Jurnal Bidang Pendidikan Dasar
Vol 9 No 1, January 2025, pp 59 - 68
Available at:
http://ejournal.unikama.ac.id/index.php/JBPD

Analysis of computational and critical thinking skills in elementary school science students

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Abstract: *Computational and critical thinking skills are important skills in the 21st century, but the reality in the field is that these abilities are still underdeveloped in elementary school students. This study aims to analyze the computational thinking skills of elementary school students. This research approach uses a qualitative and quantitative descriptive approach. The subjects of the study involved 70 fifth grade students at an elementary school in Malang City. The research instruments were in the form of observation sheets and tests, the data obtained were analyzed qualitatively and quantitatively. The results of the analysis of critical and computational thinking of elementary school students showed that computational thinking skills were still lacking, 35.4% and 54% for critical thinking. The recommendation from the research results is to make it a habit for elementary school students to continue practicing high-level thinking skills through the learning process and the use of learning devices based on high-level thinking skills.*

Keywords: *Computational Thinking Skils*, Critical Thinking Skills; Science Learning; Elementary School

Introduction

The curriculum in Indonesia has undergone several significant changes, one of which is the emergence of the independent curriculum. This curriculum offers a varied, fun, and pressure-free learning approach, with the aim of optimally developing students' talents. Within this framework, teachers are given the freedom to choose teaching materials that suit the needs of each student, as well as to develop thematic projects that can strengthen the profile of Pancasila learners, without being tied to certain learning outcomes (Kemendikbudristek, 2022).

Schools also have three options in implementing independent learning, independent change, and independent sharing, which are designed to suit each individual's readiness, although challenges in implementation must still be faced to ensure long-term benefits for students (Iskandar et al., 2023). One of the skills that is essential in realizing the Independent Curriculum is computational thinking (CT). CT has been adopted globally, including in Indonesia, and is integrated into mathematics, Indonesian, and science learning at the elementary school level. Computational thinking is the ability to solve problems systematically with an approach that is similar to how computers work, although it does not always require the use of technology (Angeli and Giannakos, 2019). This skill is important for everyone, not just programmers or computer scientists, because it can be applied to various everyday problems without having to involve programming.

Computational thinking skills include analytical and mathematical thought patterns used to solve problems, as well as design and evaluate complex systems in the real world with an emphasis on computer science concepts (Kumala, Yasa, Wibawa, et al., 2024). These skills

https://doi.org/10.21067/jbpd.v9i1.1180

form abstract, algorithmic, and logical ways of thinking, thus helping to solve complex problems while improving academic abilities (Juldial and Haryadi, 2024). Currently, computational thinking skills are also one of the pillars in the Indonesian Government's development program which emphasizes the importance of creative thinking skills. Creative thinking involves the ability to create works with new and unique ideas, and produce distinctive solutions to a problem, with indicators including fluency, flexibility, originality, and elaboration (Kumala, Yasa, Salimi, et al., 2024). Computational thinking skills are closely related to students' capacity to solve problems quickly, accurately, and systematically. This skill has a level of importance comparable to other skills, such as communication, digital literacy, critical thinking, and creativity (Weintrop et al., 2014). In today's digital era, where dependence on technology is increasing, the importance of integrating computational thinking into the curriculum is becoming increasingly relevant. This is to meet the need for a workforce that is skilled in the use of technology, able to develop innovation, and has critical thinking skills (Surmilasari, Nora. and Ayu, 2024).

One of the factors that influences computational thinking skills is the gender of students. There are cognitive differences between male and female students that affect their learning abilities, which cause differences in how they solve mathematical problems. These cognitive differences are also seen in solving mathematical problems based on problem solving. Thus, the computational thinking skills of male and female students in solving number patterns will certainly also show differences (Danindra and Masriyah, 2020). The reality in the field shows that the computational thinking skills of elementary school students are currently still relatively low.

Computational thinking theory includes processes such as decomposition (breaking a problem into smaller parts/ able to identify the known information from the given problem, able to identify the requested information from the given problem), pattern recognition (identifying similarities/ able to recognize the same/different patterns in solving the given problems.), abstraction (ignoring irrelevant details/ able to identify the general patterns of similarities/differences found in the given problem, able to draw conclusions from the patterns found in the given problems), and algorithms (designing logical steps to solve a problem/ able to mention the steps used to formulate a solution to the given problem.) (Shute et al., 2017). In an educational context, the application of computational thinking helps students develop critical, creative, and analytical thinking skills to solve complex problems. These abilities are essential in various fields of knowledge, including mathematics and science, where the ability to solve problems logically and systematically is needed (Putri et al., 2024). In the world of education, computational thinking makes it easier for students to solve problems in mathematics and science. This method supports the development of skills in designing and implementing effective and efficient solutions by utilizing technology. In addition, computational thinking allows individuals to identify errors or deficiencies in a solution and make improvements quickly (N. Christi and Rajiman, 2023).

The results of interviews with one of the schools in Malang City indicate that there is an urgent need to improve computational thinking skills. Teachers explained that although most students are able to solve problems in a structured and systematic manner, they often

still need assistance in the process. The available data revealed that only about 35% of fifth grade students are able to think computationally in science subjects, while most students still have difficulty applying computational thinking skills in the context of the lesson.

In addition to computational thinking skills, one of the most important thinking skills in today's era is critical thinking. Critical thinking is the ability that encourages students to make decisions based on problem solving through analysis, evaluating solutions, and drawing appropriate conclusions (Susanto et al., 2021). The critical thinking process involves identifying and combining existing knowledge with more relevant information, which is then processed according to the mathematical context. This process includes problem solving, formulating conclusions, calculating possibilities, and making decisions (Kusumawati et al., 2022). Thus, critical thinking is a skill that allows students to actively think logically and rationally in solving a problem, so that they can reconstruct the information into new knowledge. There are five indicators of critical thinking that need to be considered, namely delivering simple explanations, developing basic skills, drawing conclusions, making further explanations, and implementing strategies and tactics (Ilhamdi et al., 2020). At the Elementary School level, critical thinking includes several indicators, such as the ability to identify problems or questions, gather relevant information, analyze information to find relationships or patterns, draw conclusions based on evidence, and evaluate solutions or opinions with logical reasons.

Indicators of students' critical thinking skills can be seen if teachers can choose and apply the right learning strategies or models as stated (Sa'adilla et al., 2020). In addition, Susanto et al. (2021) also stated that to achieve successful learning, a quality process is needed, namely learning that is able to involve activeness and hone students' critical thinking skills. There are 5 indicators of critical thinking in this study, namely, providing simple explanations, building basic skills, conclusions, making further explanations and strategies and tactics (Ilhamdi et al., 2020). Critical thinking skills are one of the four essential skills that every individual needs to master to face challenges, problems, and careers in the 21st century. The other three skills are communication, collaboration, and creativity. Critical thinking itself is a cognitive process that encourages students to direct their thinking in more depth and detail by applying basic principles and concepts. The purpose of critical thinking is to produce logical decisions about what is believed and what actions are taken.

Critical thinking skills aim to apply high-level cognitive abilities, such as conceptualization, analysis, evaluation, and the disposition to think intellectually open, which in turn leads to logical and appropriate actions. Critical thinking skills are very important for solving problems both in individual and group contexts. Critical thinking is the process of analyzing problems, evaluating, formulating solutions, and drawing conclusions. The advantage of critical thinking lies in its ability to help individuals make smart decisions, face challenges effectively, and provide innovative solutions. Moreover, critical thinking also contributes to the development of effective communication skills, teamwork, and conflict management.

Indicators of of critical thinking skills uses several indicators, (Ilhamdi et al., 2020): 1) identifying facts (able to distinguish between fact and opinion, using valid and reliable sources

of information., mentioning data or events based on existing evidence, not influenced by personal opinions or assumptions., 2). summarizing information (processing and summarizing information from various sources, drawing conclusions based on the available data, connecting the existing information with the context or issue being discussed and ensuring that the conclusions drawn are logical and unbiased, 3) finding a connection (analyzing the interconnections between various facts or concepts, identifying patterns or cause-and-effect relationships, using logic to connect different ideas, able to see the relationship between concepts in various contexts, 4) evaluating impact (evaluating the consequences or outcomes of a decision or event, using data and analysis to assess positive and negative impacts., considering various perspectives before drawing conclusions, providing solutions or recommendations based on the evaluation conducted.

Critical thinking is an important requirement in the education system, as it is not just a skill that must be taught, but also a goal of education in Indonesia that needs to be practiced. The results of the 2022 PISA survey show that Indonesia only scored an average of 383, ranking 71st out of 81 participants. Supported by research conducted by Agnafia, it shows that students' critical thinking skills have not yet reached an optimal level. This is due to the learning process that has not fully supported the development of critical thinking skills. This suboptimality is evident from the types of exam questions presented, which still require more memorization and recall rather than in-depth analysis. Suryanti's research also concluded that the critical thinking skills of elementary school students are still very low. One of the causes is the less-than-optimal role of teachers in involving students in activities that can hone critical thinking skills. Students tend to rely on books and memorization to answer questions, so their analytical skills and understanding of the material are still inadequate. The low development of critical thinking skills among students is caused by several factors, such as poor reading comprehension, passive student behavior, low motivation, and a lack of training in analyzing or solving problems objectively.

In a preliminary study, researchers conducted interviews with elementary school teachers in a city in Malang to understand the process of critical thinking learning among students. The results of the interview with one of the teachers showed that the implementation of critical thinking learning is still relatively low. The informant revealed that students have quite limited abilities in focusing on problems and seeking alternative solutions. Although most students exhibit a kinesthetic learning style and enjoy exploring the learning process through practice, the teacher stated that not all students are active in concrete critical thinking skills. Based on the initial observations that have been conducted, the purpose of this research is to analyze the computational thinking and critical thinking abilities of elementary school students.

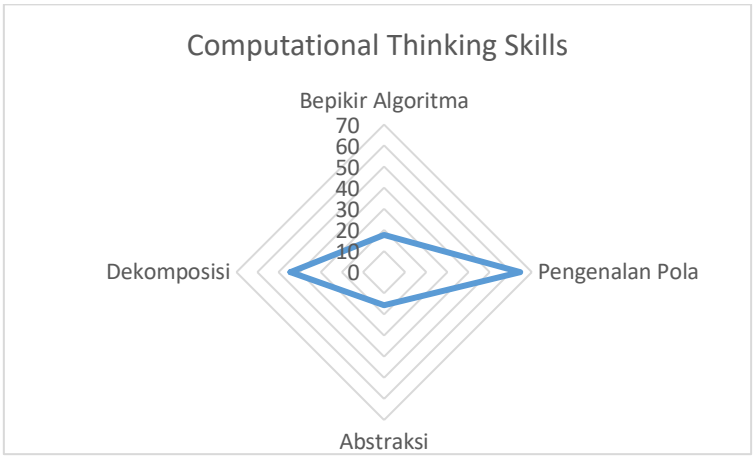
Method

This study uses qualitative and quantitative approaches that aim to analyze students' computational thinking and critical thinking abilities. This study involved 70 fifth grade students at SDN Ciptomulyo and SDN Mergosono Malang as subjects. The instrument used in this study used a test instrument in accordance with the grid of indicators of students'

computational thinking and critical thinking abilities. Data collection techniques used tests. Data analysis techniques used quantitative descriptive analysis through percentage calculations and qualitative analysis using miles and huberman.

Result and Discussion

Based on the results of measuring the critical and computational thinking abilities of elementary school students in the Malang city sample, as shown in Graph 1.



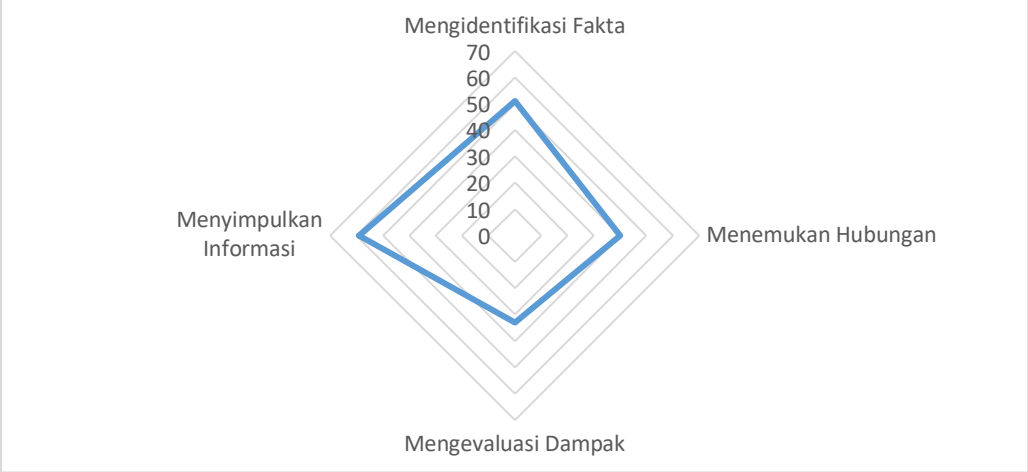
Graph 1. Results of Elementary School Students' Computational Thinking Skills on Each Indicator

Based on graph 1, it can be seen that the average for algorithmic thinking is 17%, pattern recognition is 64.5%, abstraction is 15.6%, and for decomposition is 44.5%. Based on the data, it can be seen that the computational thinking ability of elementary school students is still quite low, around 35.4%. The ability to think computationally in the aspect of algorithmic thinking is still quite low. Algorithmic thinking is the ability to outline the steps used to formulate a solution to a given problem. Students still struggle to organize the steps in a structured and patterned manner. Students' logical thinking skills still need further development. The ability to recognize patterns, namely identifying similarities/differences in solving given problems, is quite good, as students determine the similarities and differences in a situation. It is felt to be easier for students if supported by clear instructions or questions for them. In the aspect of abstraction, which is the ability to identify general patterns of similarities/differences found in the given problems and draw conclusions from the patterns identified in the given problems. This ability is quite low among students, in line with their previous abilities, as they have not yet been able to determine the structure and pattern of the given problems. In terms of decomposition ability, the assessment received was quite high, as students were able to identify the known and questioned information from the given problem. Based on the results of the observation, it is known that the elementary school students who are the subjects of the study still experience some difficulties in solving computational thinking problems. This is also influenced by the fact that students have some difficulty in understanding the language used in the developed questions. Students also

experience difficulties in structured writing, most students are already quite capable of comparing. In general, the main key is the clarity of the developed questions.

Based on the data that has been obtained computational thinking Skills and problem solving training are important and interrelated (Rijke, W. J., Bollen, L., Eysink, T. H. & Tolboom, 2018). by applying learning using computational thinking skills and problem solving skills (Ansori, 2020) learning outcomes (Pei, C., Weintrop, D., & Wilensky, 2018) and one's depth of thought can be increased (Bundy, 2015). For recommendation, computational thinking skills can be improved using problem solving based learning (Latifah et al., 2022) game-based learning (Cheng et al., 2023), and curriculum policy (Lemay et al., 2021).

Computational thinking is closely related to students' ability to solve problems quickly, accurately, and systematically. These skills are equally important as other skills, such as communication, digital literacy, critical thinking, and creativity (Weintrop et al., 2014). Therefore, the integration of computational thinking into the curriculum is becoming increasingly relevant to meet the demand for a skilled workforce in the digital field, capable of developing technology, and applying critical thinking (Surmilasari, Nora, and Ayu, 2024). Thus, computational thinking can help students hone critical, creative, and analytical thinking skills in facing complex problems (Putri et al., 2024). Next, the results of the critical thinking ability measurement are shown in Graph 2.



Graph 2. Results of Elementary School Students' Critical Thinking Skills on Each Indicator

Based on graph 2, it can be seen that 51% of students are already able to identify facts, 40% have been able to find relationships between situations, 33% have been able to evaluate the impacts that occur, and 59% have been able to conclude information in general. On average, from all aspects of students' critical thinking abilities, it is still low at around 54%. Based on the measurement results, it can be seen that in the aspect of the ability to identify facts, students are quite capable and have achieved a satisfactory score. In this aspect, students identify the facts presented in the given reading. Next, in the aspect of finding relationships, students received quite low scores because they often still struggle to determine relationships and patterns from a situation. In the aspect of evaluating the impact, students experience obstacles or difficulties in carrying out evaluation activities. The evaluation activity requires initial ability to understand the appropriate standards. Based on

those standards, students are able to evaluate the activities conducted. The last aspect is the ability to conclude information. The ability to summarize information receives the highest score, as this skill is often applied in various learning activities, such as summarizing and concluding. The activity of summarizing is an activity to determine important information and eliminate non-essential information. Based on the obtained data, it is known that students' critical thinking skills still need to be improved and trained in elementary school students so that they become accustomed to having these skills through the application of appropriate learning strategies or models that are indicated to be able to improve students' critical thinking skills (Sa'adilla, 2020).

Kusumawati et al. (2022) explain that critical thinking is the ability to reason in a structured manner in systematically evaluating the quality of thought, based on findings and experiences. This process involves integrating existing knowledge with relevant new information, which is then applied to solve problems, formulate conclusions, estimate possibilities, and make appropriate decisions according to the context faced. Ilhamdi et al. (2020) added that the goal of training critical thinking skills in elementary school students is to prepare them to become individuals who can think critically, solve various problems, and make appropriate and responsible decisions, so that they are ready to face challenges in adulthood.

The research results show that students still have difficulty in deeply analyzing problems, logically connecting information, and systematically finding solutions. This indicates that the learning process in schools has not yet fully optimized the development of higher-order thinking skills. The lack of practice in solving problem-based questions and the limited project-based learning contribute to the low critical and computational thinking skills of students.

In addition, the limited use of technology in learning also became one of the factors influencing the results of this research and the need for habituation in learning. However, the application of technology in learning, such as the use of educational software and coding-based approaches, can help students develop logical and systematic thinking. Therefore, it is important to enhance the integration of technology into the elementary school curriculum so that students can become accustomed to the concept of computational thinking from an early age. Next, the role of teachers in guiding and stimulating students' critical thinking skills is also an important aspect that needs to be considered. Teachers should implement more interactive learning strategies, such as group discussions, case studies, and project-based learning that challenge students to think analytically. In addition, the development of questions that encourage critical thinking as well as the application of inquiry and problem-based learning methods can be effective alternatives to enhance these skills. Thus, students will become more accustomed to identifying problems, constructing logical arguments, and making appropriate decisions based on the analysis conducted.

One of the learning approaches that encourages students to think critically in solving problems is the Project Based Learning (PjBL) model. According to Natty et al. (2019), PjBL is a teaching model that trains students to work both independently and in groups, with the aim of creating and producing a work. In this model, students are confronted with problems that

often arise in their daily lives, from which they are required to develop projects as solutions to these issues. Meanwhile, Utami et al. (2023) assert that Project Based Learning (PJBL) is a strategy capable of enhancing various competencies, including academic achievement, thinking skills, critical thinking, problem-solving abilities, creativity, independence, and the ability to analyze situations from a better perspective.

To enhance the effectiveness of this learning, strong collaboration between schools, teachers, and parents is needed to create a learning environment that supports the development of students' critical and computational thinking skills. Schools need to provide facilities that support in-depth exploration of concepts, while teachers are required to continuously improve their teaching skills with innovative methods. In addition, parents also play an important role in training their children to think critically through daily activities, such as engaging them in discussions or giving them simple problem-solving challenges. Through these joint efforts, it is hoped that students' critical and computational thinking skills can significantly improve, making them more prepared to face various challenges in the future.

Conclusion

The research results indicate that the critical and computational thinking skills of elementary school students still need to be improved. Data analysis reveals that computational thinking skills still need improvement, particularly in aspects such as abstraction and algorithmic thinking. In critical thinking skills, what is still lacking is the students' ability to determine relationships and evaluate the impact of a situation. This is caused by several factors, such as the lack of experience in exploration-based learning, limited use of technology in the learning process, and the still conventional teaching methods, which all contribute to this low ability. Therefore, efforts are needed to improve through more interactive innovative learning strategies, the use of appropriate educational technology, and the implementation of project-based and problem-solving approaches to hone students' critical and computational thinking skills from an early age.

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