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A Systematic Literature Review: Problem-Solving Skills in Physics Teaching

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Abstract

Empowerment of problem-solving skills is one of the many goals 21st-century education intends to achieve. This research employs content analysis on several articles published in journals between January 2017 and December 2022, primarily focusing on problem-solving skills in physics teaching. This study aims to identify annual trends in research on problem-solving skills in physics teaching, identify the most frequently researched physics materials related to these skills, and identify the most frequently used grade students as research subjects for these skills. This study uses content analysis guidelines as a research instrument. In this study's content analysis, there are four main aspects reviewed. These aspects include (1) the number of publications per year, (2) the type of research, (3) the research subjects, and (4) the material selected for research. The results of this study indicate that in 2020 there will be a higher increase compared to previous years. The most widely used research subjects. The topic most often used as research material was the topic of physics in general. Quantitative research and research and development (R&D) were the most commonly used types of research. The study's findings have led to the proposal of several recommendations for future research that prioritizes problem-solving skills. Some of these recommendations include increasing the diversity of types of research and reviewing the data analysis techniques used.

Keywords: problem-solving skills, physics teaching, systematic literature review

INTRODUCTION

The 21st century is the century of globalization which is marked by the era of the Industrial Revolution 4.0 (Mardhiyah et al., 2021). This century is defined by technological advancements, the internet, and global competition, presenting new challenges across various domains of life (Van laar et al., 2019). Currently, the Industrial Revolution 4.0 is experiencing development into the era of Society 5.0. This development affects various aspects including aspects of education (Mursyidah & Muhammad, 2023). The era of Society 5.0 is a refinement of the era of Industrial Revolution 4.0 which is a big problem as well as a big opportunity in the aspect of education (Astini, 2022). Education in the 21st century is often referred to as focusing on the 4C skills: Creativity, Critical Thinking, Communication, and Collaboration (Prayogi & Rio, 2019). Students in this era are expected to possess six foundational literacies and competencies such as critical thinking, reasoning, creativity, communication, collaboration, and problem-solving skills (Kim, 2019). These competencies are essential for survival and advancement in the 21st century (Priyatni & Martutik, 2020).

Problem-solving skills is a very important skill and must be possessed by every student. This ability is fundamental in learning (Capenter & Deliema, 2024), therefore it must be improved so that it can train and prepare students to be successful in the school, work, and life environments (Sun et al., 2020). Applying problem-solving skills in everyday life makes a person better able to face the challenges of the 21st century (Stadler, 2020). Problem-solving skills are a process of actualizing students' thinking in solving a problem (Bariyyah, 2021). In every facet of life, students inevitably encounter various challenges. Proficiency in problem-solving demonstrates a solid grasp of concepts (Wu et al., 2022). Problem-solving skills in uncertain and complex situations are needed (Keane et al., 2016). Students need problem-solving skills to solve various unusual problems, identify optimal solutions, and apply their knowledge in new contexts (Barak, 2018). Students who focus more on problem-solving skills rather than the process of understanding problems have higher academic performance. This is because students repeatedly modify/improve solutions to a problem (Du et al., 2022). Students/graduates need to develop and utilize abilities in transdisciplinary problem-solving to meet assessment standards and work demands (Mehrabi & Hosseini, 2021). The challenge currently faced is that many graduates do not match the abilities/competencies needed in the world of work (Bammer, 2023). This is because problems are still found in student learning activities (Kaufman & Ireland, 2016).

Several learning problems, especially learning physics, such as students' low problem-solving skills, difficulty learning abstract concepts, and challenges in identifying quantities and linking relationships between variables (Fathiah et al., 2015). Physics is a subject that is not easily mastered by students, so many students get low physics scores (Pols et al., 2021). These problems include that physics learning is closely related to using equations, graphs, symbols, and diagrams (Munfaridah et al., 2021). Solving physics problems is still a tough challenge for students because it requires knowledge of certain abstract concepts and problem-solving skills (Pals, 2023). Physics learning can be improved by focusing on problem-solving, and discussion/feedback about values, variables, and concepts rather than carrying out simple calculations continuously (Bowers et al., 2023). Students are taught to solve relevant and meaningful problems, look for relationship patterns in data, and cause and effect relationships (Schneider et al., 2022). Therefore, it is necessary to investigate and develop effective learning techniques in physics (Pols et al., 2021). The education system needs to improve the important skills that students must have in the 21st century (Bao & Koenig, 2019). Specifically, there is a need to improve the teaching of problem-solving skills (Fiore, 2018). Teachers should focus on creating conducive learning environments that facilitate students' understanding and expression of scientific method ideas and concepts (Wöhlke & Höttecke, 2022). Improvements in the education system can be achieved through enhancing the quality of teaching, implementing contextual teaching practices (Kim et al., 2019), and aligning curriculum materials, assessments, and professional development (Tong et al., 2023).

Research on problem-solving skills in Indonesia, especially in physics teaching, examines the development of problem-solving skill assessment instruments (Permatasari et al., 2019), how to improve problem-solving skills (Annisa et al., 2020), the effect of a treatment on problem-solving abilities (Rahmatullah et al., 2022) and measure the extent of problem-solving skills (Istiyono et al., 2019).

Based on the explanation previously described, the researcher wants to examine problem-solving skills in physics teaching. The purpose of this study is to find out research trends regarding problem-solving skills in physics teaching from year to year, what physics materials are most researched on problem-solving skills, and what grade students are most often used as research samples on problem-solving skills in physics teaching. A similar study conducted by Susetyarini & Fauzi (2020) focused on critical thinking, whereas this study specifically examines problem-solving skills in the context of physics teaching.

METHODS

Research Design

This study uses a qualitative approach that adheres to the content analysis method. The focus of this research is on findings from various studies that have been published in scientific journals. The research method used is similar to that used by Susetyarini & Fauzi (2020).

Data Source

This study uses data collected from content analysis results on physics education articles. All articles are taken from research journals accredited by the Science and Technology Index (SINTA) or SCOPUS. Furthermore, all articles reviewing problem-solving skills were collected from each journal. The articles analyzed in this study were published online between 2017 and 2022. Of the 164 articles collected, there were 20 articles examining problem-solving skills in physics teaching.

This study used the PRISMA-P 4-step systematic review rule (Moher et al., 2015). The research process includes the following stages: identification, screening, classification, and inclusion.

Identification: Search for articles using several terms, namely physics problem solving, PPS, problem-solving skills, and problem-solving ability to find articles with various topics when used in the initial search database for articles. The search for these articles was limited to certain years by selecting only articles that fit the criteria. The last database search was carried out on May 7, 2023.

Screening: At this stage, articles that have been identified are then filtered to exclude articles that: (1) were published before January 2017 and after December 2022, (2) are not indexed by Sinta or Scopus, (3) are not research that discusses physics education in high school or college, and (4) are not relevant to this review. 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.

Classification: Articles are classified into aspects and categories that have been determined by researchers, such as types of research and research subjects, as shown in TABLE 1.

TABLE 1. Aspects and Categories of Content Analysis in Research

Aspects	Category	
Types of Research (1a)	A.1-R and D B.2-CAR	C.3-Qualitative Research D.4-Quantitative Research
Types of quantitative (1b)	B.1-Observation Studies (OS) B.2-Correlation Research B.3-Survey Research (SR) B.4-Pre-Experimental Design (PED)	B.5-True Experimental Design (TED) B.6-Quasi-Experimental Design (QED) B.7-Ex Post Facto Design (EPFD)
Research subject	C.1-X Grade SHS students C.2-XI Grade SHS students C.3-XII Grade SHS students	C.4-SHS in general C.5-Undergraduate students

Inclusion: Selected articles are limited from January 2017 to December 2022 and are accompanied by the words, phrases, or sentences physics problem solving, pps, problem-solving skills, and problem-solving ability either in the title, abstract, or keywords. All of these stages are used to select articles to be reviewed, and the appropriate graph is shown in PRISMA which can be seen in FIGURE 1.

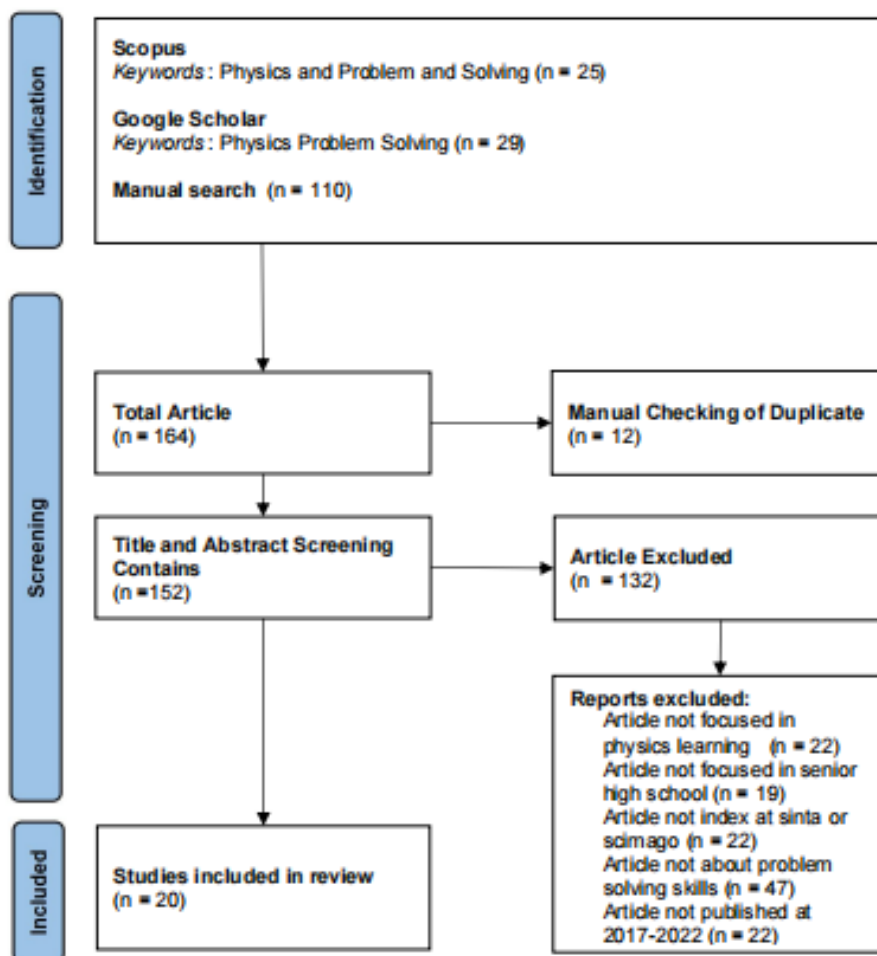


FIGURE 1. Prism Model Graph

Research Instrument

This study uses content analysis guidelines as a research instrument. Content analysis guidelines contain the aspects studied (TABLE 2). There are four main aspects reviewed in the content analysis of this study. These aspects include (1) the number of publications per year, (2) the type of research, (3) the research subjects, and (4) the material selected for research. These aspects are shown in TABLE 2, which was adapted from (Susetyarini & Fauzi, 2020).

Data Analysis

Each article is grouped into a certain category based on the aspects it fulfills. Furthermore, the data that has been collected is presented in the form of a diagram.

RESULTS AND DISCUSSION

Prism-P

An initial database search identified 164 articles related to physics problem-solving ability. Articles were selected based on the year of publication between January 2017 and December 2022 so the number of articles found was 142 articles. Following the aspects and categories of article retrieval made by the author, 20 articles were obtained as shown in TABLE 2.

TABLE 2. Synthesized Articles

No	Author	Journal
1.	Argaw et al., 2017	EURASIA Journal of Mathematics Science and Technology Education.
2.	Batlolona et al., 2018	Jurnal Pendidikan IPA Indonesia.
3.	Istiyono et al., 2018	REiD (Research and Evaluation in Education).
4.	Gunawan et al., 2018	International Journal of Pedagogy and Teacher Education.
5.	Ince, 2018	Journal of Education and Learning.
6.	Permatasari et al., 2019	International Journal of Education Research Review.
7.	Istiyono et al., 2019	Jurnal Pendidikan IPA Indonesia.
8.	Abdulfattah & Supahar, 2019	Journal for Education of Gifted Young.
9.	Balta & Asikainen, 2019	Journal of Technology and Science Education.
10.	Liana et al., 2020	Jurnal Penelitian dan Pengembangan Pendidikan Fisika.
11.	Annisa et al., 2020	Berkala Ilmiah Pendidikan Fisika.
12.	Naqiyah et al., 2020	International Journal of Instruction.
13.	Astuti et al., 2020	Journal of Physics: Conference Series.
14.	Aristiawan & Istiyono, 2020	Jurnal Pendidikan Fisika Indonesia.
15.	Haeruddin et al., 2020	International Journal of Instruction.
16.	Abtokhi et al., 2021	Journal of Technology and Science Education.
17.	Guntara & Utami, 2021	Jurnal Penelitian dan Pengembangan Pendidikan Fisika.
18.	Prahani et al., 2022	Journal of Technology and Science Education.
19.	Rahmatullah et al., 2022	Jurnal Pendidikan Fisika dan Teknologi.
20.	Viyanti et al., 2022	Indonesian Journal of Science and Mathematics Education.

Based on data obtained by researchers, the number of keywords is 104. There are 14 relevant keywords which can be seen in FIGURE 2.

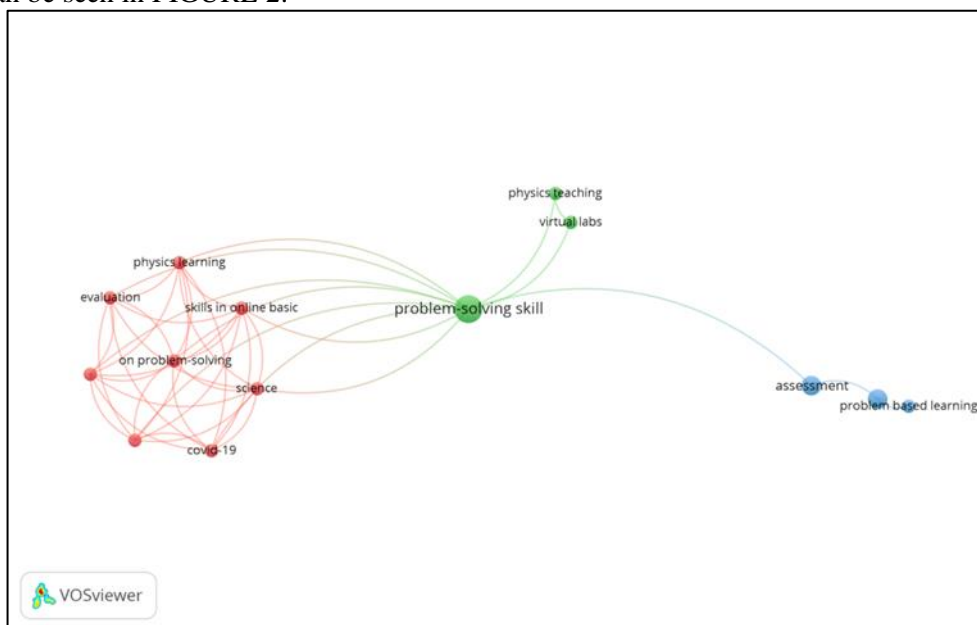


FIGURE 2. Network Visualization Results

Of the 14 keywords generated in FIGURE 2, three clusters were found in the visualization including (1) evaluation, on problem-solving, COVID-19, science, skills in online basic and physics learning; (2) problem-solving skills, virtual labs, and physics teaching; (3) assessment and problem-based learning.

Number of Publication

The number of article publications shows how often the research was carried out within a certain period. The number of these publications refers to FIGURE 1 which discusses further. This study discusses problem-solving skills in physics teaching from January 2017 to December 2022. A graph of the number of publications in a certain period can be seen in FIGURE 3.

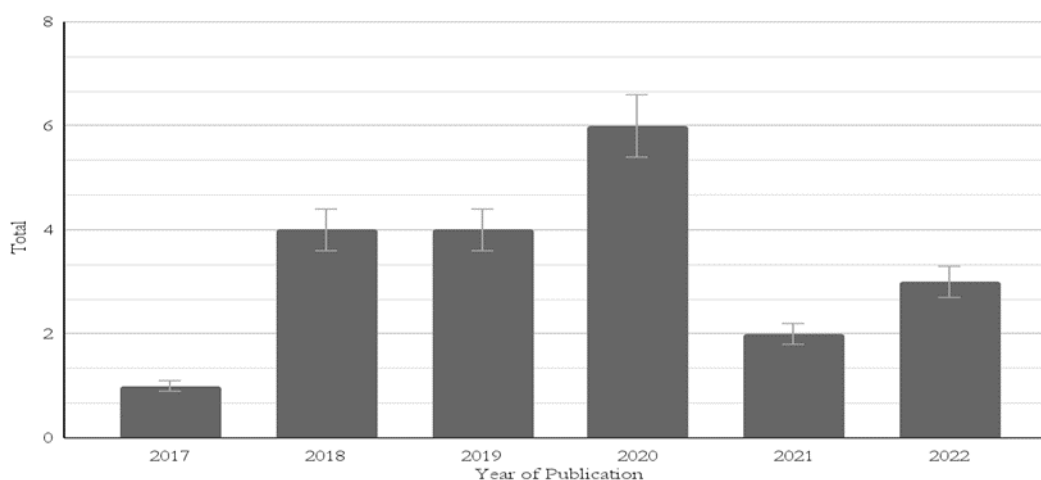


FIGURE 3. Trends in Increasing Number of Research Concerning Problem-Solving Skills in Physics Teaching in the Last 5 Years

Research on problem-solving skills in learning physics does not show a specific shift pattern in decreasing or increasing the number of publications from year to year. However, concerning FIGURE 3, the number of publications in 2020 experienced a higher increase compared to previous years. The increase in the number of publications regarding problem-solving skills shows that more and more researchers are interested in researching problem-solving skills in physics teaching.

Research Subjects

Researchers need subjects to test existing hypotheses. The distribution of subjects used in the period from January 2017 to December 2022 can be seen in FIGURE 4.

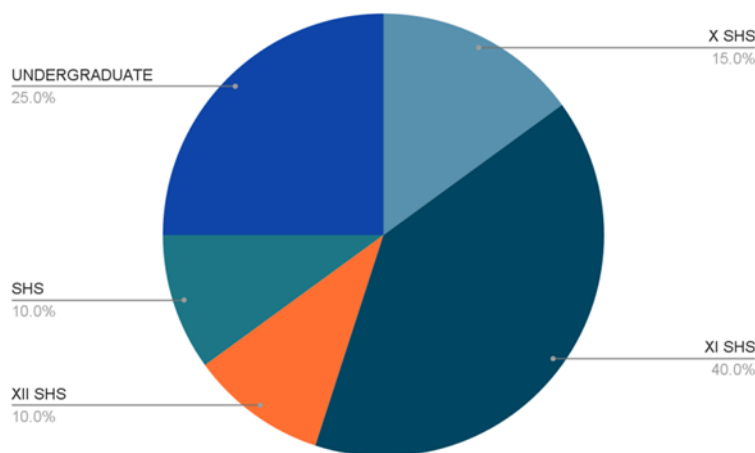


FIGURE 4. Trends in Research Subjects Concerning Problem-solving Skills in Physics Teaching in the Last 5 Years

The trend of the most used research subjects is grade XI students of high school, followed by higher education students. In FIGURE 4, it can be seen that the least frequent subject is grade XII students of high school. Susetyarini & Ahmad (2020) write that this phenomenon occurs because schools in general do not permit to use of grade XII students as research subjects due to preparation for taking the national exam.

Physics Topics for Research

Research that examines problem-solving skills in physics teaching certainly chooses topics in their research. In the various articles synthesized, the physics topics studied can be seen in FIGURE 5.

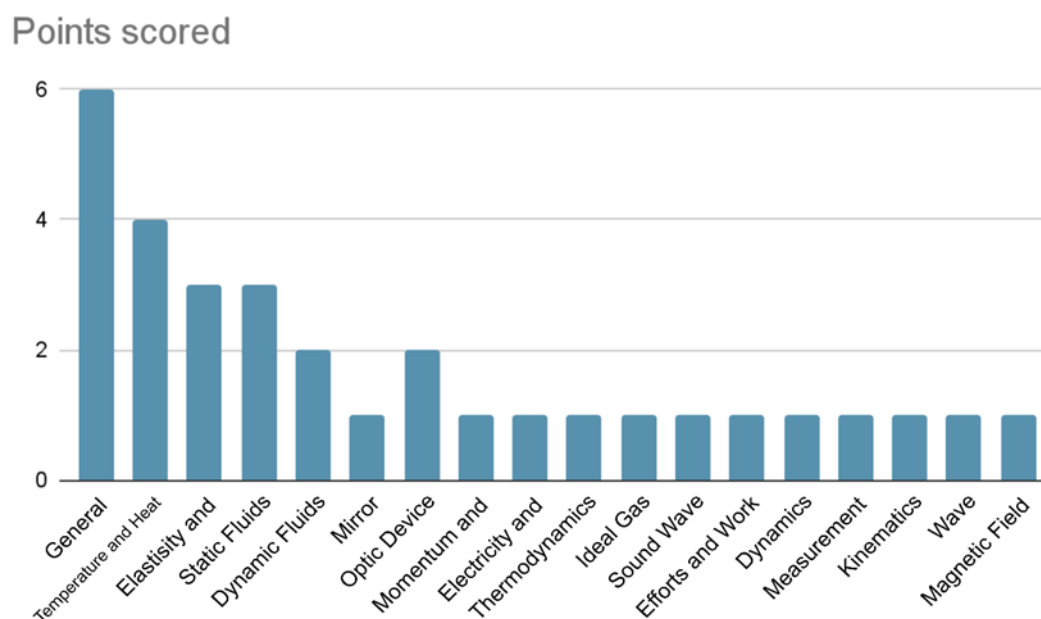


FIGURE 5. Trends in Physics Material in Research Regarding Problem-Solving Skills in the Last 5 Years

FIGURE 5 shows that the topic most often used as research material is the topic of physics in general. Followed by the topic of physics on temperature and heat. Each research examines not only one topic, but also more than one physics topic.

Types of Research

The type and research design describe the focus of the research. Further description can be seen in TABLE 4.

TABLE 4. Trends in Types of Research Concerning Problem-Solving Skills in the Last 5 Years

Types of Studies	Total
Qualitative	-
Quantitative	8
Mix-Method	1
R&D	8
CAR	-
No Description	3

TABLE 4 shows that quantitative research and R&D research are the most widely used types of research compared to other types of research. This is because the synthesized articles discuss the effect of problem-solving skills and the development of problem-solving skills assessment instruments.

CONCLUSION

The focus of this research is problem-solving skills and it was issued in a journal from 2017 to 2022. Several recommendations have been made for further research. First, the frequency of conducting qualitative research to investigate the development of problem-solving skills needs to be increased. Second, R&D which aims to develop instructional products must be targeted to improve student's problem-solving abilities which are still low. Third, researchers must be informed about their research instrument, along with the validity and reliability of the instrument. Lastly, it is suggested that the researchers choose the most suitable test for the hypothesis and research design in conducting the research.

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