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The Ability of Computational Thinking in Physics Learning

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Abstract. The introduction describes the critical role of computational thinking in the digital era and ecosystem and developments in the global economy, work, and everyday life. Computational thinking skills are critical, especially in the Industrial Revolution 4.0 era, where technology and automation play a central role. Computational thinking includes problem solving, critical thinking, and integrating digital technology with human ideas. Abstraction, decomposition, algorithms, and evaluation are some of the main aspects of computational thinking skills. The research method used is a literature study with content analysis techniques. This research concludes that Computational Thinking is an approach that can improve the quality of physics learning, concept understanding, critical thinking skills, and student learning outcomes. Obstacles can be overcome by collaborating with other learning methods and approaches.

Keywords: computational thinking; digital era; physics learning

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INTRODUCTION

The condition of society today is inseparable from computers and digital technology. This is evidenced by the demands of global economic competition based on digital advancements, where people's lives are consistently intertwined with digital devices and computer programming. This trend ultimately impacts the job sector, which is constantly shaped and influenced by computing. Computational thinking has become a vital competency to meet the needs of modern society

Computational thinking skills are essential competencies for both the present and future. With the advent of the Fourth Industrial Revolution, in which human life has become increasingly dependent on computers and automation systems, these skills are necessary to ensure that people do not merely remain technology users. Therefore, computational thinking skills must be integrated into the education system.

Computational thinking is a problem-solving and critical-thinking approach that supports the integration of digital technology with human ideas (CSTA & ISTE, 2011). Computational thinking skills are also closely related to digital competencies (Juškevičienė & Dagienė, 2018). Grover & Pea (2018) describe computational thinking as a process that involves formulating a problem to the point where a solution can be represented as computational steps and algorithms.

In line with this, Kalelioğlu et al. (2016) describe computational thinking as a complex, high-level cognitive process that supports the use of machines in problem-solving. It involves recognizing computational aspects in the world around us and applying computational tools and techniques to understand systems and processes. Computational thinking includes breaking down complex problems into familiar and manageable sub-problems, creating sequences of steps to solve issues, evaluating solutions for similar problems, and assessing whether computers can effectively aid in problem-solving (Yadav et al., 2016). This series of essential steps forms the foundation of computer science but can be applied across various disciplines.

There are four aspects of computational thinking skills, including the following:

Table 1. Aspects of Computational Thinking Skills.

References	CT Aspects
ISTE & CSTA (2011)	1. Data collection 2. Data analysis 3. Data representation 4. Problem decomposition 5. Abstraction 6. Algorithms and procedures 7. Automation 8. Simulation 9. Parallelization
Selby, C. C., & Woollard, J. (2013).	1. Ability to think abstractly 2. Ability to think decomposing 3. Ability to think algorithmically 4. Evaluation skills 5. Ability to generalize
Csizmadia et al. (2015)	1. Ability to think algorithmically 2. Ability to think decomposing 3. Ability to generalize 4. Ability to think abstractly and choose the appropriate representation 5. Ability to evaluate
Shute et al. (2017)	1. Decomposition 2. Abstraction 3. Algorithm 4. Debugging 5. Iteration 6. Generalization
Rich et al. (2019)	1. Abstraction 2. Algorithmic thinking 3. Automation 4. Decomposition 5. Debugging 6. Generalization
Psycharis & Kotzampasaki (2019)	1. Algorithm 2. Decomposition 3. Abstraction 4. Evaluation 5. Generalization
Yin et al. (2020)	1. Abstraction 2. Decomposition 3. Algorithm design 4. Pattern generalization
Juškevičienė et al. (2020)	1. Analysis and representation of data 2. Computing artifact 3. Decomposition 4. Abstraction 5. Algorithm 6. Communication and collaboration 7. Computing and society 8. Evaluation
Asbell-Clarke et al. (2021)	1. Problem decomposition 2. Pattern recognition 3. Abstraction 4. Algorithm design

Weintrop et al. (2016)	1. Data Practice, which includes collecting data, creating data, manipulating data, analyzing data, and visualizing data. 2. Modeling and simulation practices, include using computational models to understand concepts, using computational models to search for and test solutions, evaluating computational models, designing computational models, and constructing computational models. 3. Computational problem-solving practices include: preparing problems for computational solutions, programming, selecting practical computational tools, creating computational abstractions, and debugging. 4. System thinking practices include: investigating complex systems, understanding relationships within systems, thinking hierarchically, communicating information about systems, defining systems, and managing complexity.

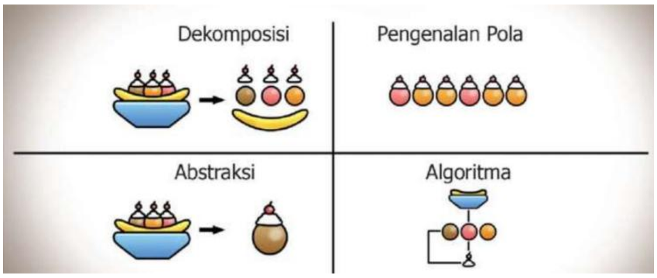

Figure 1. Aspects of Computational Thinking Skills.

Developing computational thinking skills is highly relevant to the goals of physics education in schools. One objective of physics education is to cultivate reasoning skills in both inductive and deductive analytical thinking, using physics concepts and principles to explain various natural phenomena and to solve problems both qualitatively and quantitatively. Physics, as a field of knowledge, includes concepts that challenge analytical thinking by requiring interpretation and evaluation of findings obtained during experiments or investigations.

Data and information about students' abilities are essential for developing a physics learning design aimed at enhancing students' computational thinking. Analyzing students' computational thinking abilities provides a basis for identifying the difficulties and obstacles they face in learning.

METHOD

The research method used is a literature study. The literature study method involves a series of activities related to collecting library data, reading and taking notes, and processing research materials. Data collection was obtained from books or journals regarding the role of school principals. Research data was collected through a text study and then analyzed using content analysis techniques.

The steps are as follows: First, the collected data is classified based on the studied issues. Second, the data examined qualitatively is analyzed using content analysis. Third, based on the analysis and interpretation of the data, the author will draw conclusions based on the obtained data.

RESULT AND DISCUSSION

In this study, the literature findings related to computational thinking in physics education are presented in the following table:

Table 2. Data sources for analysis

No.	References	Title	Method	Results
1	Kawuri, K. R., Rini Budiharti, R., & Fauzi,	*Penerapan* Computational	This research is a Classroom Action	The critical thinking skills of the students in

	A. (2019)	Thinking *untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas X MIA 9 SMA Negeri 1 Surakarta pada Materi Usaha dan Energi 6*	Research (CAR) conducted collaboratively between the researcher and the Physics teacher of class X MIA 9 at SMA Negeri 1 Surakarta for the 2017/2018 academic year. The teacher is involved in planning, implementation, observation, and reflection.	class X MIA 9 at SMA Negeri 1 Surakarta for the 2017/2018 academic year on the topic of Work and Energy improved using the Computational Thinking (CT) approach, which consists of five steps: thinking, Creating, Debugging, Persevering, and Collaborating. This was carried out in two cycles: in Cycle I, only seven indicators met the minimum achievement target, while five did not. In Cycle II, there was an improvement in critical thinking skills across eight indicators, surpassing the minimum achievement target for each indicator.
2.	Jannah, M. (2020)	*Kemampuan Berpikir Komputasi Siswa Sekolah Menengah Kejuruan (SMK) Jurusan Teknologi Komputer dan Jaringan (TKJ) dalam Menyelesaikan Permasalahan Gelombang*	This research uses a qualitative method with a phenomenological interpretive design. The number of students participating in the computational thinking skills test on wave material is 15 students from the IX TKJ class at SMK Negeri 2 Makassar, who have studied wave material in the VIII grade. Three out of these 15 students were selected to be research participants. The three students can write down the solutions to wave problems.	Students can demonstrate the fulfillment of all stages of computational thinking skills in solving problems in parts a, b, and c. However, they need help with problems that involve changes in context.
3.	Nuvitalia, D., Saptaningrum, E., Ristanto, S., & Putri, M.R. (2022)	*Profil Kemampuan Berpikir Komputasional* (Computational Thinking) *Siswa SMP Negeri Se-Kota Semarang Tahun 2022*	This research uses a quantitative approach with descriptive analysis methods. This research aims to determine the profile of computational thinking skills of junior high school students in Semarang City in 2022 by describing the data obtained. The population in this study is all public junior high	Based on research conducted on the profile of computational thinking in solving Bebras tasks (Bebras test) about mathematical-logical intelligence, it concludes that students with high mathematical-logical intelligence can apply five components of computational thinking skills, namely decomposition, pattern

		schools in the city of Semarang. The sample used purposive sampling, a data collection technique based on specific considerations.	recognition, algorithms, generalization, and abstraction. Meanwhile, students with medium mathematical-logical intelligence can apply three components of computational thinking skills in solving Bebras tasks: decomposition, pattern recognition, and algorithms. Lastly, students with low mathematical-logical intelligence can apply two components of computational thinking skills in solving Bebras tasks: decomposition and algorithms.

From the research results above, studies one and two have proven that students can use computational thinking skills based on their aspects of physics learning. In addition to physics learning, students can undergo tests that apply the five components of computational thinking skills.

CONCLUSION

Based on the data analysis and discussion results, Computational Thinking was implemented in Physics education as it can enhance the quality of learning, conceptual understanding, critical thinking skills, problem-solving abilities, learning outcomes, and the effectiveness of student learning, despite facing several obstacles. The challenges include the insufficient instillation of concepts, students' knowledge about technology, prior knowledge, attitudes, and experiences with learning approaches. Computational Thinking as a learning approach can be integrated with other approaches and methods such as Project Based Learning, Inquiry Based Learning, STEM or STEAM, and also Computer Assisted Instruction (CAI) like Scratch in science education.

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