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The Relationship Between Computational Thinking Ability and Logical Mathematical Intelligence

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Abstrak

Artikel ini menyajikan hasil penelitian tentang keterkaitan antara kemampuan *Computational Thinking* siswa dan kecerdasan logis matematis. Hal ini dilakukan karena *computational thinking* sangat diperlukan dalam menumbuhkan kecerdasan logis matematis. Metode yang digunakan dalam artikel ini adalah *literature review*. Penulis melakukan pengkajian terhadap beberapa artikel terkait, kemudian memahami masing-masing isinya dan melakukan penarikan kesimpulan berdasarkan kesamaan antara indikator kemampuan *computational thinking* dan kecerdasan logis matematis. Hasil kajian terhadap beberapa artikel menunjukkan bahwa terdapat hubungan selaras antara kemampuan *computational thinking* dengan kecerdasan logis matematis. Seseorang dengan kemampuan *computational thinking* dalam proses pemecahan masalah akan berusaha merumuskan kembali atau merinci suatu masalah menjadi bagian yang lebih sederhana sehingga mudah untuk diselesaikan. Hal tersebut sangat erat hubungannya dengan tingkat kecerdasan logis matematis, karena seseorang dituntut akan ketelitian pengamatan, penilaian pemahaman, dan kemampuan memprediksi kejadian yang berurutan secara alami. Rekomandasi dari penelitian ini adalah perlunya kegiatan pelatihan untuk mempelajari atau mengkaji bagaimana menggunakan *computational thinking* dan kecerdasan logis-matematis sebagai alat yang efektif dalam proses belajar mengajar matematika.
Kata kunci: Computational Thinking; Kecerdasan Logis Matematis; *literature review*

Abstract

This article presents the findings of a study examining the relationship between students' computational thinking abilities and their logical mathematical intelligence. This exploration is warranted due to the critical role computational thinking plays in fostering logical mathematical intelligence. The methodology employed in this article is a literature review. The author systematically reviewed several pertinent articles, analyzing their contents and synthesizing conclusions based on the commonalities between the indicators of computational thinking abilities and logical mathematical intelligence. The results of the analysis indicate a positive correlation between computational thinking abilities and logical mathematical intelligence. Individuals with strong computational thinking skills tend to decompose complex problems into simpler, more manageable components, facilitating the problem-solving process. This aptitude is closely linked to logical mathematical intelligence, which requires individuals to be meticulous in their observations, assess their understanding, and predict events in a coherent and sequential manner. Based on the findings of this study, it is recommended that training programs be implemented to teach and enhance the use of computational thinking and logical-mathematical intelligence as effective tools in the mathematics teaching and learning process.
Keywords: Computational Thinking; Logical Mathematical Intelligence; literature review

I. INTRODUCTION

The concept of computational thinking has its roots in the ancient practices of the Babylonians, who employed primitive calculation methods to solve mathematical problems around 1800 to 1600 BCE (Denning & Tedre, 2019; Junaeti et al., 2023; Gunawan et al., 2023). However, the term "computational thinking" was first coined by Seymour Papert, a mathematician, computer scientist, and educational expert from the Massachusetts Institute of Technology (MIT), in 1980. Papert described computational thinking as the outcome of an educational approach that encompasses students' social and affective abilities (Papert, S., 1980). In 2006, the term was revitalized by computer scientist Jeannette Wing, who asserted in her influential article that computational thinking is a cognitive process that involves constructing a systematic approach to problem-solving and understanding human behavior through fundamental concepts of computer science. Wing highlighted that computational thinking enables individuals to decompose complex problems into simpler, manageable components, employing methods such as reduction, insertion, transformation, or simulation (Wing, 2006; Islami, Fatra, & Diwidian, 2023).

According to the PISA 2021 framework, computational thinking is defined as an ability that encompasses the processes of decomposition, abstraction, algorithmic thinking, automation, and generalization, all integrated into the problem-solving process (Zahid, 2020; Aminah & Maat, 2023). In the context of mathematics education, three main concepts require emphasis for students: conceptual understanding, reasoning based on prior material, and problem-solving (Wulandari, 2016; Sabaruddin et al., 2023). Nonetheless, it is not uncommon for students to encounter difficulties when faced with problem-solving questions, as each student possesses varying levels of problem-solving abilities. This variance in abilities is inherent, with each student exhibiting distinct levels of competency.

Intelligence is a natural characteristic that individuals utilize to interpret behaviors related to intellectual capabilities and the creative thinking processes involved in learning material (Milsan & Wewe, 2018; Zubaidah et al, 2023). A significant form of intelligence that influences mathematical problem-solving is logical-mathematical intelligence, defined as the capacity to handle reasoning regarding patterns or sequences (Adnyani, 2018; Setyaningsih & Kustiana, 2023). Logical-mathematical intelligence encompasses abilities related to mathematical calculations, logical reasoning, problem-solving, deductive and inductive reasoning, as well as pattern recognition and relational accuracy (Milsan & Wewe, 2018; Tajuddin et al., 2023). Just as students exhibit diverse levels of intelligence, their levels of logical-mathematical intelligence also vary (Yunisca & Nasution, 2023). This variation depends on individuals' observational acuity, evaluative skills, comprehension, and ability to predict events occurring in a natural sequence (Adnyani, 2018; Atuyah & Nuraeni, 2022). Wulandari (2016) found that students with high levels of logical-mathematical intelligence typically possess the ability to understand problems, formulate and implement problem-solving strategies, and re-evaluate the results of their solutions.

The relationship between students' logical-mathematical intelligence and their computational thinking abilities is a focal point of this study. To foster logical, structured, and creative thinking processes, students can be trained to enhance their computational thinking skills (Mufidah, 2018). Consequently, the researchers are keen to further investigate whether a correlation exists between computational thinking abilities and students' logical-mathematical intelligence.

II. METHOD

This study aims to theoretically explore the relationship between computational thinking and logical-mathematical intelligence. The research method employed is a literature review, a systematic approach to data collection that involves gathering information from various sources, such as books, journals, theses, and other academic publications. Researchers engage with existing literature to read and comprehend relevant secondary data, analyze the findings, and draw conclusions. Through this literature study, the researcher seeks to identify one or more principles or theories applicable to the topic under investigation. Upon compiling information from pertinent sources, the researcher conducts a qualitative analysis, presenting the results in a descriptive format.

III. RESULT AND DISCUSSION

Results of the Study on the Concept of Computational Thinking

The Babylonian calculation methods, employed around 1800 to 1600 BCE, can be considered the precursor to the term "Computational Thinking," although at that time, it was primarily utilized for solving mathematical problems in a primitive manner (Denning & Tedre, 2019). Furthermore, in an opinion piece presented by Katz (1960), Alan Perlis predicted that computers would ultimately dominate processes across all fields, a concept he referred to as "algorithmizing." This notion of algorithmic thinking is inherently linked to computational thinking. Edsger Dijkstra, a pioneer in the field of computer science, articulated that thinking entails an individual's ability to identify the form and concepts of a problem within a system known as an algorithm in the problem-solving process (Dijkstra, 2022).

Historically, Seymour Papert first articulated the term "computational thinking" in his seminal book Mindstorms: Children, Computers, and Powerful Ideas, published in 1980. He defined computational thinking as a construct arising from an educational approach that emphasizes social engagement and the affective abilities of students (Papert, 1980). At that time, however, the term had not yet gained widespread acceptance or definition.

In antiquity, the concept of computational thinking evolved through various methodologies and techniques in the domain of computer science. Nonetheless, the foundational principles of computational thinking are more closely aligned with mathematics and logical reasoning, particularly within the context of problem-solving processes. As technological systems and artificial intelligence concepts have developed, the scope of computational thinking has expanded significantly, encompassing logical, systematic, and creative approaches to problem-solving, effectively emulating how computers resolve issues (Christi & Rajiman, 2023).

The Computer Science Teachers Association (CSTA) and the International Society for Technology in Education (ISTE) define computational thinking as a problem-solving process characterized by several key features: 1) formulating problems that can subsequently be addressed with computer assistance, 2) logically organizing and analyzing data, 3) depicting data through an abstraction process, 4) automating problem-solving through algorithmic (sequential) thinking, 5) identifying, analyzing, and applying potential solution methodologies, and 6) generalizing and transferring problem-solving processes to diverse contexts (Mufidah, 2018).

Computational thinking embodies an ability that incorporates fundamental computer science principles and concepts, applied to real-life situations. This capacity enables individuals to broaden their cognitive processes, effectively tackle challenges, and enhance the efficiency of problem-solving through systematic and logical processing of substantial amounts of data or information (Kale et al., 2018).

According to Lee (2012), four primary computational thinking skills, as demonstrated by Google, include decomposition (or problem analysis), pattern recognition, abstraction and generalization of patterns, and algorithmic thinking. Csizmadia et al. (2015) provide definitions for each of these skill aspects as follows:

a. Problem Decomposition: This skill involves the ability to disaggregate a problem into several simpler components, making it easier to comprehend, solve, develop, and evaluate each part independently.
b. Pattern Recognition: This fundamental skill is essential for problem-solving, as it allows individuals to identify specific types of problems and determine appropriate methods for addressing them.
c. Abstraction and Generalization of Patterns: This aspect pertains to the ability to discern and extract crucial information from a problem, enabling the identification of relevant features and relationships.
d. Algorithmic Thinking: This skill entails the formulation of a sequential and logical plan for executing the steps necessary to solve a problem effectively.

Computational thinking represents a distinct approach to problem-solving, encompassing stages such as data representation, problem decomposition, review, pattern recognition, logical reasoning, and algorithm design (Grover & Pea, 2018). According to Grover and Pea, the ability to engage in computational thinking is a competency that facilitates analytical activities.

To enhance computational thinking skills, students should develop several critical dimensions, including: self-confidence in addressing complex problems, persistence when tackling non-routine challenges, tolerance for multiple interpretations, the capacity to devise solutions through various methodologies, and effective communication skills (Maharani, 2020).

Results of the Study on the Concept of Logical-Mathematical Intelligence

Intelligence refers to an individual's capacity to comprehend, acquire knowledge, make informed decisions, and take action to resolve issues by studying and applying their existing knowledge (Mufidah, 2018). Logical-mathematical intelligence specifically denotes the type of intelligence employed to analyze problems logically, particularly in the context of solving mathematical or scientific inquiries (Kamsari & Winarso, 2018).

Demirdash (2008) defines logical-mathematical intelligence as the capacity of students to manipulate and interact with numbers and symbols, facilitating problem-solving through calculations, classifications, inferences, and the analysis of relationships. Armstrong (2009) further elucidates logical-mathematical intelligence as the ability to use numbers effectively, demonstrate sensitivity to logical patterns and relationships, engage in classification and generalization, perform calculations and hypothesis testing, and reason logically about abstract problems while relating them to other issues.

According to Walters (as cited in Ekasari, 2014), individuals with high logical-mathematical intelligence exhibit several key characteristics, including strong mathematical calculation skills, logical thinking abilities, effective problem-solving capabilities, a deductive-inductive mindset, and the aptitude to recognize patterns and their interrelations (Ekasari, 2014). Individuals with elevated levels of logical-mathematical intelligence often display traits such as a preference for structured and organized tasks, enthusiasm for coherent and systematic instructions, and an affinity for problem-solving. They tend to engage in critical questioning, resolve calculation problems rapidly, and enjoy rational puzzles. Challenges may arise for them when tackling new problems without having resolved previous ones, and they often rely on clear procedures while exhibiting the ability to articulate problems logically (Mufidah, 2018).

Moreover, Gardner (2011) identifies characteristics of individuals with high logical-mathematical intelligence in his book "Theory of Multiple Intelligences." These include the ability to analyze problems, accurately detect patterns, perform mathematical calculations proficiently, engage in scientific reasoning and deduction, understand cause-and-effect relationships, and produce verifiable outcomes.

Students who adopt a logical-mathematical learning style tend to excel in problem-solving, numerical reasoning, abstract visualization, and analyzing cause-and-effect relationships (Shirawia et al., 2023). Such students typically adhere strictly to scientific methods, think logically, possess strong mental mathematics skills, enjoy logic-based puzzles, achieve high scores on IQ tests, and exhibit a keen interest in mathematics, computer science, and technological challenges. Furthermore, they demonstrate determination, prefer orderly environments, possess strong memory retention, exhibit effective problem-solving skills, and appreciate the application of mathematical concepts through computers and programming.

The analysis of various articles on computational thinking and logical-mathematical intelligence reveals a significant relationship between the two constructs. This relationship can be examined from two perspectives: the cognitive processes involved and the attitudes shaped by the interplay of computational thinking and logical-mathematical intelligence.

The cognitive processes associated with computational thinking enable students to engage in logical and structured reasoning. This is achieved through the application of systematic thought patterns governed by principles such as decomposition, pattern recognition, abstraction, algorithms, and generalization. Similarly, students exhibiting logical-mathematical intelligence tend to adopt scientific methodologies, employing logical reasoning and comprehending cause-and-effect relationships (Malik, 2018). Moreover, students with strong logical-mathematical intelligence engage in sequential reasoning governed by strict rules, which aligns with the algorithmic and generalization aspects of computational thinking.

The attitudes cultivated through habitual computational thinking encompass self-confidence in addressing complex problems, persistence in solving non-routine issues, tolerance for multiple interpretations, the ability to tackle problems with various solutions, and effective communication skills. In parallel, students demonstrating logical-mathematical intelligence display determination, a preference for orderly environments, strong memory retention, and an appreciation for mathematical concepts facilitated by computers and programming. Thus, a predominant attitude among students who excel in both computational thinking and logical-mathematical intelligence is characterized by resilience and robust self-confidence.

The most favorable outcome for students possessing both computational thinking abilities and logical-mathematical intelligence is the enhancement of their problem-solving skills. This assertion aligns with the findings of Mufidah (2018) and Eka & Teguh (2018), who indicated that the level of logical-mathematical intelligence significantly influences students' problem-solving capabilities.

Students with elevated levels of logical-mathematical intelligence engage in activities that involve accurate analysis and understanding of cause-and-effect relationships (Pane et al., 2013). Furthermore, computational thinking serves as a versatile problem-solving technique applicable across various domains. Consequently, cognitive skills within the problem-solving process reveal a symbiotic relationship between logical intelligence and computational thinking, encompassing several mutually reinforcing attributes. Additionally, incorporating computational thinking into mathematics instruction can significantly enhance students' problem-solving skills across diverse scenarios, fostering improved logical-mathematical reasoning and analytical capabilities (Riley & Hunt, 2014; Abdurrahman, as cited in Tisngati, 2015).

IV. CONLUSION

The synthesis of findings from various studies indicates a significant relationship between students' computational thinking abilities and their logical-mathematical intelligence. Specifically, indicators of computational thinking align closely with key components of logical-mathematical intelligence. These components include the identification of relevant information from problems (decomposition), the formulation of logical steps within the problem-solving process (algorithmic thinking), the recognition of patterns or characteristics inherent to a problem, and the derivation of conclusions based on identified patterns (generalization and abstraction). Furthermore, the level of logical-mathematical intelligence exhibited by students can influence their computational thinking abilities during the mathematics learning process.

Based on the analysis of multiple articles, the researchers advocate for the implementation of training activities designed to enhance the understanding and application of computational thinking and logical-mathematical intelligence as effective pedagogical tools in the teaching and learning of mathematics. Such training can assist educators in developing instructional strategies that prioritize the cultivation of students' computational thinking skills alongside their logical-mathematical intelligence. Moreover, it is important to note that this study is primarily theoretical; therefore, further research is warranted to explore the development of teaching materials and their practical application within classroom settings.

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