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A Systematic Literature Review: Implementation of Computational Thinking in Physics Learning in Indonesia

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Abstract: The implementation of computational thinking in learning can help students have 21st century skills. This research aims to review the implementation of computational thinking in physics learning in Indonesia. Systematic literature review research using content analysis methods was used to review articles published from 2019 to 2023. The analysis techniques used were planning, conducting and reporting. Of the 170 articles, there are 20 articles that match the focus of this research. The results of the research are the type of experimental research that is most widely used with test instruments. The research subjects were high school students. Physics materials that are often used in research are kinematics and energy and work. Computational thinking is widely integrated with learning media. The media often used by researchers is scratch. This research needs to be studied further with other inclusion criteria so that there are more references regarding the implementation of computational thinking, especially in physics learning.

Keywords: Computational thinking; Physics learning; Systematic literature review; 21st century learning

Introduction

Current technological advances have entered the field of education. Implementation of technology in the field of education for learning media, administrative tools, and learning resources (Lestari, 2018). Utilizing today's technology is one of the basic skills that everyone must have, because with these skills we can more easily solve problems. Therefore, it is undeniable that technological skills are a fundamental element in the development of today's and future students (Rodríguez-Martínez et al., 2020).

One of the skills that everyone needs is computational thinking skills (Wing, 2017). With computational thinking, a person is able to identify patterns, formulate problems, and design algorithms to achieve optimal solutions (Angeli et al., 2016; Harmini et al., 2020). These skills support effective and efficient problem solving skills. The ability to solve problems with a computational approach not only improves work efficiency, but also enables better innovation and rapid response to change (Irvani et al., 2024).

In the world of education, CT is an approach to solving problems that can be integrated into physics learning (Vinayakumar et al., 2018). CT integration in learning can encourage analytical problem solving and creative expression because it focuses on introducing programming to children (Kawuri et al., 2019). CT also encourages learners to engage in critical thinking on topics such as computing, logic with a focus on complex problem solving (Chevalier et al., 2020; Nopyyana, 2023). This is important to prepare students to face future challenges that are increasingly complex and require higher thinking skills.

In the context of science and physics learning, problem solving skills are the main skills that students must have (Irvani et al., 2024). Problem solving includes cognitive processes in which a person identifies,

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formulates, and resolves the problems or challenges faced (Irvani et al., 2020). Then, it involves steps such as understanding the problem, developing strategies, implementing solutions, and evaluating the results (Syahidi et al., 2020). This explanation of CT convinces us that CT is very much needed in the future and needs to be prepared for today's students.

Educational practice in schools still refers to memory, understanding, and application, less refers to thought processes (Kawuri et al., 2019). Based on research conducted on teachers in madrasah Boyolali Regency, it is known that as many as 80% are familiar with CT. However, only 16% have applied CT in learning (Budyastomo, 2022). This happens because teachers do not understand how to implement CT in their lesson curriculum. Therefore, resources are needed related to the implementation of computational thinking in learning so that teachers can add references related to how to integrate CT with their lessons.

Based on the above context, the purpose of this study is to examine the application of CT to analyze the impact of the application of computational thinking on physics learning in Indonesia. This study is important to provide information to readers, especially physics teachers in Indonesia, that CT has a positive impact on education. The application of CT in physics is expected to not only improve students' understanding of the material, but also train them to think critically and creatively. Therefore, the focus of this study is A Systematic Literature Review: Implementation of Computational Thinking in Physics Learning in Indonesia.

Method

This research is a systematic literature review research using data analysis methods, namely content analysis. This method is used to identify, review, evaluate, and interpret studies with specific relevant topics (Triandini et al., 2019). There are three stages in the SLR method, namely planning or the search process, conducting or filtering, and reporting or delivering results in written form (Ibrahim et al., 2021). The process stages in this study can be seen in Figure 1.

Planning or search process of this research is articles indexed by science and technology index (Sinta), digital reference garba (Garuda), and Scopus with searches carried out through the official websites of Sinta, Garuda, Scopus, and Google Scholar. The keywords used in this search are "Physics learning with Computational Thinking approach in Indonesian", "Computational Thinking in physics learning Indonesian", "Implementation of Computational Thinking in physics learning", and "Learning physics with Computational Thinking". There are 170 articles obtained in the search process.

Conducting is done after the planning step. Conducting or screening process is determined based on inclusion criteria, namely journal publications carried out in the 2019-2023 period, data obtained from Google Scholar, data has clear sources and is published in accredited journals, and indexed nationally and internationally. Of the 170 articles obtained, there are 20 articles that match the criteria for research focus. Therefore, further analysis was carried out on those 20 articles.

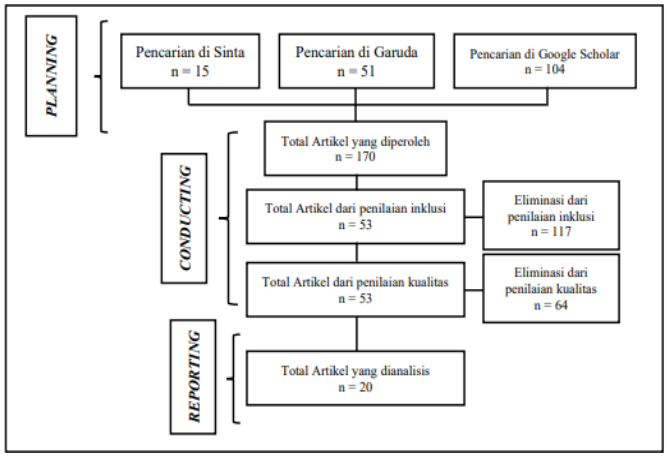

Figure 1. Research stages process

Of the 20 articles, 6 were indexed in Sinta 2, 5 were indexed in Sinta 3, 3 were indexed in Sinta 4, 2 were indexed in Sinta 5, 2 were indexed in Q2, 1 was indexed in Q3, and 1 was indexed in Q1.

A total of 20 articles obtained were then assessed by the rater based on the indicators provided by the author. The resulting values were then processed to obtain validity and reliability values. Validity testing was carried out using SBi while reliability was carried out using Cohen Kappa.

The validity value obtained is 0.83 with a good category. While the reliability value is 0.5 with a sufficient category. With the validity and reliability values obtained, the analysis can be continued according to the information needed.

The article analysis method used is the analysis content from Marín-Marín et al. (2021) which is modified according to the research objectives. Analysis of selected articles includes the year published, type of research, research subject, research instruments, physical materials, media and technology used, and efforts developed.

Reporting is the stage of delivering results in the form of writing. After the analysis of articles that fit the criteria was carried out, the results of the study were reported to provide information to readers about the implementation of computational thinking in physics

learning in Indonesia and its impact when applied to physics learning.

Result and Discussion

The implementation of computational thinking in physics learning in Indonesia is still very minimal. This is because teachers still have difficulty in implementing it. Learning physics by implementing computational thinking has been carried out by several researchers. This can be a reference for teachers in applying computational thinking to physics learning.

Based on the results of studies that have been conducted, the application of computational thinking is closely related to skills to solve existing problems in everyday life (Limbong et al., 2023). Therefore, there is a need for activities that can train critical and creative thinking skills in order to solve problems. Through creativity, students are able to solve problems and understand physics concepts (Fitria et al., 2023).

Amount of Articles

The importance of computational thinking in the 21st century causes many researchers to conduct research on computational thinking. It can be seen from the publication of articles related to the implementation of computational thinking in physics learning has increased from year to year. In this study, 7 published articles were found in 2022 and 2023 that are closely related to the implementation of computational thinking in physics learning in Indonesia. Figure 2 shows the distribution of article publications from 2019-2023.

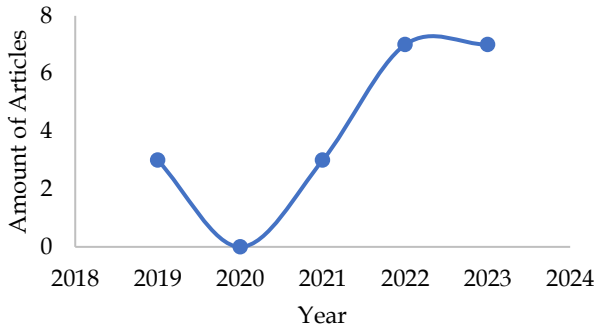

Figure 2. Article publication year 2019-2023

Based on the graph, it can be seen that there has been an increase in the number of article publications on computational thinking in physics learning from 2019-2023. The term CT became popular when the Informatics subject was officially included in the 2013 Curriculum structure through the Minister of Education and Culture Number 35, 36, and 37 of 2018 (Marifah et al., 2022). Computational thinking is considered important to be applied in learning, especially science learning in schools, especially since computational thinking skills are correlated with students' motivation to learn science (Taupik et al., 2023). Then, the Indonesian Ministry of Education and Culture considered computational thinking skills very important and integrated them into the curriculum currently being implemented, namely the Independent Curriculum (Marifah et al., 2022).

Research Types

Various studies were conducted to determine the impact of CT implementation. The types of research used in the articles analyzed can be seen in Figure 3.

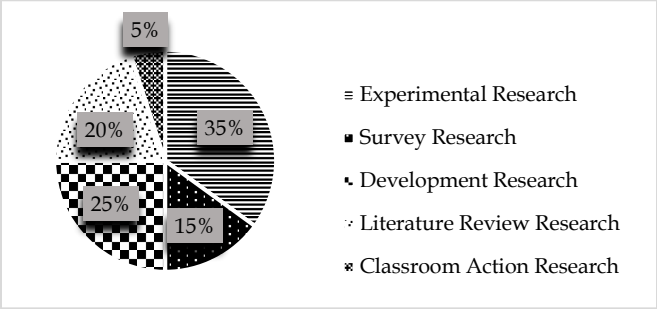

Figure 3. Analysis of research types on articles

Figure 3 shows that this type of experimental research is most widely used by researchers. This is because many researchers are testing the effectiveness and implementation of computational thinking in physics learning in Indonesia. Experimental research examines the cause-and-effect relationship between the independent variable contained in the experimental object and the dependent variable contained in the characteristics of the treated subject (Payadnya et al., 2021). In experimental research, two types of groups are usually selected, namely the experimental group (the group that is treated) and the control group (the group that is not given treatment). This is done to determine whether or not there is an influence of the treatment given on the independent variable chosen by the researcher. Based on the analysis in this study, the researchers provided treatment in the form of learning media, learning models, and learning approaches to see whether there was an influence on students' computational thinking skills. Based on the results of the experimental research conducted, it was stated that media, models and approaches can improve students' CT (Bufasi et al., 2022; Cirit et al., 2023; Latifah et al., 2022; Ridlo et al., 2022). Then, the research had an impact on improving students' critical and creative thinking skills (Kawuri et al., 2019).

Research Subject

Furthermore, researchers also analyzed research subjects used by other researchers. The research subjects used in the analyzed articles can be seen in Figure 4.

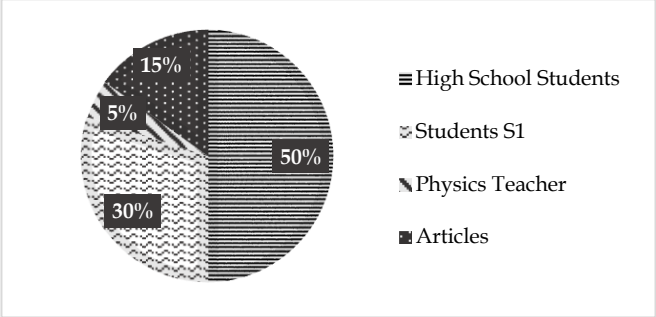

Figure 4. Analysis of research subjects in articles

Based on Figure 4, it can be seen that high school students are the most research subjects. At the elementary and junior high school levels, physic learning is still incorporated with other science families so that subjects with the category of elementary and junior high school students are not included in the criteria determined by the researcher. Researchers only analyze articles that teach physics. Articles and the like are the subject of research in the articles analyzed as much as 3% because of the 20 selected articles there are articles with the type of literature review research. While physics teachers are the subject of research articles as much as 5% because there is research with the type of survey research.

Research Instrument

In addition to the type and subject of research, the instruments used in the study were also analyzed to see what instruments were used in the studies that had been conducted. The instruments used in the research can be seen in Figure 5.

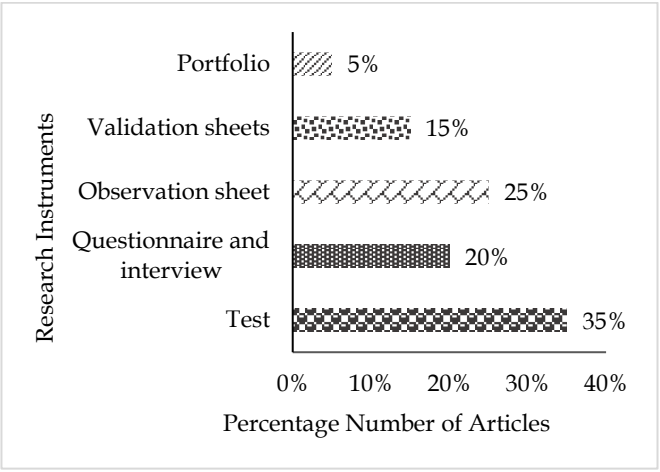

Figure 5. Analysis of research instruments in articles

Based on Figure 5, it can be seen that tests are the most widely used instruments by researchers. The types of questions used are multiple choice and essay. Test instruments are the most widely used because the answers are objective and more efficient for analyzing validity and reliability, level of difficulty, discriminating power, and distractors (Suhandi et al., 2022).

Physics Material

The focus of the research conducted by the researcher is the implementation of computational thinking in physics learning in Indonesia. There are many physics materials that can be integrated with computational thinking skills. The physics materials used in the articles studied can be seen in Figure 6.

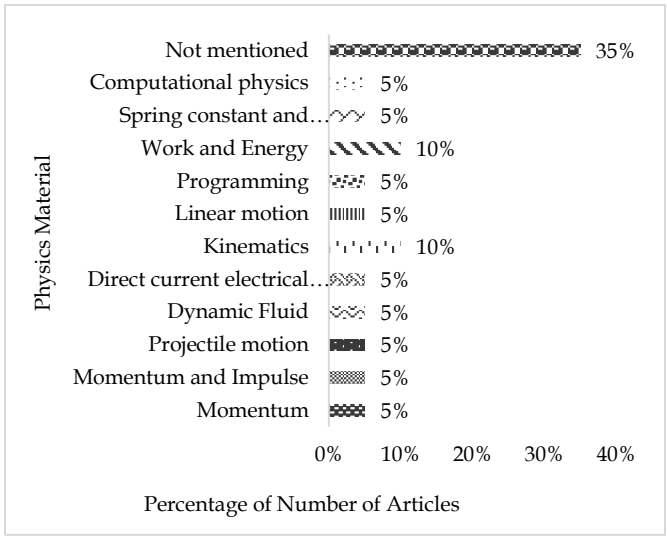

Figure 6. Analysis of physics material in the article

Based on Figure 6 it can be seen that as many as 35% did not mention physics material in the analyzed research. This is because some studies use literature review and survey research types. As many as 13 out of 20 articles that mention physics material in their research, it can be seen that the physics material most widely used in research is kinematics and work and energy at 10%.

Kinematics is one of the important materials to be studied in high school physics. This is because kinematics is the basic material for understanding subsequent physics concepts (Amin et al., 2020; Parmalo, 2016). Based on research conducted by Amin et al. (2020) stated that as many as 90 students or 25.94% were in the low category, and 257 students or 74.06% were in the very low category in studying kinematics material. The factors causing the low level were because students did not yet understand in depth how to read graphs, how to solve problems in graphical form, and did not understand the formulas used to solve the problems. Therefore, kinematics is often chosen as a physics subject studied by many researchers.

Efforts Developed in Research

Educational practices in schools still refer to memory, understanding and application, with less

reference to the thinking process (Kawuri et al., 2019). In fact, problems in everyday life are closely related to physics. Therefore, in studying physics, there needs to be a thinking process. Partnership for 21st Century Learning (P21) develops a learning framework in the 21st century that requires students to have skills, knowledge and abilities in the fields of technology, media and information, learning and innovation skills and life and career skills (P21, 2015).

The following is an analysis of the efforts developed in the articles studied, which can be seen in Figure 7.

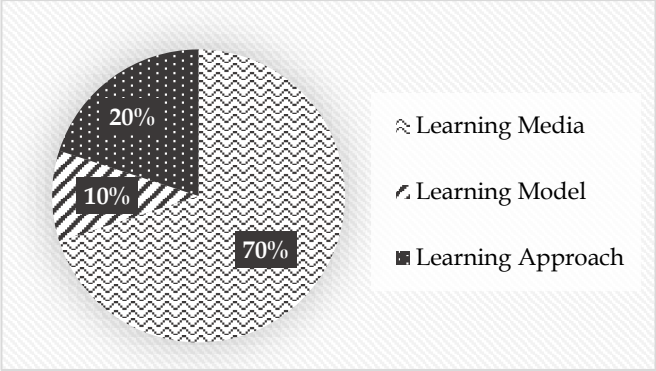

Figure 7. Analysis of efforts developed in research

Based on Figure 7, it can be seen that the development efforts of researchers in applying computational thinking are mostly in learning media. This means that researchers are more interested in integrating learning media in physics learning activities to improve computational thinking skills.

Learning media makes it easier for teachers to transfer knowledge. As stated by Arsyad (2011), media is a tool used to convey or deliver learning messages. The use of media in learning can arouse students' interest and motivation (Guslinda et al., 2018). In addition, it can improve computational thinking skills (Octalia et al., 2021). The ease of using media can cause many researchers to be more interested in using media in an effort to measure computational thinking skills.

Learning Media/Technology

Furthermore, the learning media used were analyzed to find out what media can be used to support physics learning so that computational thinking skills can be accustomed. The results of the media analysis used in the studies that have been conducted can be seen in Figure 8.

Figure 8 shows various media in the form of technology used to support the implementation of computational thinking in physics learning. Of the 20 articles analyzed, there were 14 articles that used media and technology while the rest focused on models and approaches to improve computational thinking skills. Based on the analysis in Figure 8, it can be seen that scratch media is most widely used by researchers to implement computational thinking in physics learning in Indonesia.

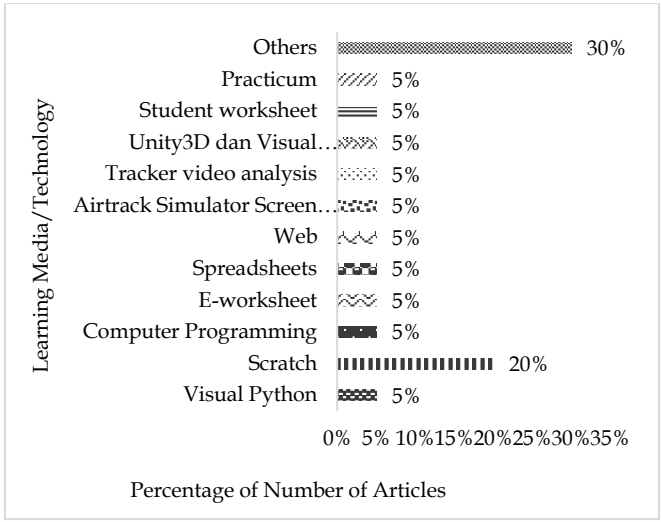

Figure 8. Analysis of media/technology used based on articles

Scratch is one of the results of the development of computer programming-based technology in the form of simulation media. Scratch has advantages including being able to be used to create interactive stories, games, art, simulators, and there are tools that can be used to compile a program by dragging and sliding (Isnaini et al., 2021). The features of the scratch application provide learning facilities for students to be active by involving high-level thinking processes.

Most physics materials are abstract. Integrating more sophisticated technology will make it easier for teachers to teach and help students understand abstract physics materials (Ley et al., 2022). Moreover, in the field, there are already many students who have smartphones and are good at operating them. This can certainly be an advantage in implementing technology in physics learning.

Computational thinking skills integrated into physics learning have an impact on students' critical and creative thinking skills. To improve computational thinking skills that have an impact on students' critical and creative thinking, effective, interesting, and appropriate learning media are needed for students' world. Learning media can help explain difficult material more simply so that students find it easy to understand the learning.

Learning Models

The use of media in the CT implementation process is related to the learning model used. Some of the learning models used can be seen in Figure 9.

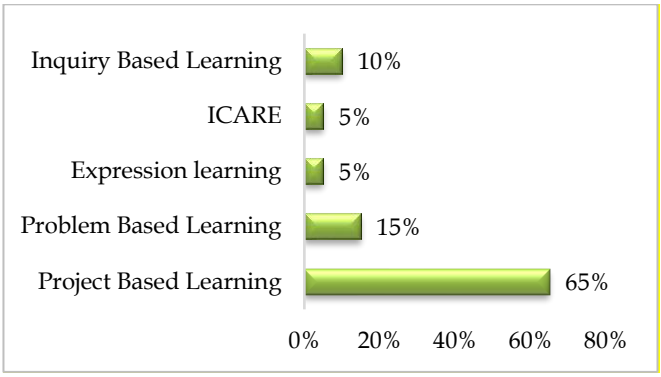

Figure 9. Analysis of learning models used based on articles

Based on Figure 9, it can be seen that PjBL is the most widely used model by researchers in research on CT by 65%. Learning with the Project Based Learning model is closely related to Computational Thinking Skills because the syntax in PjBL is related to CT indicators such as opening learning, project monitoring, and evaluation in PjBL is related to the abstraction indicator in CT, formulation of project design in PjBL is related to the decomposition indicator in CT, determining the project work schedule in PjBL is related to the algorithm in CT, and project testing in PjBL is related to the pattern generalization indicator in CT (Mukles et al., 2024). In addition, the Problem Based Learning model is a learning model that can be integrated with CT (Azkia et al., 2024; Manullang et al., 2023).

The results or impacts that emerge from the application of CT integrated with PjBL and PBL in learning are an increase in students' critical thinking skills (Ahmad et al., 2024; Aini, 2018; Fitri et al., 2024; Nurliana et al., 2023). The critical and creative thinking skills that students develop can influence students' cognitive learning outcomes (Aini, 2018; Wahyudi et al., 2018).

Conclusion

Systematic literature review analysis was obtained from articles published between 2019 and 2023. The development of research on the implementation of computational thinking in physics learning in Indonesia has increased. This is due to the awareness of researchers of the importance of computational thinking today. The implications that are often used in the results of systematic literature reviews are the type of experimental research as much as 15% with the research instrument used in the form of a test as much as 35%. Then, the research subjects were high school students as much as 50% with kinematic physics material and work and energy as much as 10%. As much as 70%, researchers chose to use learning media to implement computational thinking in physics learning. One of the media that is often used to be integrated with computational thinking based on article analysis is scratch with a percentage of 20%. While the learning models that are widely used in the application of computational thinking are Project Based Learning with a percentage of 65% and Problem Based Learning with a percentage of 15%. The impact of implementing CT integrated with PjBL and PBL in the physics learning process can affect the results of students' critical and creative thinking abilities. Therefore, teachers can apply computational thinking in learning that is integrated with projects or problems to improve students' critical and creative thinking skills, especially in the field of science.

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