. This study emphasizes the need for effective teaching strategies that encourage critical thinking and enhance students' ability to approach complex problems. The visualized connections highlight the interdisciplinary nature of problem-solving in education, where physics teaching and learning methods are deeply intertwined. By focusing on the dynamics of problem-solving abilities, this research aims to propose innovative pedagogical approaches that foster deeper understanding and analytical thinking among students.

Research Subjects

Researchers need subjects to test existing hypotheses. The distribution of subjects used in the period January 2015 to December 2024 can be seen in figure 3.

Researchers need subjects to test existing hypotheses. The distribution of subjects used in the period January 2015 to December 2024 in Figure 3 shows that the most subjects are high school students, then college students, in some studies also use teachers and lecturers as research subjects.

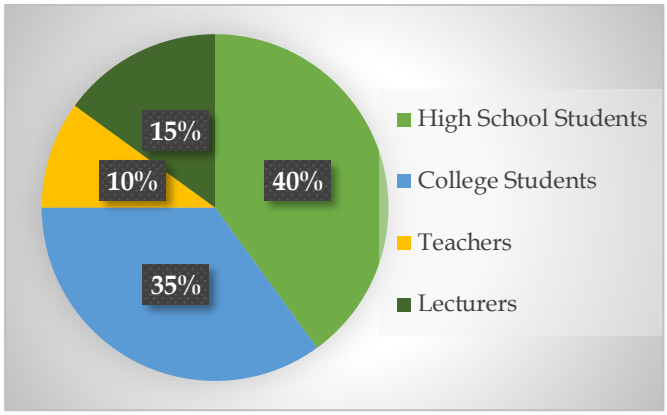

Figure 3. Trends in research subjects concerning problem-solving skills in physics teaching

Number of Publication

This study discusses problem-solving skills in physics teaching from January 2015 to December 2024. The graph of the number of publications within a certain period can be seen in figure 4.

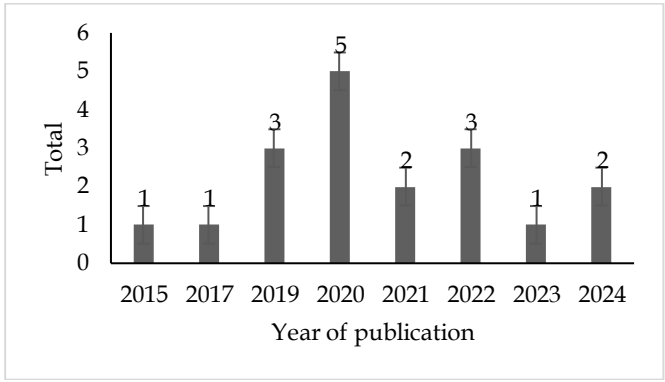

Figure 4. Trends in increasing number of research concerning problem-solving skills in physics learning

The number of article publications indicates how often research is conducted within a certain period of time. The number of publications refers to Figure 1 which will be discussed further in Figure 2. This study discusses problem-solving skills in physics learning from January 2015 to December 2024. in 2015, 2017 and 2023 there was only 1 article. then in 2021 and 2024 there were 2 articles, in 2019 and 2022 there were 3 articles, 2020 contributed the most to the discussion of problem-solving skills, namely 5 articles. Research on problem-solving skills in physics learning does not show a particular shift pattern in the decrease or increase in the number of publications from year to year. However, as seen from Figure 4, the number of publications in 2020 experienced a higher increase compared to previous years. The increase in the number of publications on problem-solving skills indicates that more and more researchers are interested in researching problem-solving skills in physics learning.

Types of Research

The type and research design describe the focus of the research. Further description can be seen in table 2.

Table 2. Trends in Problem-Solving Skills Research

Types of Studies	Total
Qualitative	1
Quantitative	12
Mix-Method	4
R&D	-
CAR	-
No Description	1

Table 2 shows that quantitative research and mixed-method research are the most widely used types of research compared to other types of research. This is because the synthesized articles discuss the influence of problem-solving skills and how process skills are important in every physics learning.

This study discusses problem-solving skills in physics learning based on 18 selected articles published between 2015 and 2024. The articles come from leading journals such as the European Journal of Physics and the Journal of Technology and Science Education. The topics discussed include physics education, learning technology, and gifted student education. The articles provide in-depth insights into innovative approaches to physics learning, including technology integration, as discussed by Weissman et al. on quantum technology. The selection of the articles reflects the diversity of topics and relevance to current developments in education. The European Journal of Physics (Gibson et al., 2015; Šarlah & Planinšič, 2023) focuses on innovations in physics teaching, with new approaches to make physics concepts more understandable to students. The EURASIA Journal of Mathematics, Science and Technology Education (Argaw et al., 2017; Munfaridah et al., 2021) shows consistency in publishing STEM (Science, Technology, Engineering, Mathematics)-based research, which includes innovative learning methods to improve students' skills in science and technology.Other studies provide additional insights into the field of gifted student courses and education. The Sustainability Journal (Aşiksoy, 2019) discusses the integration of continuity in learning, while the Journal for Education of Gifted Young Scientists (Abdulfattah & Supahar, 2019; Haviz & Maris, 2020) discusses educational strategies for gifted students in the modern era.

The results of visualization analysis using Vosviewer show that research related to problem-solving skills in physics learning centers on students as the key element. Key topics include problem-solving skills, teaching, physics education, and technology integration, such as e-learning and STEM (Modesto, 2018). The diagram is divided into three main clusters: the green cluster highlights the integration of curriculum, professional learning, and technology in teaching. The red cluster emphasizes the role of problem-solving skills in physics learning. The blue cluster focuses on general education, including the development of critical thinking skills and learning innovation. The strong relationship between teaching, students, and problem-solving skills shows the importance of innovation in learning, especially in utilizing technology to improve learning outcomes. Future research could lead to further exploration of the relationship between critical thinking and problem-solving, especially in the era of technology-based learning and 21st-century skill needs (Wibowo, 2023).

The subjects most often used in this study were grade XII high school students, although there were also studies involving students, teachers, and lecturers. The varied distribution of subjects provides a comprehensive picture of how problem-solving skills are applied at various levels of education. From the data presented, the number of publications related to problem-solving skills in physics learning does not show a significant increase or decrease pattern throughout the 2015-2024 period. However, the peak number of publications occurred in 2020 with 5 articles. This shows that this topic received more attention in that year. The relatively stable publications from year to year indicate that problem-solving skills in physics are still an important issue that continues to attract the attention of researchers.

The research mostly used a quantitative approach (12 articles), followed by mixed methods (4 articles), while research with a qualitative approach was only one article. The dominance of quantitative research shows that researchers mostly measure the influence and effectiveness of problem-solving skills statistically. Mixed methods research provides additional insights through combined analysis of quantitative and qualitative data. The absence of research and development (R&D) and classroom action research (CAR) suggests opportunities to explore practical and intervention-based approaches in future research.

Overall, research on problem-solving skills in physics learning reflects the importance of this topic as part of efforts to improve the quality of education. Focusing on recent years, research trends show increasing attention to the innovation and effectiveness of technology-based learning approaches and the development of student skills. The results of keyword analysis and distribution of research subjects underline the focus on students as the center of learning, indicating that the development of analytical skills and critical thinking skills is a top priority. Research aimed at students also reinforces the important role of physics as a discipline that requires students to connect theoretical

concepts with practical applications through problem-solving. Future research can focus on developing more adaptive learning models, which focus not only on mastery of concepts but also on students' ability to solve complex problems relevant to real life.

Conclusion

A review of research on problem-solving skills in physics education between 2015 and 2024 shows the importance of this skill in creating an effective learning environment. This research identified a primary focus on high school students and the application of technology in physics instruction. Findings suggest that while research has predominantly used quantitative and mixed approaches, more qualitative studies are needed to gain a deeper understanding of problem-solving in physics. Future research should explore the effectiveness of adaptive learning models, as well as the validity and reliability of research instruments, in improving problem-solving skills among students. Overall, these efforts are expected to improve educational outcomes and prepare students for the challenges of the 21st century. Practically, educators can apply these findings by integrating technology-driven teaching tools that facilitate adaptive learning and by adopting instructional strategies that promote critical thinking and active problem-solving. Additionally, schools and educational institutions should consider investing in professional development programs for teachers to better equip them with the skills to foster problem-solving abilities in their students.

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The author has no conflict of interest.

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