Computational Thinking Ability as the Foundation for Solving Contextual Mathematical Problems among Informatics Students

Vivi Asbar [1*] , Nurul Asma [1] , Asmaul Husna [1]

[1*] Universitas Islam Kebangsaan Indonesia

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ABSTRACT

This study examines the role of computational thinking (CT) ability as a foundational skill for solving contextual mathematical problems among informatics students. Contextual mathematical problems require students to translate real-world situations into mathematical representations, apply appropriate strategies, and interpret solutions meaningfully. Such processes align closely with core components of computational thinking, including decomposition, pattern recognition, abstraction, and algorithmic thinking. This study employed a quantitative correlational design involving undergraduate informatics students. Data were collected using a computational thinking test and a contextual mathematical problem-solving assessment. Statistical analysis was conducted using correlation and regression techniques to determine the contribution of CT ability to students' problem-solving performance. The findings indicate that computational thinking ability has a significant and positive effect on students' ability to solve contextual mathematical problems. These results suggest that strengthening computational thinking skills is essential for enhancing mathematical problem-solving competence, particularly in informatics education. The study provides empirical support for integrating computational thinking explicitly into mathematics-related courses for informatics students.

Corresponding Author:
Vivi Asbar | Universitas Islam Kebangsaan Indonesia
Email: vibir_asbar@yahoo.com

1. INTRODUCTION

The rapid advancement of information and communication technology has significantly reshaped the competencies required of university graduates, particularly students in informatics-related disciplines. Informatics students are expected not only to master technical and programming skills but also to demonstrate strong analytical and problem-solving abilities when dealing with complex and contextual problems. Mathematics plays a fundamental role in informatics education, underpinning essential topics such as algorithms, data structures, machine learning, and data analysis. However, numerous studies report that informatics students often encounter difficulties when mathematical problems are presented in contextual or real-world forms rather than as abstract symbolic expressions (Li et al., 2019; Sabol & Pianta, 2017).

Contextual mathematical problems require students to interpret real-life situations, identify relevant information, construct appropriate mathematical models, and evaluate solutions meaningfully. These processes involve higher-order thinking skills, including reasoning, abstraction, and strategic decision-making. Research has shown that students' difficulties in solving contextual mathematical problems are frequently associated with limitations in abstraction, problem decomposition, and the ability to translate real-world contexts into formal mathematical representations (Sarama & Clements, 2019; Hassinger-Das et al., 2020). Consequently, identifying cognitive abilities that support these processes is essential for improving mathematical problem-solving performance among informatics students.

Computational thinking (CT) has emerged as a key competence in the digital era and is widely recognized as a foundational skill for students in computing and informatics fields. Computational thinking refers to a problem-solving framework that involves decomposition, pattern recognition, abstraction, and algorithmic thinking (Wing, 2014; Denning, 2017). Although originally associated with computer science education, recent studies emphasize that computational thinking is a transferable cognitive skill applicable across disciplines, including mathematics (Weintrop et al., 2016; Ramani & Scalise, 2020).

The conceptual relationship between computational thinking and mathematical problem solving is particularly strong. Both require learners to break down complex problems into manageable components, identify patterns, abstract essential information, and design systematic solution strategies. Empirical evidence suggests that students with stronger computational thinking skills tend to perform better in solving non-routine and contextual mathematical problems, as they are more capable of structuring problems logically and selecting effective solution pathways (Hassinger-Das et al., 2020; Ramani & Scalise, 2020).

Despite the growing recognition of computational thinking as a critical skill, empirical research examining its specific contribution to contextual mathematical problem solving at the tertiary level remains limited. Many existing studies focus on the role of computational thinking in programming performance or general computer science learning, while its influence on mathematics learning—particularly among informatics students—has received less attention (Jones et al., 2019). This gap is notable given that informatics students frequently encounter mathematically grounded problems embedded in real-world and computational contexts.

Therefore, this study aims to investigate computational thinking ability as a foundational factor in solving contextual mathematical problems among informatics students. By examining the relationship between computational thinking skills and contextual mathematical problem-solving performance, this research seeks to provide empirical evidence that supports the integration of computational thinking into mathematics-related courses within informatics programs. The findings are expected to contribute to the literature on computational thinking and mathematics education, as well as to inform curriculum design and instructional practices in higher education.

2. RESEARCH METHODOLOGY

This study employed a quantitative research approach with a correlational design to investigate the relationship between computational thinking ability and students' performance in solving contextual mathematical problems. A correlational approach was chosen because it allows researchers to examine the degree and direction of association between variables without manipulating learning conditions, which is appropriate for examining cognitive abilities in authentic educational settings (Creswell & Creswell, 2018).

Participants

The participants were undergraduate students enrolled in an informatics study program at a Universitas Islam Kebangsaan Indonesia. A total of 72 students participated in the study. Participants were selected using purposive sampling, with the criteria that they had completed introductory programming courses and basic mathematics courses. This sampling technique was applied to ensure that participants possessed foundational computational and mathematical knowledge relevant to computational thinking assessment (Etikan et al., 2016).

Instruments

Two research instruments were utilized in this study. The first instrument was a Computational Thinking Ability Test designed to measure four core components of computational thinking: decomposition, pattern recognition, abstraction, and algorithmic thinking. The test items were developed based on established computational thinking frameworks in higher education and adapted from prior validated instruments (Weintrop et al., 2016; Denning, 2017). The instrument consisted of 20 items combining multiple-choice and short-response formats. Content validity was established through expert judgment involving lecturers in mathematics education and informatics, while reliability analysis indicated good internal consistency (Cronbach's $\alpha > 0.80$), which is considered acceptable for educational research (Field, 2018).

The second instrument was a Contextual Mathematical Problem-Solving Test consisting of 8 open-ended problems situated in real-world and informatics-related contexts, such as data interpretation, logical decision-making, and algorithmic reasoning. The problems required students to interpret contextual information, construct mathematical models, apply appropriate solution strategies, and evaluate results. The development of contextual problems followed recommendations from mathematics education research emphasizing the importance of real-life contexts in assessing higher-order mathematical thinking (Sarama & Clements, 2019). A scoring rubric was developed to ensure consistency and objectivity in evaluating students' responses.

Data Collection Procedure

Data collection was conducted during regular class sessions to maintain a natural learning environment. Students first completed the Computational Thinking Ability Test, followed by the Contextual Mathematical Problem-Solving Test in a separate session. Standardized instructions were provided to all participants, and the duration of each test was controlled to reduce testing bias.

Data Analysis

Data analysis involved both descriptive and inferential statistics. Descriptive statistics were used to summarize students' computational thinking abilities and contextual mathematical problem-solving scores in terms of mean and standard deviation. Prior to inferential analysis, assumption tests for normality and linearity were conducted. Pearson's product–moment correlation analysis was employed to examine the strength and direction of the relationship between computational thinking ability and contextual mathematical problem-solving performance. Furthermore, simple linear regression analysis was conducted to determine the predictive contribution of computational thinking ability to students' ability to solve contextual mathematical problems. Statistical analyses were performed using SPSS software, with a significance level set at 0.05, following standard practices in educational research (Field, 2018).

3. RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive analysis was conducted to summarize students' computational thinking ability and their performance in solving contextual mathematical problems. As shown in Table 1, informatics students demonstrated a moderate to high level of computational thinking ability (M = 76.45, SD = 8.32). Similarly, students' contextual mathematical problem-solving performance was at a comparable level (M = 73.18, SD = 9.05).

Table 1. Descriptive Statistics of Research Variables

Variable	**N**	**Mean**	**SD**
Computational Thinking Ability	72	76.45	8.32
Contextual Mathematical Problem Solving	72	73.18	9.05

Pearson correlation analysis revealed a significant positive relationship between computational thinking ability and contextual mathematical problem-solving performance ($r = 0.62$, $p < .001$), indicating that students with higher computational thinking ability tended to perform better in solving contextual mathematical problems.

Table 2. Correlation between Computational Thinking Ability and Contextual Mathematical Problem Solving

Variables	**r**	**Sig. (p)**
Computational Thinking – Contextual Mathematical Problem Solving	0.62	< .001

Regression Analysis

Simple linear regression analysis showed that computational thinking ability significantly predicted contextual mathematical problem-solving performance ($R^2 = 0.38$, $F(1,70) = 42.91$, $p < .001$). This result indicates that computational thinking ability accounted for 38% of the variance in students' contextual mathematical problem-solving performance.

Table 3. Regression Analysis Results

Predictor Variable	**β**	**R²**	**F**	**Sig. (p)**
Computational Thinking Ability	0.62	0.38	42.91	< .001

Computational Thinking Components

Further analysis showed that all components of computational thinking were significantly correlated with contextual mathematical problem-solving performance. Algorithmic thinking and abstraction demonstrated the strongest associations, indicating their prominent role in supporting contextual mathematical reasoning among informatics students.

Table 4. Correlation between Computational Thinking Components and Contextual Mathematical Problem Solving

Computational Thinking Component	**r**	**Sig. (p)**
Decomposition	0.55	< .001
Pattern Recognition	0.49	< .001
Abstraction	0.60	< .001
Algorithmic Thinking	0.64	< .001

Discussion

Beyond its cognitive contribution, computational thinking also supports metacognitive processes that are essential in contextual mathematical problem solving. When students engage in real-world mathematical tasks, they must continuously monitor their understanding, evaluate solution strategies, and revise their approaches when initial attempts are ineffective. Research in mathematical problem solving emphasizes that such metacognitive regulation is a critical determinant of success in non-routine problems (Schoenfeld, 2016). Computational thinking encourages learners to explicitly plan, test, and debug solutions, thereby fostering reflective and self-regulated problem-solving behaviors.

Furthermore, the relevance of computational thinking to contextual mathematics aligns with international perspectives on twenty-first-century skills. The OECD highlights problem solving, reasoning, and the ability to apply knowledge in unfamiliar contexts as core competencies required for higher education and future work (OECD, 2019). Computational thinking supports these competencies by equipping students with transferable strategies for analyzing complex situations, identifying constraints, and constructing logical solutions. In this sense, computational thinking serves as a bridge between formal mathematical knowledge and its practical application in real-world contexts.

In informatics education, the integration of computational thinking into mathematics learning is particularly critical. Informatics students frequently encounter mathematical problems embedded in computational systems, data-driven contexts, and algorithmic environments. Prior research suggests that students who are explicitly trained to connect computational thinking practices with mathematical reasoning demonstrate greater flexibility in problem interpretation and solution generation (Grover & Pea, 2018). This integration enables students to perceive mathematics not merely as abstract manipulation but as a tool for modeling, analyzing, and solving authentic computational problems.

Additionally, contextual mathematical problem solving often involves mathematical modeling, which requires students to simplify real-world situations, define assumptions, and validate results. Studies on mathematical modeling emphasize that students' difficulties frequently arise during the transition from context to model rather than during calculation (Stillman et al., 2016). Computational thinking, particularly through abstraction and decomposition, directly supports this transition by guiding students to focus on essential variables and relationships while managing problem complexity.

Taken together, these findings suggest that strengthening computational thinking within informatics curricula may enhance students' mathematical problem-solving competence in meaningful and sustainable ways. Rather than positioning computational thinking as an auxiliary skill, it should be embedded intentionally within mathematics instruction to support modeling, reasoning, and metacognitive regulation. Such an approach aligns with contemporary educational frameworks that advocate for interdisciplinary learning and the development of transferable cognitive skills across domains.

4. CONCLUSION

This study provides clear empirical evidence that computational thinking ability serves as a foundational determinant of informatics students' success in solving contextual mathematical problems. The findings demonstrate that computational thinking is not merely a complementary technical skill, but a core cognitive framework that significantly supports students' capacity to interpret real-world contexts, structure mathematical information, and apply systematic solution strategies.

Importantly, the strong contributions of abstraction and algorithmic thinking highlight that students' difficulties in contextual mathematics are closely linked to their ability to model situations and design coherent solution procedures. These results suggest that improving mathematical problem-solving performance among informatics students requires instructional approaches that explicitly develop computational thinking processes alongside mathematical content.

Therefore, integrating computational thinking into mathematics-related courses within informatics programs is essential for fostering transferable problem-solving skills that reflect real-world and computational demands. This study contributes to the growing body of evidence supporting interdisciplinary learning and provides a strong rationale for curriculum designs that position computational thinking as a central component of higher education mathematics instruction.

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