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How to Improve Problem Solving Ability in Learning Physics: A Systematic Review

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Abstrak. Development of Problem-solving skills is needed in physics to master concepts. This goal can be achieved through the implementation of the right steps. The purpose of this research is to describe models, strategies, media, and instruments that can be used to develop problem-solving skills. Learning models that can be applied include PBL, PIL, Inquiry, IBMR, PO2E2W, Discovery Learning, PjBL, Virtual Laboratory, CPSL, and CTL learning models. Learning strategies can be in the form of peer instruction, scaffolding, Polya strategies, Heller, Keith, and Enderson strategies, knowledge planning strategies, Rosengrant strategies, and visualization of the imaginary world. Various supporting media can be in the form of computing media, the development of teaching materials, mobile applications, and games. The instruments used for assessment and questionnaires.

Keywords: problem-solving, physics learning, learning model, problem-solving strategy

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INTRODUCTION

Physics is a part of science that requires strong logical thinking skills. Writing problem solving paths according to logical thinking can improve students' knowledge and problem solving skills (Zhu et al., 2020). The teaching process not only develops students' content knowledge but also their approaches and strategies towards solving the problems that must be developed. This change is influenced by several factors. Curriculum and pedagogical factors used in teaching actively involve students in the learning process (Good et al., 2019).

Research on problem solving skills in physics learning is still a hot topic that has an increasing graph until 2021 (Masitoh et al., 2021). The discussion of problem solving skills is important because it makes it easier for students to learn physics and helps develop the skills needed to solve real-world problems (Sukariasih et al., 2020). Mitrevski (2019) in his research found a close relationship between critical thinking and problem solving as a form of higher-order thinking. Problem-based learning that contains real-world contexts can serve to increase student interest levels and can help create better attitudes and approaches to problem-solving (Good et al., 2018). This step helps students in learning conceptual knowledge (Weaver et al., 2018).

The flow of problem-solving in mathematics and physics is almost the same as the flow of thinking (Sardi et al., 2018). The difference between the two is that physics problem-solving involves evaluating the answer, while mathematics does not evaluate the answer. These differences are not caused by differences in background knowledge. The transition phase from numbers to concepts does not always run smoothly, resulting in a low understanding of conceptual physics (Kattayat et al., 2020). To find out the low and high levels of problem solving ability in solving physics problems is to look at how students organize and use knowledge, and relate how the concepts they have mastered when solving problems (Yuliati & Munfaridah, 2018). Students can solve problems if they can recognize the concept of the problem. For this reason, it is necessary to know how cognitive processes and learning strategies are used by students when solving problems (Minozzi & Marzoli, 2019).

Various strategies have been carried out to improve students' problem-solving abilities in learning physics. Ropika applies modeling learning, while Silitonga uses problem-solving strategies to achieve these goals ((Ropika et al., 2019; Silitonga et al., 2020). Leak et al., (2017) provide evidence that the problems faced by students affect the strategies they use. Observation of visual strategies provides a guiding tool for the design of effective instructional instruction and monitoring student performance levels and non-verbal fluency using each strategy is beneficial to teachers (Mozafari et al., 2020). In addition, students will receive

objective feedback about their learning progress, especially in problem-solving skills.

The contextual approach has become popular in recent years. Teachers have used it in class, but it seems that the evaluation technique is less favored (Ültay, 2017). This is a problem for students because they are taught using a contextual approach which is enriched with examples of everyday life, but is measured by classical tests. Teachers and students realize the importance of problem solving abilities, but both of them fail to reach the peak in the learning process. Students do not realize that the final answer of an assignment is not an important result. It is the learning process and skills acquired through problem solving that should be considered important (AR Malkawi & Rababah, 2018). Zuza (2016) described that students tend to solve problems superficially, without applying basic problem-solving strategies such as qualitative analysis, hypothesis formation, and analysis of results. This hinders students in reaching the right solution. Lucas & Lewis (2019) pointed out a critical need for the use of multiple teacher representations in learning practices such as pictures, diagrams, written explanations, and mathematical expressions to improve students' problem-solving abilities. The use of this strategy affects the performance of problem solving and the use of their representations. Çıldır (2019) sees that problem solving skills are still weak so to increase problem solving creativity it is suggested that problem solving skills become part of the curriculum.

The problem of problem-solving ability needs to be described. Williams (2018) argues that what is missing in teaching problem solving is the practice of identifying gaps in knowledge and framing these knowledge gaps as questions of a kind that can be answered using techniques students have already learned. The writing of this review article is composed of several research questions, namely: 1) What learning models are used to grow students' problem-solving abilities? 2) What learning media can be used?, 3) How problem-solving strategies are applied, and 4) What kind of instrument is used to measure problem-solving ability? The results are expected to help teachers and students to be able to represent and organize information from problems into appropriate and useful representations, as well as summarize the essence of the information provided symbolically, visually, and in writing (Sukariasih et al., 2020).

METHODS

Based on the research objectives, this study examines the scope of research related to problem-solving abilities in learning physics systematically. A systematic review was carried out using a procedure adapted from the Preferred Items for Systematic Review and Meta-Analysis Statement (PRISMA). This procedure consists of four main steps, namely: identification, screening, eligibility, and inclusion (Page et al., 2021). The flow chart of the research procedure in this study is shown in Figure 1.

At the identification stage, article searches are performed by typing the keywords “problem solving, physics” in the search box of Harzing's Publish or Perish software for journals indexed by Scopus. A search was conducted for publications in the period 2016 to 2021. In the screening and feasibility step, all articles are identified based on title, abstract, keywords and topic relevance. Text articles were analyzed by topic suitability for research purposes.

This type of research is obtained by analyzing and classifying each article. Articles are classified according to the purpose of the research topic. Each published article is categorized into one of the following three categories: (1) learning models used as an effort to develop problem-solving abilities, (2) problem-solving strategies, and (3) factors that affect problem-solving abilities.

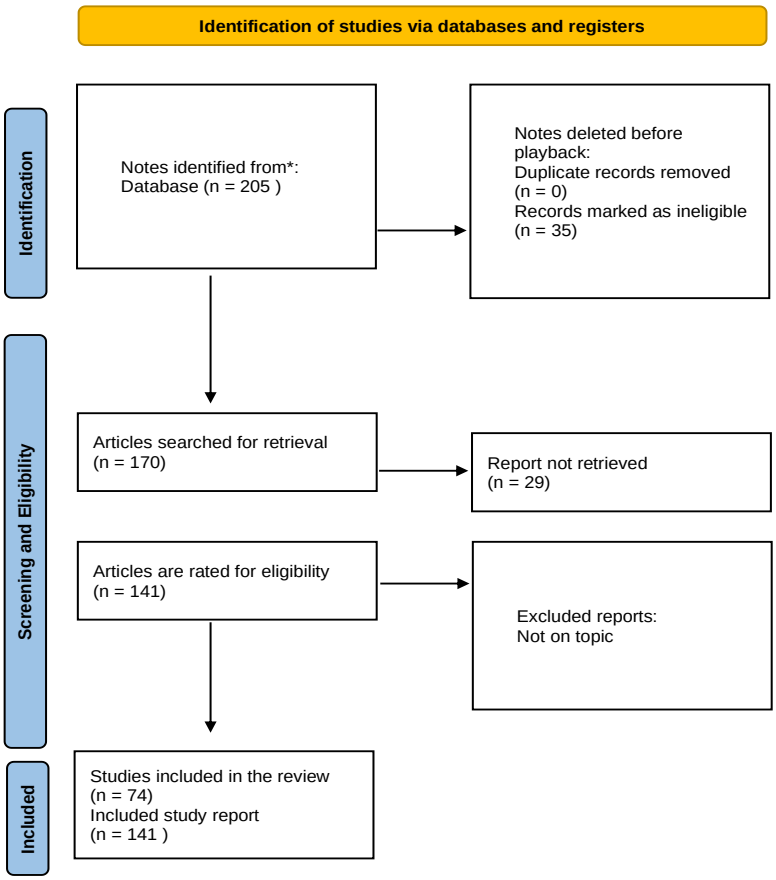

Figure 1. Flowchart of Research Procedures

RESULTS AND DISCUSSION

A total of 205 articles were collected with a time limit of publication from 2016 to 2021. Based on the results of filtering the suitability of the types and topics of articles for the purpose of this research, there were 170 articles with titles according to the desired theme. The results of the analysis of the title of this article obtained as many as 74 articles that deserve to be analyzed further. The search results and the number of articles used are shown in Table 1.

Table 1. The Results of the Identification and Screening of the Article

Year	Number of Articles		
	Initial Search	Title Filtration	Fill Filtration
2016	20	16	12
2017	28	23	20
2018	38	36	33
2019	41	36	31
2020	45	37	29
2021	33	22	16
Amount	205	170	141

The following are the findings of the analysis of the articles according to the main discussion:

Learning model

There are various models that have been carried out by researchers in an effort to grow problem solving skills in learning physics. The learning model is of course applied according to the circumstances of each student or school. The intended learning model is shown in Table 2.

Table 2. Learning Model in Efforts to Grow Problem Solving Ability

Researcher	Publication Year	Models Used
Argaw et al.	2016	PBL
Pandiangan et al.	2017	Physics Independent Learning (PIL) is an authentic problem-based model (modified PBL and CL)
Yuliati et al.	2018	Inquiry with a STEM approach
Olaniyan & Govender	2018	Collaborative learning approach Polya Problem Solving and Task-Target
Siswanto et al.	2018	IBMR (Investigation-Based Multiple Representation)
Soros et al.	2018	STEM Education plan
Sari et al.	2018	PO2E2W (Problem Orientation, Observation, Explanation, Elaboration, And Write In Science) assisted by PhET media
Yuliati & Munfaridah	2018	Discovery Learning oriented thinking map
Susanti & Fitri	2019	empirical learning cycle
Hidayayatullah et al.	2020	PBL
Retno et al.	2019	PjBL
Putri et al.	2019	CPSPL (cooperative problem solving physics laboratory)
Apriliasari et al.	2019	Web-assisted PBL
Gunawan et al.	2019	Virtual lab
Kurniawan et al.	2019	Problem solving oriented
Naqiyah et al.	2019	Direct Instruction with the help of the Plickers app
Suastra et al.	2019	Problem Based Learning (PBL) with the application of the Physics module and authentic assessment.
Wibowo et al.	2019	Virtual Physics Laboratory (VPL)
Zhu et al.	2020	MAPS (modeling applied to problem solving)
Herayanti et al.	2020	A collaborative inquiry-based blended learning model
Maynastiti et al.	2020	Flip Books based on CTL (Contextual Teaching Learning)
Lestari & Deta	2021	Hybrid learning
Fitriani et al.	2021	PjBL with a STEM approach

Strategy

Strategies for overcoming challenges to problem solving abilities are derived from the extensive literature on representations and qualitative reasoning (Liao, 2018). Learning effective problem solving strategies makes it easy to achieve the desired goals (Mason & Singh, 2016). Table 3 shows the strategies used by researchers in an effort to grow problem solving abilities.

Table 3. Strategies in Efforts to Improve Problem-Solving Ability

Researcher	Publication Year	Strategy Used
Rhee	2016	Peer instruction strategy
Mason & Singh	2016	Scaffolding
Leak et al.	2017	Problem solving strategies: solving problems, evaluating options, using test cases or estimates
Liao	2018	Scaffolding development strategy with Causalitic-Thinking Approach
Jua et al.	2018	Polya's strategy, namely recall (problem understanding), planning (strategy planning for problem solving), implementation (strategy implementation), and evaluation (rechecking)
		Heller, Keith, and Anderson strategies: visualize the program, draw a description of its physics, plan the solution, execute the plan, examine and evaluate
Abdullah	2018	The knowledge sketching strategy solves multi-concept physics problems: (1) identifying variables, (2) using formulations or

Researcher	Publication Year	Strategy Used
		formulating equations, and (3) solving equations. The stages in the sketching strategy are: (1) sketching, (2) formulating equations, and (3) solving equations
Festiyed et al.	2018	Authentic Task Implementation (Results of acting steps with integrated discussion methods, case studies, and presentations including self-assessments for individuals and groups).
Asa'd & Gunn	2018	Kahoot! Strategy: solve problems on their own and use their phones to answer problems in class.
Song	2018	Peer-Leader Collaboration Problem Solving (PLCPS) Strategy. PLCPS consists of leader selection, team composition and problem solving with leaders.
Hidayati & Ramli	2018	Application of Physics Problem Solving strategies combined with concept maps
Sartika & Humairah	2018	Troubleshooting steps taken by Polya
Rokhmat et al.	2019	Scaffolding
Koes-H et al.	2019	E-scaffolding in hybrid learning
Simbolon et al.	2019	Rosengrant problem solving stages: ability to describe problems, simplify problems, describe physical forms, and describe mathematical forms.
Shakhman & Barak	2019	Physics Problem Solving Taxonomy (PPST), which consists of five levels: retrieval, diagnosis, strategy, conceptual, and creative thinking.
Burkholder et al.	2020	Scaffolding.
Nikat et al.	2020	Scaffolding Computer Packet Instruction (SCPI). SCPI learning package consists of materials, Check your knowledge, feedback and evaluation column
Bancong & Song	2020	Visualization of the imaginary world
Prahani et al.	2021	ACCES problem solving strategies: (1) Assessing the problem, (2) Create a drawing, (3) Conceptualize the strategy, (4) Execute the solution, and (5) Scrutinize the result, in solving dynamic electricity problems
Parrot	2021	Visualize the situation/problem to replace the formula.

Media

The use of media is a way to facilitate students regarding different representations. Multiple Representation refers to using more than one way to represent ideas, concepts, and processes. This method can be in the form of images, graphics, numeric, verbal and tables (Murshed et al., 2021). The development of learning media continues to develop following the development of science and technology itself. Table 4 shows the media used in an effort to develop problem solving abilities.

Table 4. Media Growing Problem Solving Ability

Researcher	Publication Year	Media used
Ryan et al.	2016	Combination of modern computing power, web application interactivity and object-oriented programming flexibility
Ceberio	2016	Interactive computer simulation
Sabrina et al.	2018	Android-assisted mobile physics learning program
Yanto	2019	Development of teaching materials At the initial stage of the research is to conduct needs analysis, student analysis, curriculum analysis, concept analysis, and analysis of existing teaching materials. At the prototype stage, validity and practicality, a formative evaluation is carried out which includes self-evaluation, and

Researcher	Publication Year	Media used
		one-to-one evaluation. At the evaluation stage, a brief evaluation is carried out to determine the effectiveness of the product.
Darmaji et al.	2019	This problem-based physics practicum e-module uses the Kvisoft application
E. Malkawi et al.	2019	Technology and mobile applications
Hu et al.	2019	Games
Bahaudin et al.	2019	Multi-representation-based physics learning module
Wulantri et al.	2020	Use of creative inquiry-based worksheets
Wati et al.	2020	Development of teaching materials. Novelty: (1) case study; (2) let's find out; (3) problem solving plan; (4) Investigation activities
Abdillah et al.	2020	Android-based physics learning media
Gebze et al.	2020	Android-based learning media
Manurung & Panggabean	2020	Interactive multimedia
Citra et al.	2020	Multiple representation-based teaching materials
E. Malkawi et al.	2021	Interactive mobile app
Wati et al.	2021	Module

Instrument

The use of the instrument is applied to a problem solving test designed to determine problem solving ability based on the strategy used. There are various instruments that have been developed. Table 5 shows the instruments used to assess problem solving abilities.

Table 5. Problem Solving Ability Assessment Instruments

Researcher	Publication Year	Instruments Used
Doctor	2016	Assessment rubrics identify: organize problem information, select appropriate principles, apply principles to specific conditions in the problem, use Mathematical Procedures appropriately, and display evidence of organized reasoning patterns (Logical Progression).
Hill	2016	MAUVE (magnitude, answers, units, variables, and equations).
Tientongdee	2018	IPST (Institute for Promoting Science and Technology Teaching) problem-solving assessments and rubrics: 1) understand the problem, 2) decide how you will solve the problem, 3) solve the problem, and 4) look back and examine it.
Istiyono et al.	2019	PhysTeProSS tes test
Abdulfattah & Supahar	2019	test instrument with Operational Framework Test Development: Conceptual Definition, Conceptual Framework, Operational Framework.
Sirait et al.	2019	Physics Problem Solving Questionnaire (PPSQ), aims to investigate problem solvers' beliefs about the role of mathematics, representations, concepts, and problem solving strategies, as well as their interest in solving problems.
Naqiyah et al.	2019	Partial Credit Model (PCM) Instruments
Hutapea et al.	2020	Development of question instruments
Yusal et al.	2020	The construction of the scaffolding test instrument includes the following stages: description of problem solving skill indicators, operationalization of indicators, item scenario construction, test item

Researcher	Publication Year	Instruments Used
		writing, test item validation, and reliability testing.
Sukariasih et al.	2020	Assessment of problem solving: useful descriptions, physics approaches, specific applications of physics, mathematical procedures, logical developments adopted from the research of Docktor et al. (2016)
Istiyono et al.	2020	Development of CBT-based IRT to assess student problem solving (PhysTePSoS-CBT): multiple choice test with five options divided into two sets, Set A and Set B, covering topics
Hasan et al.	2021	The problem-solving strategy test instrument developed by Heller, et al.
Murshed et al.	2021	Multiple Representation (MR) refers to the use of more than one way to represent ideas, concepts, and processes such as pictures, graphics, numeric, spoken and tabular.

The application of the four components (models, strategies, media, and instruments) mentioned has a significant impact on improving students' problem-solving abilities in learning physics. Rahayu et al., (2018) showed that all participants went through all the steps of cognition regulation, even though they worked at different speeds. Students with intermediate and high-level problem-solving skills can plan quickly and effectively. High-level students need diagrams, pictures, and so on to ensure the chosen concept solves the problem. Students who have intermediate-level abilities are less confident in monitoring. Meanwhile, low-level students presented answers in different versions, correct in guessing, but wrong on physics concepts during monitoring. Students with more content knowledge are more successful at reaching a reasonable solution to each problem, experiencing fewer obstacles (Milbourne & Wiebe, 2018). These students also use a greater variety of solution paths. Sutarno et al., (2021) pointed out the importance of developing and implementing physics learning programs that are able to improve students' higher-order thinking skills, including physics problem-solving skills.

CONCLUSION

Students' problem-solving ability can be achieved through the application of the right steps. These steps are effective selections of models, strategies, media, and instruments. Learning models that can be applied include PBL, PIL, Inquiry, IBMR, PO2E2W, Discovery Learning, PjBL, Virtual Laboratory, CPSL, and CTL learning models. Learning strategies can be peer instruction, scaffolding, Polya strategies, Heller, Keith, and Enderson strategies, knowledge planning strategies, Rosengrant strategies, and visualization of the imaginary world. Various supporting media can be in the form of computing media, the development of teaching materials, mobile applications, and games. The instruments used for assessment and questionnaires. The assessment rubrics include MAUVE, IPST, PhysTeProSS, PPSQ, and PCM.

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