

Profile of Students' Computational Thinking Skills in Solving Algebraic and Geometric Mathematical Problems: Systematic Literature Review

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ABSTRACT

Researchers systematically examine the profile and characteristics of students' computational thinking abilities when they tackle math problems in algebra and geometry, as computational thinking counts as one of the key competencies in 21st-century math learning that bolsters students' problem-solving skills. This study uses a Systematic Literature Review (SLR) and reviews articles published between 2015 and 2025, so researchers search those articles in databases like Google Scholar, Scopus, ERIC, SpringerLink, and DOAJ with keywords linked to computational thinking and math learning. They base the selection process on inclusion and exclusion criteria, which leads to 12 relevant articles ready for analysis. The results show students' computational thinking skills marked by four main aspects decomposition, pattern recognition, abstraction, and algorithmic thinking and its use in algebra and geometry learning happens via problem-based approaches, algorithmic representations, as well as visualization and simulation activities. Decomposition and algorithmic thinking emerge as the dominant aspects students use, whereas abstraction and pattern recognition pose the biggest challenges, particularly in geometry, and these insights point to the need for more systematic design in blending computational thinking into math learning to strengthen abstraction and pattern recognition so students improve their math problem solving quality.

Keywords: Computational Thinking, Mathematical Problem Solving, Algebra, Geometry, Systematic Literature Review.

ABSTRAK

Peneliti secara sistematis menelaah profil dan karakteristik kemampuan berpikir komputasional siswa ketika mereka menyelesaikan masalah matematika pada materi aljabar dan geometri, karena berpikir komputasional merupakan salah satu kompetensi kunci dalam pembelajaran matematika abad ke-21 yang memperkuat kemampuan pemecahan masalah siswa. Penelitian ini menggunakan Systematic Literature Review (SLR) dan meninjau artikel yang diterbitkan antara tahun 2015 hingga 2025. Para peneliti menelusuri artikel-artikel tersebut dalam basis data seperti Google Scholar, Scopus, ERIC, SpringerLink, dan DOAJ dengan kata kunci yang berkaitan dengan berpikir komputasional dan pembelajaran matematika. Proses seleksi didasarkan pada kriteria inklusi dan eksklusi, sehingga diperoleh 12 artikel relevan yang siap dianalisis. Hasil penelitian menunjukkan bahwa kemampuan berpikir komputasional siswa ditandai oleh empat aspek utama, yaitu dekomposisi, pengenalan pola, abstraksi, dan berpikir algoritmik. Penerapannya dalam pembelajaran aljabar dan geometri dilakukan melalui pendekatan berbasis masalah, representasi algoritmik, serta aktivitas visualisasi dan simulasi. Dekomposisi dan berpikir algoritmik

muncul sebagai aspek yang paling dominan digunakan siswa, sedangkan abstraksi dan pengenalan pola menjadi tantangan terbesar, khususnya dalam geometri. Temuan ini menunjukkan perlunya perancangan yang lebih sistematis dalam mengintegrasikan berpikir komputasional ke dalam pembelajaran matematika guna memperkuat kemampuan abstraksi dan pengenalan pola sehingga kualitas pemecahan masalah matematika siswa dapat meningkat.

Kata Kunci: Berpikir Komputasional, Pemecahan Masalah Matematika, Aljabar, Geometri, Tinjauan Literatur Sistematis.

INTRODUCTION

Mathematics helps develop students' logical, analytical, and problem-solving skills in formal education and stands as a key subject for building higher-order thinking skills because students are trained to analyze problems, develop strategies, and evaluate solutions rationally (Suryawan, Sudiarta, *et al.*, 2023). Solving contextual math problems requires students to go through a series of thinking processes, starting from understanding the problem situation, building a model of the situation, constructing a mathematical model, to reinterpreting the results of the solution in a real context (Suharta & Astawa, 2024).

Modern mathematics education emphasizes the importance of problem-solving skills as the core of mathematical activities, rather than merely mastering procedures (Schoenfeld *et al.*, 2024). In addition, the international mathematics literacy framework also places problem solving as a key competency that must be developed through meaningful learning. Mathematics shapes students' thinking so this subject plays a strategic role in preparing them to face 21st-century challenges (Ye *et al.*, 2023).

Students often have difficulty formulating problems, interpreting real-world contexts into mathematical models, and understanding relationships or patterns in mathematical problems (Damayanti *et al.*, 2025). Algebra and geometry are two areas of mathematics that often cause difficulties for students, especially in understanding concepts and applying problem-solving strategies. In algebra, students often encounter obstacles in understanding variable relationships and the process of algebraic thinking conceptually (Purwa Kusuma *et al.*, 2024).

Meanwhile, in geometry, difficulties in visualization and spatial reasoning are factors that influence students' success in solving problems (Widodo, 2024). Mathematics learning that focuses on memorizing formulas causes students to be less able to apply geometric concepts when faced with problems that are different from the examples given (Kertiani *et al.*, 2024). Many students still experience difficulties in solving geometry problems that require illustrations to solve them (Pratiwi *et al.*, 2025).

Other studies also show that geometric problem-solving skills are closely related to students' higher-order thinking skills (Nurwita *et al.*, 2022). Students' mistakes in solving geometry problems generally occur at the analysis and modeling stage, especially when students have to relate abstract concepts to the given contextual situation (Suryawan *et al.*, 2023). This condition shows that mathematics learning should not only emphasize procedural mastery, but also develop higher-

order thinking skills that help students understand problem structures and design solutions systematically.

Computational thinking offers an approach to thinking that uses processes like decomposition, pattern recognition, abstraction, and algorithmic thinking to solve problems and various international studies focus heavily on integrating it into K-12 education. A systematic review shows that computational thinking has a significant contribution to improving problem-solving skills.

Computational thinking ranks as one of the key 21st-century skills and countries including Indonesia integrate it into education curricula to boost students' mathematical thinking and problem-solving skills (Suarsana *et al.*, 2024). so it plays a vital role in helping students build systematic and structured steps for problem-solving and students really need these skills especially in math learning (Hartawan *et al.*, 2025).

Studies prove that integrating computational thinking into algebra learning improves students' algebraic thinking and problem-solving strategies (Knutson & Stagg, 2025). Through the application of decomposition and algorithmic thinking, students become better able to understand problem structures and design logical solutions (Knutson & Stagg, 2025). Other findings also indicate that this approach strengthens the connection between conceptual and procedural understanding in mathematics (Ye *et al.*, 2023).

Computational thinking is a way of thinking about solving problems that involves decomposition, pattern recognition and generalization, abstraction, and algorithmic thinking to understand and simplify complex problems (Hartawan *et al.*, 2024). Researchers analyze students' computational thinking skills through profiles across four aspects namely decomposition, abstraction, pattern recognition, and algorithmic thinking and research in geometry contexts reveals students still face difficulties with abstraction when solving Pythagorean theorem problems (Nurwita *et al.*, 2022).

Other studies find problem-based learning in geometry significantly develops those skills (Widodo, 2024). In addition, variations in computational thinking profiles are influenced by individual characteristics and student learning experiences (International Journal of STEM Education, 2023). Although research on computational thinking in mathematics education continues to evolve, most studies still focus on the impact or effectiveness of interventions rather than on in-depth mapping or profiling of student abilities.

A systematic review shows that studies on the characteristics of students' computational thinking in specific mathematical domains are still limited (Ye *et al.*, 2023). In addition, research that specifically integrates the contexts of algebra and geometry in a single profile study is still rare (Knutson & Stagg, 2025). Strengthening mathematics learning that integrates computational thinking is important to support the development of students' higher-order thinking skills and problem-solving skills in a sustainable manner (Juliangkary *et al.*, 2025). Therefore, this study is important to provide a comprehensive overview of students' computational thinking skills in solving mathematical problems in algebra and geometry as a basis for developing more effective learning.

METHODS

This study applies a Systematic Literature Review (SLR) approach to identify, analyze, and synthesize empirical evidence on students' computational thinking abilities as they solve math problems especially in algebra and geometry. Researchers chose the SLR method because it provides a systematic, transparent, and replicable way to review existing research so conclusions become comprehensive and grounded in scientific evidence and this review follows three research questions: (1) what characterizes students' computational thinking abilities in solving math problems? (2) how do they implement computational thinking in algebra and geometry learning? (3) which aspects dominate or challenge students in algebra and geometry problems. Researchers conduct the literature search systematically across national and international academic databases namely Google Scholar, Scopus, ERIC (Education Resources Information Center), SpringerLink, and DOAJ (Directory of Open Access Journals) and they select these databases to access high-quality, reliable, and relevant scientific articles. The search process combines keywords like computational thinking and mathematics, computational thinking and algebra, computational thinking and geometry, computational thinking and mathematics learning, and problem solving and computational thinking and they limit it to articles published from 2015 to 2025 to keep findings relevant and current. Clear inclusion and exclusion criteria were applied to select articles for analysis. The inclusion criteria require that articles be published in accredited or reputable scientific journals, focus on computational thinking in the context of mathematics learning, involve school-level students (elementary, junior high, or high school) in a formal educational setting, present empirical data or systematic reviews, and be written in Indonesian or English. Articles are excluded if they are not directly related to computational thinking or mathematics, consist of opinions, editorials, or proceedings that are not peer-reviewed, are not accessible in full text, or focus on higher education or professional training contexts outside of school.

The article selection process consisted of four stages: identification of studies through database searches, initial screening based on titles and abstracts, assessment of eligibility through reading the full text, and determination of articles to be analyzed. This structured process was applied to minimize bias and increase the validity of the review results. Data extraction was performed systematically for each included article, covering author names and year of publication, research context or country, participants' education level, mathematics topics discussed (algebra, geometry, or other fields), research methods used, and computational thinking components evaluated, namely decomposition, pattern recognition, abstraction, and algorithmic thinking. The main findings of each study were also extracted to support the analysis and synthesis. Data analysis was conducted using thematic analysis, in which the findings extracted were grouped into main themes related to students' computational thinking profiles in solving algebra and geometry problems. The synthesized results were then used to identify recurring patterns, dominant trends, and existing research gaps, providing a comprehensive picture of students' computational thinking abilities in the context of mathematical problem solving.

RESULTS AND DISCUSSION

To ensure the rigor and transparency of the review process, this study adopted a systematic procedure for identifying, screening, and selecting relevant articles. The selection stages were conducted in accordance with the principles of a Systematic Literature Review to obtain high-quality and relevant studies aligned with the research objectives. An overview of the article identification and selection process is presented in Figure 1.

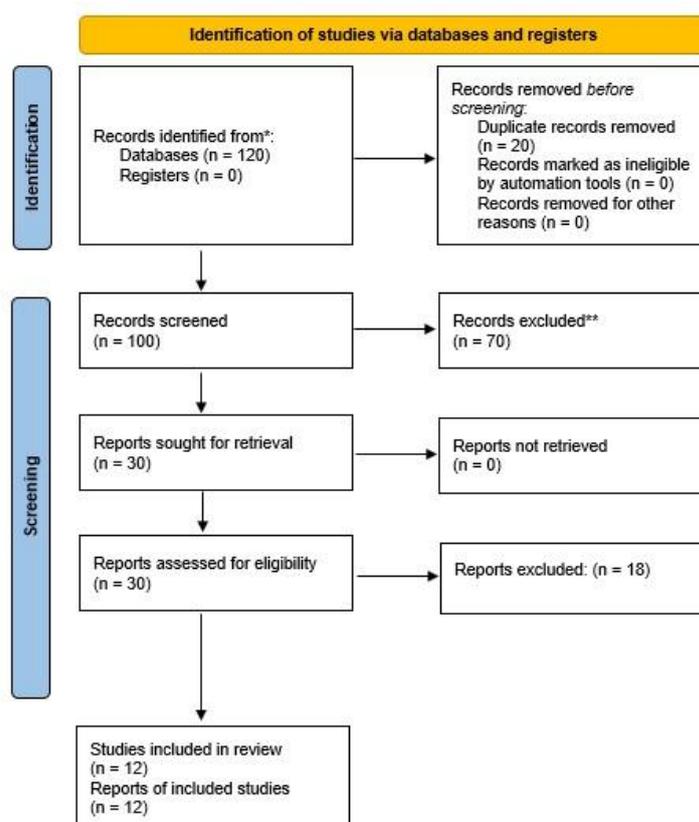


Figure 1. Identification of Studies Via Database and Registers

The article selection process in this study was conducted systematically with reference to the Systematic Literature Review stages. At the identification stage, researchers found 120 articles obtained from various scientific databases. There were no articles from additional registers. Next, duplicate articles were removed, resulting in the elimination of 20 articles and leaving 100 articles for the initial screening stage.

At this stage, screening was conducted based on titles and abstracts to assess their relevance to the research focus, namely students' computational thinking skills in solving mathematical problems in algebra and geometry. From this process, 70 articles were deemed irrelevant and excluded from the study. A total of 30 articles that passed the screening stage were then traced and read in full (full-text) at the eligibility assessment stage. All articles were successfully accessed, so there were no reports that could not be obtained.

Based on an in-depth evaluation of the inclusion criteria, such as the suitability of the research subject, focus on mathematics learning, and relevance to computational thinking indicators, 18 articles were found to not meet the criteria and were eliminated. Thus, 12 articles were found to meet *all* inclusion criteria and were used as the main sources in this systematic review to analyze the profile of students' computational thinking abilities in solving mathematical problems in algebra and geometry.

Table 1. Data Extraction Article

N o	Author & Year	Country/C ontext	Level	Material	Method	CT aspect	Key Findings
1	Knutson & Stagg (2025)	United States	Junior High School / Senior High School	Algebra	Eksperiment	Decomposition, algorithmic	CT improves algebraic thinking skills
2	Nurwita <i>et al.</i> (2022)	Indonesia	Junior High School	Geometry (Pythagoras)	Qualitative	Abstraction, decomposition	Difficulties with abstraction
3	Alyani & Hasannah (2024)	Indonesia	Senior High School	Problem solving	Quantitative	All aspects	Differences in CT profiles based on gender
4	Widodo <i>et al.</i> (2023)	Indonesia	Elementary School	3D Geometry	Descriptive	Patterns, visualization	CT aids in spatial understanding
5	Jupri <i>et al.</i> (2024)	Indonesia	Prospective teacher	Geometry	Quantitative	Algorithmic, abstraction	CT supports geometric strategies
6	Fitdyawati <i>et al.</i> (2025)	Indonesia	Junior High School	Problem solving	Eksperiment	Decomposition, algorithmic	CT improves problem solving
7	Veronica <i>et al.</i> (2023)	Indonesia	Elementary School	Mathematical problems	Qualitative	All aspects	CT profiles are influenced by learning styles
8	Ye <i>et al.</i> (2023)	International	K-12	General	SLR	All aspects	CT has a positive impact

9	Lee <i>et al.</i> (2023)	Taiwan	Junior High School	General	Korelasi	All aspects	Mathematical literacy predicts CT
10	Pangari buan & Sidabutar (2025)	Indonesia	Senior High School	3D Geometry	Quantitative	Abstract, algorithmic	Influenced by cognitive abilities and styles
11	Maharani <i>et al.</i> (2019)	Indonesia	Junior High School	Problem solving	Descriptive	All aspects	CT is important in the solution structure
12	Lye & Koh (2016)	Singapura	K-12	General	Review	All aspects	CT as a 21st century competency

The SLR results show that students' computational thinking skills in solving mathematical problems are characterized by their ability to decompose problems, identify patterns, perform abstractions, and develop algorithmic solution steps. Maharani *et al.* (2019) found that students with good CT abilities tend to be able to break down complex mathematical problems into simpler subproblems, thereby facilitating the solution process.

This finding is also reinforced by Lee *et al.* (2023) which shows that students' CT competence correlates with mathematical ability, particularly in developing systematic solution strategies. The findings in this study are in line with the results of the study Suarsana *et al.* (2024) which shows a direct relationship between computational thinking and mathematical problem-solving skills, particularly in algebra and geometry, which are the most widely studied subjects in Indonesia.

In addition, another notable characteristic is the variation in CT ability levels among students. Alyani dan Hasanah (2024) shows that there are differences in CT ability profiles based on individual characteristics, such as gender and learning experience. Veronica *et al.* (2023) also reported that students' learning styles influence how they apply aspects of CT in solving mathematical problems. This shows that students' computational thinking abilities are heterogeneous and influenced by both cognitive and contextual factors.

The results of the study show that computational thinking is applied in algebra and geometry learning through various approaches, such as problem-based learning, the use of algorithmic representations, and the use of programming or simulation activities. In the context of algebra, Knutson dan Stagg (2025) found that integrating CT into algebra learning helps students understand patterns, relationships between variables, and procedures for solving equations through an

algorithmic thinking approach. This approach enables students to organize the steps for solving problems in a more structured manner.

In geometry learning, CT is widely applied to support students' visualization and spatial reasoning. Widodo *et al.* (2023) shows that CT-based geometry learning, especially in three-dimensional shapes, can improve students' ability to understand the relationships between geometric elements. Similar findings have also been reported by Pangaribuan dan Sidabutar (2025) which states that the application of CT in geometry helps students develop more systematic problem-solving strategies, especially for problems that require visualization and abstraction.

Based on the synthesis results, the most dominant computational thinking aspects in algebra and geometry learning are decomposition and algorithmic thinking. Maharani *et al.* (2019) reported that decomposition is an important initial step in helping students break down mathematical problems into simpler parts. In addition, Knutson dan Stagg (2025) shows that algorithmic thinking plays a significant role in helping students organize the sequence of steps for solving algebraic problems.

However, abstraction is one of the main obstacles students face, especially in the context of geometry. Nurwita *et al.* (2022) found that students still have difficulty with abstraction, particularly in identifying important information and connecting symbolic representations with visual representations.

Pangaribuan dan Sidabutar (2025) also reported that weaknesses in abstraction and visualization caused students difficulty in solving three-dimensional geometry problems. These findings indicate that although decomposition and algorithmic skills are relatively well developed, aspects of abstraction and pattern recognition still need to be strengthened in algebra and geometry learning.

CONCLUSION

The results of the Systematic Literature Review (SLR) show that students' computational thinking skills in solving mathematical problems are characterized by their ability to decompose, recognize patterns, abstract, and think algorithmically. These skills help students solve problems more systematically, although there are variations in skill levels among students. The application of computational thinking in algebra and geometry learning is carried out through a problem-based approach, algorithmic representation, and visualization and simulation activities. This approach has been proven to support students' understanding of concepts and problem-solving strategies. In addition, decomposition and algorithmic thinking are the most dominant aspects, while abstraction and pattern recognition remain major obstacles, especially in the context of geometry. Therefore, mathematics learning needs to be designed to strengthen the aspects of abstraction and pattern recognition so that students' computational thinking skills can develop more optimally.

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