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META-ANALYSIS: PROBLEM SOLVING SKILLS IN PHYSICS EDUCATION

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Abstract. The purpose of this study is to analyse articles on the application of problem solving skills in physics education from 2019 to 2023. This analysis is expected to provide information to researchers, especially in Indonesia, on the application and benefits of Problem Solving Skills in physics education. This analysis focuses on the distribution of research locations (based on educational level, research objectives, research methods, and research results/findings). The data collection method uses the Publish or Perish (PoP) application, which consists of three main steps: identification, screening and inclusion. A total of 988 articles were found. After analysing the PRISMA 2020 model, this study decided to analyse 17 articles that corresponded to the topic set, namely the use of problem solving skills in physics education. The results of the analysis and discussion concluded that problem solving skills can be developed through different learning models that correspond to the problem solving skills indicators. The model used can be combined with methods, media, approaches, learning tools, modules or teaching materials. The majority of problem solving skills research in Indonesia in 2019-2023 was conducted in secondary schools, both junior and senior high schools.

Keywords: *problem solving skill, Physics education, learning models.*

1. Introduction

With the rapid development of science and technology, there have been significant changes in various aspects of life. This development also has an impact on globalisation, which is becoming increasingly strong, hence the need for high-quality human resources. One way to produce good human resources is to improve the quality of education (Wiyono & Zakiyah, 2019). Education is an important and inseparable process in our lives. Through good education, people can acquire and master the knowledge needed for their lives. By improving the quality of education, we can create good quality education and high quality students.

Learning is a teaching and learning activity for teachers and students with the aim of facilitating the development of students' cognitive, affective and psychomotor skills (Kurnianto & Haryani, 2020). The main purpose of learning is for students to be able to overcome problems that arise in their daily lives. Education plays an important role in improving the quality of a person. Through education, the aim is for students to have intelligence not only in terms of theory but also in terms of other skills (Samad & Tolla, 2022).

One strategy for achieving learning objectives is to use an appropriate learning model. This learning model provides guidance and direction to teachers in implementing the learning process as a whole. Choosing the right learning model has a significant impact on learning outcomes or other learning objectives (Helaluddin et al., 2020). This is because there is no single learning model that is effective for all types of subjects, but rather depends on the characteristics of the learning material and the model used.

Physics education is an important area for developing problem-solving skills. Students' ability to solve problems is a very valuable skill in the context of physics learning. In an effort to

improve the understanding of physics concepts and their application in real situations, it is important to pay attention to the development of students' problem solving skills.

Problem solving skills require certain skills and expertise that each student possesses in order to solve a problem (Winkler et al., 2021). Problem solving skills are very important for students to develop because it will have an impact on motivation and a better cognitive level (Astuti et al., 2021). Someone who is not able to understand the problem will not be able to find and use the right strategy to deal with the problem at hand. Therefore, problem solving skills need to be trained in students throughout the learning process to create superior human resources and to be able to overcome various challenges.

Physics education is an integral part of the education system that aims to teach students the basic principles and concepts of the physical sciences (Hendra et al., 2023). However, understanding physical concepts is not enough. Students also need to develop higher order thinking skills, which include problem solving skills. Problem solving skills are closely related to physics education. In the context of physics learning, problem solving skills are very important because physics involves understanding complex concepts and applying principles to real situations. Students with good problem solving skills will be able to overcome various challenges and difficulties that arise in learning and understanding physics concepts.

In physics learning, students are challenged to apply theoretical concepts to real-life situations (Putri et al., 2019). They must be able to analyse problems, identify relevant information, use physics knowledge to formulate appropriate solutions, and solve problems using systematic methods. Problem solving skills enable students to gain a deep understanding of physics concepts and apply them in everyday contexts. Effective physics education should be able to develop students' problem-solving skills. Teachers need to encourage students to think critically, analyse situations and find innovative solutions in the context of physics. Through active and interactive learning approaches, students can engage in various activities that develop problem solving skills, such as experiments, simulations, group discussions and real-world problem solving (Gerace & Beatty, n.d.).

Overall, the development of problem-solving skills in physics education not only provides academic benefits, but also prepares students to face challenges outside the world of education. The ability to solve problems effectively is a valuable skill in everyday life and in various career fields. Therefore, physics education needs to pay sufficient attention to the development of students' problem solving skills in order to create a generation that is resilient and able to adapt to changing times.

This article aims to conduct a Literature Review on problem solving skills in physics education. Through the collection and synthesis of related research findings, this article will comprehensively discuss the relationship between the development of problem solving skills and various quality variables of physics learning, such as student learning outcomes, learning motivation, critical thinking skills, learning models, and others, according to the findings of the reviewed research articles. In addition, this article will also identify factors that influence the development of students' problem solving skills in physics learning. By examining meta-analyses of problem solving skills in physics education, it is hoped that this article can provide a better understanding of the importance of developing problem solving skills in the context of physics learning. The results of this Literature Review are also expected to provide guidance and recommendations for educators in designing effective learning strategies to develop students' problem-solving skills in physics education.

2. Research Methodology

This research investigates the extent of problem solving skills in physics education. A systematic review was conducted using the PRISMA (Preferred Items for Systematic Review and Meta-Analysis) approach, specifically the PRISMA 2020 model, through three main stages: identification, screening and inclusion. Articles were collected using the Publish or Perish (PoP) application with Google Scholar data sources by entering the keywords problem solving skills and physics education. A total of 988 articles from the period 2019 to 2023 were found. For the purpose of this study, 17 articles were selected to be reviewed, which corresponded to the topic defined by the author.

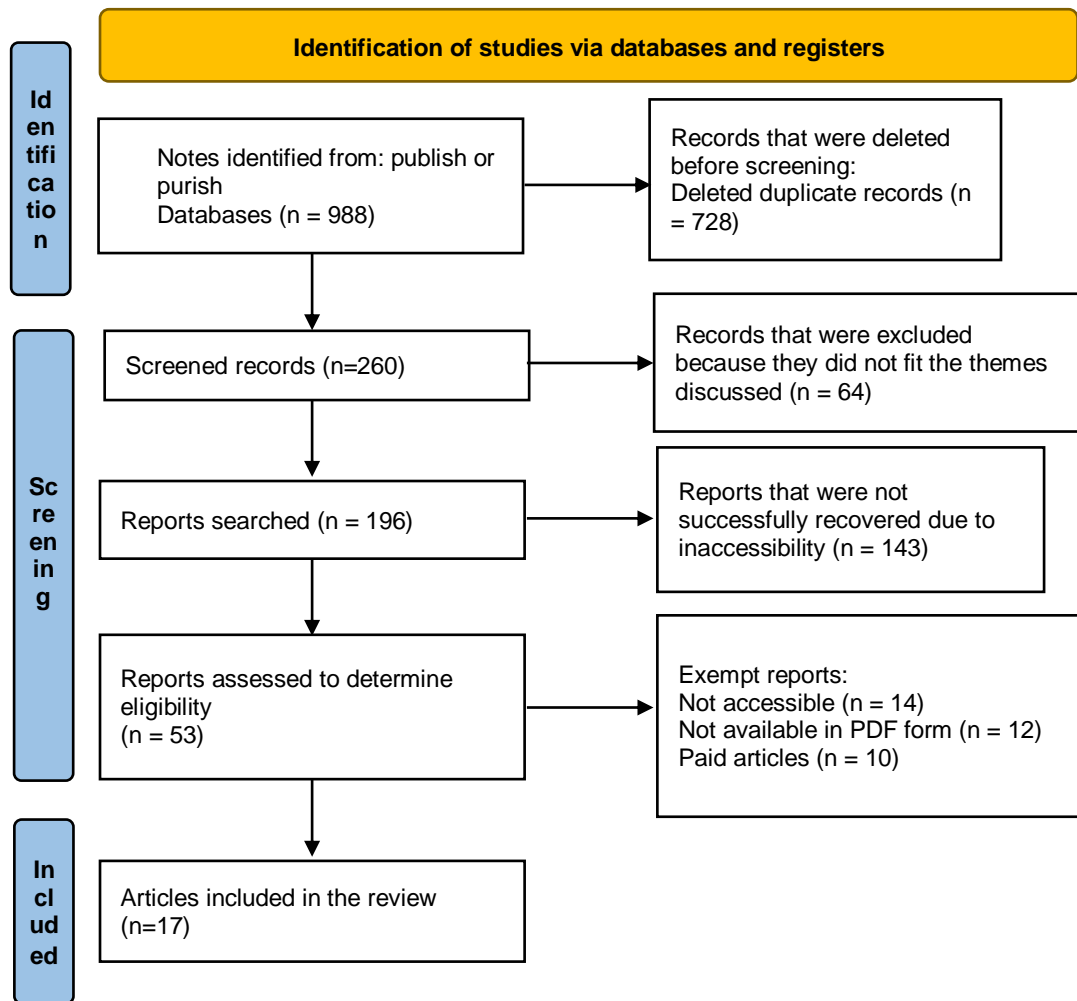


Figure 1. Literature Review diagram of the PRISMA 2020 model

3. Results and Discussion

Article searches were conducted using the Publish or Perish (PoP) application, on Google Scholar meta data, obtained 17 articles that met the analysis criteria displayed in Table 1.

Table 1. Articles included in the study

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No	Title	Authors	Year
1	The Effect of Higher Order Thinking Skills Oriented Problem Solving Model Learning on Physics Learning Outcomes and Problem Solving Ability	Safri Daryanti, Indra Sakti, Dedy Hamdan	2019
2	Development of Problem Solving Based Physics Module to Improve High Order Thinking Skill on Static Fluid Material Grade XI MAN 2 Kuningan	Sa'diah, Damar Septian, Gita Erlangga Kurniawan	2019
3	Analysis of Problem Solving Ability of Physics Concepts on the Material Impulse-Momentum in Students of SMA Muhammadiyah 1 Demak	Titik Nurhayati	2021
4	Application of Problem Based Learning (PBL) Model Assisted by Mind Mapping in Physics Learning to Improve Problem Solving Ability on the Material of Effort and Energy	A R Asuri, A Suherma, D R Darman	2021
5	Students' Physics Problem Solving Ability Through Guided Inquiry Learning Model Assisted by Post Organizer	Arini Rizqa, Ahmad Harjono, Wahyudi	2020
6	The Effect of Problem Solving Learning on the Problem Solving Skills of Junior High School Students	Muhammad Muslim, Rahmat Yunus, Arif Sholahuddin	2022
7	Application of Problem Solving Method to Critical Thinking Ability of Students in SMA Negeri 3 Makassar	Marzuki, Aisyah Azis, Salamang Salmiah Sari	2022
8	The Effect of a Problem Based Learning (PBL) Model Using STEM Approach in Improving Problem Solving Skills of Junior High School Students	Lulu Iolanessa, Ida Kaniawati, Muhamad Gina Nugraha	2020
9	Development of direct teaching tools to train problem solving skills of senior high school students	Anggun Ulil Izzati, Muhammad Arifuddin, Suyidno, Misbah	2020
10	The Effect of Cooperative Problem Solving Model on Students' Problem Solving Ability on Pressure Material	Kartika Eka Kusuma Wardani, Tomo Djudin, Syukran Mursyid	2021
11	Development of Physics Teaching Materials on the Topic of Elastasis Using the Direct Teaching Model to Train Students' Problem Solving Skills	Ramadhanti, Mastuang, Andi Ichsan Mahardika	2020
12	Whatsapp-assisted Blended Learning: Its Effect on Critical Thinking and Problem Solving Skills	Wayan Suana, Mirda Ravianny, Feriansyah Sesunan	2019
13	Inquiry-based Authentic Learning in STEM Programme on Students' Scientific Literacy Based on Students' Problem Solving Ability Levels	Idawati, Muhardjito, Lia Yuliati	2019
14	Application of Problem Based Learning (PBL) Model Using PDEODE Strategy to Train Problem Solving Skills of Learners in Senior High Schools	Irma Hidayati Haryanti, Woro Setyarsih	2020
15	The Effect of Systematic Problem Solving Learning Model on Learning Outcomes of Basic Physics 2 Direct Current Electricity Material in Physics Education Students	Tri Isti Hartini, Martin	2020
16	The Effect of POE (Predict-Observe-Explain) Learning Model on High School Physics Problem Solving Ability in View of Students' Scientific Attitude	Syarful Annam, Susilawati, Syahril Ayub	2020

The focus of this analysis in this study is the distribution of research locations (by education level), research methods, and research findings.

3.1 Location of Research

An overview of the distribution of research locations is very important in order to provide information to future researchers in considering the determination of locations and research subjects. The distribution of research locations based on the findings in this study is shown in Figure 2 below..

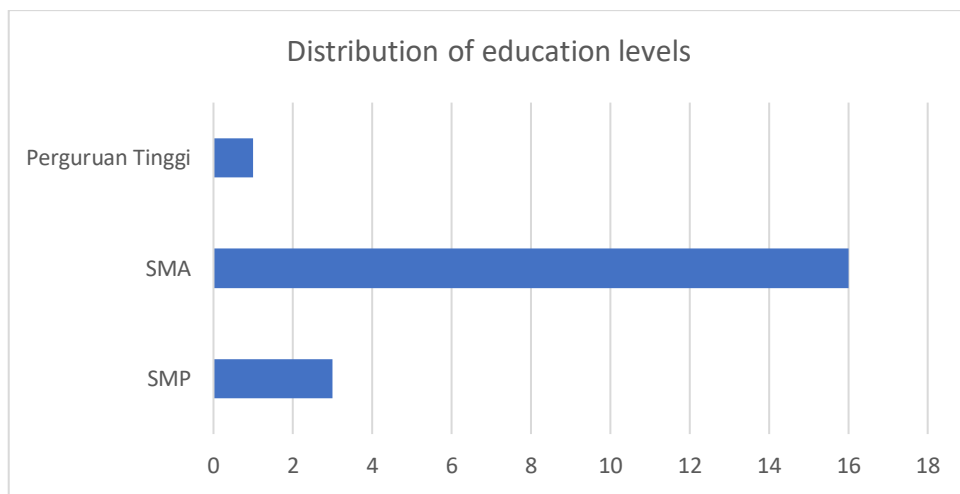


Figure 2: Distribution of Research Sites by Level of Education (Year 2019-2023)

Figure 2, shows that the distribution of research locations on problem solving skills in physics education, the majority is found at the secondary school level, both Junior High School and Senior High School, only one study was conducted in universities. Thus, there is a great potential for research on similar topics to be carried out in universities.

3.2 Research Objectives

Research objectives are important to discuss because research objectives are a guide for researchers to determine strategies in research including methods that ultimately determine the quality of research results. In general, the research formulation found corresponds to the research results found.

3.3 Research method

The choice of research method is very important because it determines the quality of the research results. Variations in research methods need to be highlighted in this study to inform future researchers in considering research methods in similar studies. An overview of the variations in method selection found in this study is shown in Figure 3 below.

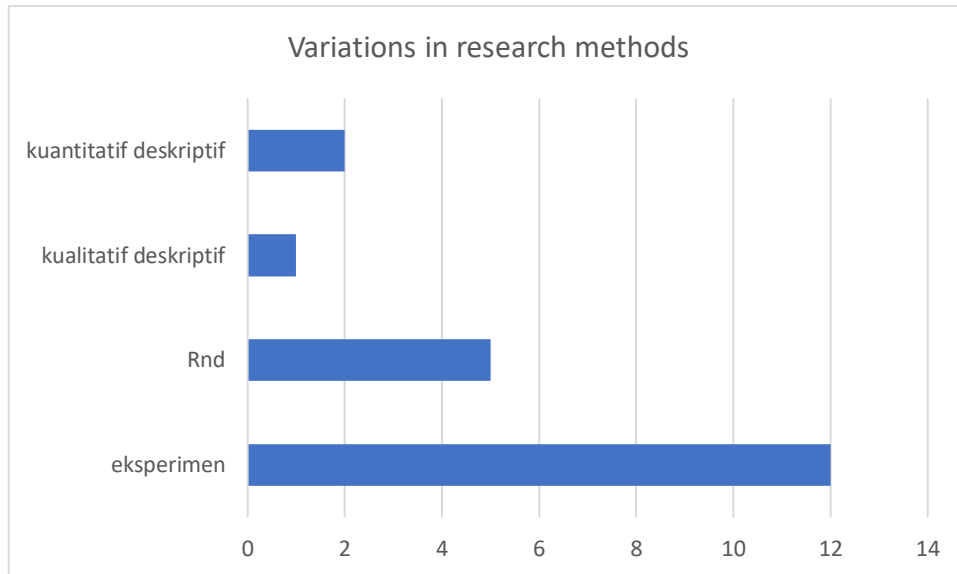


Figure 3: Variations in the Use of Research Methods

The results of this research study show that the selection of research methods has not been balanced, still dominated by experimental methods. In addition, it is still dominated by quantitative research methods. This information will provide opportunities for future researchers to consider the selection of methods in developing problem solving skills in physics learning.

3.4 Research Results.

From this study, several learning quality variables were found such as problem solving, problem solving model, problem-based learning model, guided inquiry model, problem solving method, problem solving skill, problem solving ability, high order thinking skill, STEM, mind mapping, post organiser, learning outcomes, learning tools.

In this study, the keyword set is problem solving skills but it was found that researchers used two words that actually have different meanings but are related, namely ability, and skills, so it needs to be explained to equalise perceptions in further research. According to the Big Indonesian Dictionary, ability has the root word "capable" meaning power (can, able) to do something; can; and ability means ability; proficiency; strength. Meanwhile, skill has the root word "skilled" meaning capable of completing tasks; capable and dexterous; and skill means the ability to complete tasks (<https://kbbi.web.id>). According to the Cambridge Dictionary, ability refers to the ability to do something. Ability can also be defined as the capacity that supports a person to perform a skill. Meanwhile, skill is the ability to do something well or skilfully. (<https://kumparan.com>). From this explanation, it is understood that what needs to be trained through the learning process is skill, not ability, although both are interrelated. Therefore, in this study the author uses the term problem solving skills.

The results of this study show that there is a positive relationship between problem solving skill variables and other learning quality variables. The explanation of the relationship between learning quality variables and problem solving skills based on the results of this study is divided into several topics, among others:

1. Application of the model alone (single) is able to improve problem solving skills (Muslim, M. et al, 2022; Wardani, K.E.K, et al, 2020)

2. Application of the method alone (single) is able to improve problem solving skills (Marzuki, et al, 2020)
3. Application of learning models with specific skills can improve problem solving skills (Daryanti, s. et al, 2019).
4. Module development with specific skills is able to improve problem solving skills (Sa'diah, et al, 2019).
5. The application of a model with certain media can improve problem solving skills (Asuri, A.R., et al, 2021; Rizqa, A., et al, 2020; Suana, W., et al, 2019)
6. The application of a model with a certain approach is able to improve problem solving skills (Lolanessa, L, et al, 2020; Haryanti, I.H. & Woro Setyarsi, 2020; Idawati, et al, 2019)
7. The development of certain learning tools can improve problem solving skills (Izzati, A.U., et al, 2020)
8. Development of teaching materials with a certain model is able to improve problem solving skills (Ramadhanti, et al, 2020).
9. The application of the POE model cannot improve problem solving skills (Annam, S., et al, 2020).
10. A single descriptive analysis without any treatment found that students' problem solving skills were in the good category (Nurhayati, T., 2021; Purwanto, R. 2029).

Of the 10 points of research findings above, points 1 to 8, have similarities where the combination of models, methods, media, approaches, teaching materials has a positive impact on the development of students' problem solving skills while point 9 has its own uniqueness, where the application of the POE model in physics learning is not able to improve students' problem solving skills. These results also illustrate that not all learning models can develop students' problem solving skills. Therefore, to develop problem solving skills, it is necessary to consider deeply and carefully.

4. Conclusion

From the results and discussion in this study, it can be concluded that problem solving skills can be developed by various learning models that correspond to the indicators of problem solving skills. The models used can be combined with methods, media, approaches, learning tools, modules or teaching materials. The majority of problem solving skill research from 2019-2023 in Indonesia was conducted in secondary schools, both junior and senior high schools. This condition makes it possible for lecturers to develop problem solving skills in universities, especially in physics teacher education study programmes. The distribution of research areas has not been balanced, so there is an opportunity for future researchers to research elsewhere in Indonesia, especially in East Nusa Tenggara Province..

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