

## **The Implementation of Computational Thinking on Mathematics Learning Research: A Systematic Literature Review**

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### **Abstract**

*The aim of this study is to describe the implementation of computational thinking research results on mathematics learning in Indonesia. The method used in this study is a systematic literature review (SLR) by using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) protocol. The sample consists of 25 results of computational thinking research on mathematics learning, the sample is journal articles and proceedings published in 2019-2023. The description of this research will be reviewed based on the year of research, the level of education, research location, and research methods used. The results of the study show that (1) computational thinking research on mathematics learning has increased every year where 2022 become the year with the most number of publications, there are 15 articles, (2) 32% (8 articles) of computational thinking research on mathematics learning is conducted at the university level, (3) East Java is the province with the most research on computational thinking on mathematics learning, with 7 studies, (4) quantitative method is the method most frequently used in computational thinking research on mathematics learning in Indonesia, there are 12 studies that used quantitative method, and (5) students are able to perform abstraction and algorithm processes. However, they still have difficulty in performing the decomposition and pattern recognition processes.*

**Keywords:** *computational thinking, mathematics learning, SLR*

### **INTRODUCTION**

One of the skills that students must possess in the era of globalization is computational thinking skills. Grover (2018) and Riddell (2018) state that computational thinking skills deserve to be the "5th C" in 21st century skills beside 4Cs (critical thinking, creativity, collaboration, and communication) because in this era students are



required to be able to complete computational problems, namely thinking logically, algorithmically, and being able to use computational tools and present data.

Wing (2017) defines computational thinking as a person's ability to present problem and its solution in an algorithm so that both computers and other people can use the same steps to solve the same problem. In line with Bocconi et al. (2016) who stated that computational thinking is a thinking process (one's thinking skills) that uses analytical approaches and algorithms to formulate, analyze, and solve a problem. In problem solving, Bocconi et al. (2016) also added that problem solving activities, that involve computational thinking, can be seen from a person's ability to (1) decompose, namely breaking down complex problems into small parts that are easier to understand and solve (Wing, 2011), (2) recognize patterns, (3) perform abstraction, namely the ability to formulate solutions in general terms so that they can be applied to different problems, (4) design a series of operations/actions in a systematic way (step by step) on how to solve a problem (algorithm). Computational thinking ability allows one to be able to solve complex problems (Inganah et al., 2023; Maharani et al., 2019), makes one smarter and easier to understand the technology (Cahdriyana & Richardo, 2020), and is useful for one's education and future (Adler & Kim, 2018).

The use of computational thinking is not only limited to the computer field (Nurwita et al., 2022). But it can also be applied in various scientific fields (Ansori, 2020; S. Maharani et al., 2021). Barr & Stephenson (2011) explain that computational thinking can be integrated into several subjects, such as: Mathematics, Sciences, Social Studies, Languages, and Arts. Mathematics has a close relationship with computational thinking because mathematics involves patterns, problem structures, and variables that can be used with different values (Maharani et al., 2020). Furthermore, Nurwita et al. (2022) explain that computational thinking can be applied in learning mathematics because computational thinking synthesizes critical thinking skills and creative thinking skills so that it allows students to be able to formulate problems and develop solutions to solve these problems. Teaching computational thinking means that the teacher teaches students how to think and solve problems like as computers (Zahid, 2020).

In Indonesia, computational thinking was introduced in 2018. Through Permendikbud number 37, the government stated that computational thinking is one of the Basic Skills (KD) in informatics subjects so that informatics is an important subject

that must be integrated into the curriculum structure in junior and senior high school levels (Permendikbud, 2018). However, in practice, computational thinking has begun to be taught in schools in the 2019/2020 academic year due to consideration of teacher resources and supporting facilities (Zahid, 2020).

Nowadays, research on computational thinking in mathematics learning has been carried out by many researchers in Indonesia, including research conducted by (Apriani et al., 2021; Pratiwi & Akbar, 2022; Wardani et al., 2022). In the Systematic Literature Review research conducted by Marifah et al. (2022) regarding the integration of computational thinking in the elementary school curriculum in Indonesia states that computational thinking skills are one of the competencies needed in the era of the industrial revolution 4.0 and is one of the 21st century abilities, Unplugged activities are used by several researchers to integrate computational thinking learning, and Bebras Challenge questions are widely used to assess computational thinking learning. Based on this research, the researcher is interested in conducting the same research. However, focuses on implementation of computational thinking on mathematics learning research, from elementary school to university level, since the first-time computational thinking was integrated in mathematics learning in Indonesia. This was done because researchers have not found systematics literature review research that is carried out thoroughly from elementary school to university level.

Systematic literature review, according to Petticrew & Roberts (2006), is a method of making sense of large bodies of information, and a means of contributing to the answers to questions about what works and what does not – and many others types of question too. In line, Harris et al. (2014) explain that a systematic review is a comprehensive summary which is carried out by identifying, selecting, and synthesizing to answer certain questions. Using this systematic literature review, researchers can find research gaps for further research purposes (Rum & Juandi, 2022).

This study aims to describe research results related to computational thinking in mathematics learning which are reviewed from the year of publication, the level of education, research location and type of research. Therefore, an important step in this SLR is to collect research results regarding computational thinking in mathematics learning. From the research data, the researchers ask several questions: (1) how is research description result regarding computational thinking in mathematics learning seen from

the year of publication? (2) how is research description result regarding computational thinking in mathematics learning seen from the level of education? (3) how is research description result regarding computational thinking in mathematics learning seen from the research location? (4) how is research description result regarding computational thinking in mathematics learning seen from the research method? And (5) how students' computational thinking process in mathematics learning research?

## **METHODS**

This research is a systematic literature review. Systematic literature review is secondary research that uses systematic methodology to identify, analyze and interpret all available evidence to answer a specific research question in a way that is impartial and (to a degree) repeatable (Kitchenham & Charters, 2007). In determining the appropriate data, researchers used PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) protocol. The steps of selection data are identification, screening, eligibility, and inclusion (Juandi & Tamur, 2020). Stapic et al. (2012) explained the need for inclusion criteria and exclusion criteria to find out relevant and irrelevant data. Here are several inclusion criteria that are used in this study:

1. Research articles on mathematics education
2. Articles and proceedings published in 2019-2023
3. Articles with research locations in Indonesia
4. Research on computational thinking in mathematics education

The selection data using PRISMA protocol can be seen in Figure 1.

## **Research Instruments**

The instrument that is used in this research was an observation sheet or matters that related to the inclusion criteria. The criteria that are used in this study are based on the year of research, education level, research location, and research methods conducted.

## **Population and Sample**

The research population is all researches related to computational thinking in mathematics learning which is published in various media publications. Based on the search, there were 25 articles that met the specified inclusion criteria.

**Data Collection Process**

The data collection technique that is used in this research is to collect articles that discuss computational thinking. The data collected is taken from the Google Scholar database, Google, direct links, and URL’s journals.

**Data Analysis Techniques**

The technique of data analysis in this research was a descriptive quantitative.

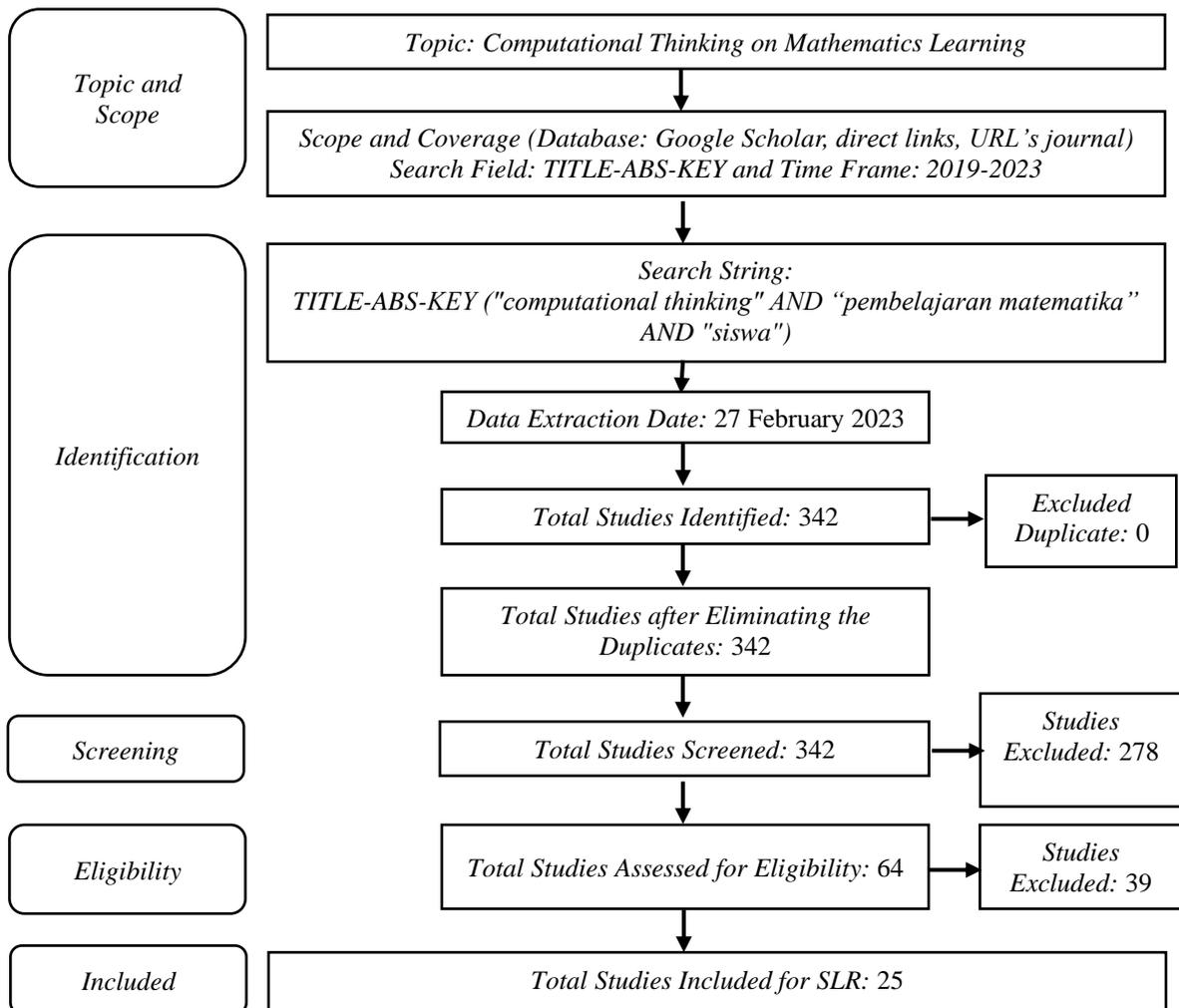


Figure 1. Stages of Systematic Literature Review

**RESULT AND DISCUSSION**

**Study by Year of Publication**

In 2019-2023, a lot of research on computational thinking in mathematics learning has been carried out. The distribution of the number of studies seen from the year of publication can be seen in Figure 2. Based on Figure 2, it can be concluded that the number of research on computational thinking is increasing every year, from 2019 to

2022. Most of the research was conducted in 2022 with a total of 15 published articles. Whereas 2019 was the year with the least amount of computational thinking research in the last 5 years, namely 1 article. This is because computational thinking has just been integrated into the 2013 curriculum in the 2019/2020 academic year, so the number of research conducted is still very limited (Zahid, 2020). Furthermore, Maharani (2020) also revealed that teachers are still in the stage of understanding computational thinking but still have difficulties integrating it in learning. While in 2023 on February there will only be 2 articles and it is possible to add even more.

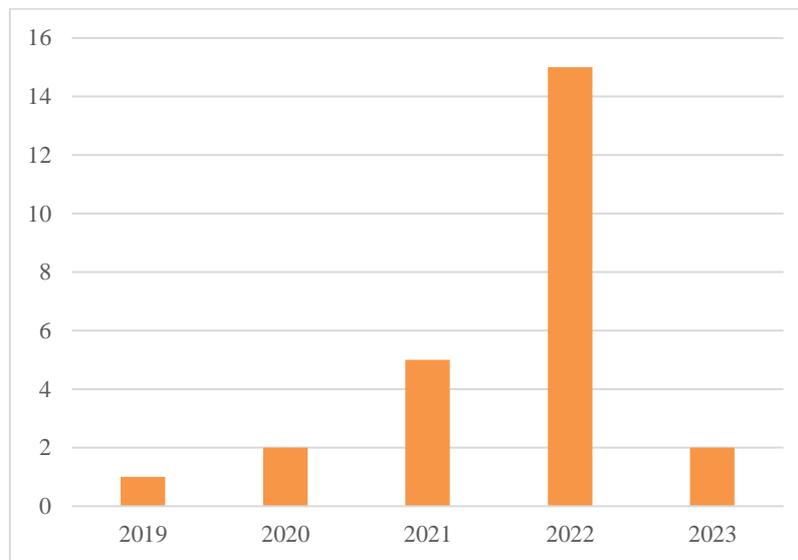


Figure 2. Research Data by Year of Publication

### **Study by Education Level**

Studies on computational thinking in mathematics learning in Indonesia were carried out at various levels of education. The number of studies seen from education level can be seen in Figure 3. Based on Figure 3, this can be inferred that most research on computational thinking in mathematics learning is carried out at the university level where there are 8 studies conducted at that level. This is because teachers need to master computational thinking, so that prospective teachers also need to be prepared to be competent in teaching computational thinking (Yuntawati et al., 2021). Meanwhile, at the elementary and high school level each has the same number of studies, namely 5 studies. This number certainly still needs to be increased because computational thinking needs to be introduced since elementary school to deal with developments in information technology (Kuswanto et al., 2020), and at the junior high school level there were 7 studies.

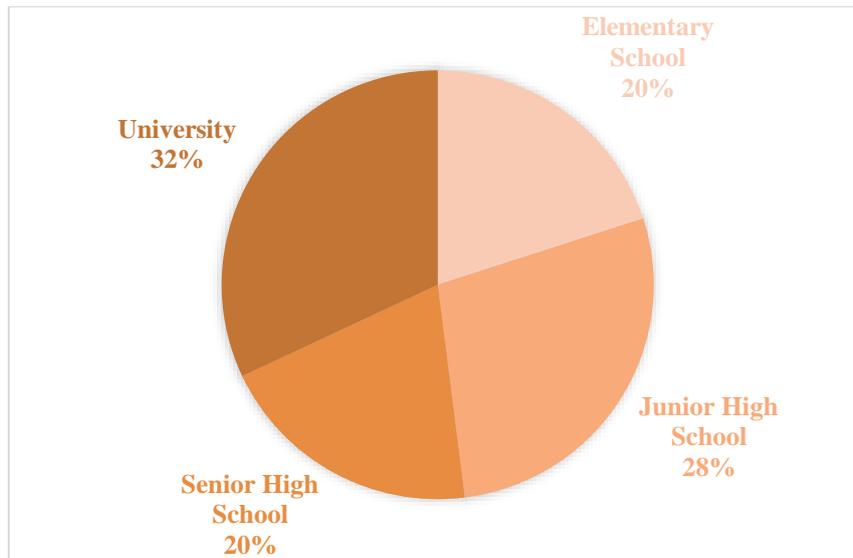


Figure 3. Research Data by the Level of Education

### Study by Research Location

Computational thinking research in mathematics learning has also been carried out in various regions in Indonesia. The following is a distribution of areas where there is research on computational thinking in mathematics learning.



Figure 4. Study Data by the Research Location

Based on Figure 4, this can be concluded that there are 7 computational thinking studies in mathematics learning conducted in East Java Province and it becomes the

largest number of studies among other provinces in Indonesia, 4 studies were conducted in West Java Province, while in Jakarta Province, Central Java Province and Riau Province each had 3 studies, and 2 studies were conducted in West Nusa Tenggara Province, while the Riau Islands Province, North Sumatra Province, and Bangka Belitung Province each had 1 study. In general, there are 17 computational thinking studies conducted on the Java Island. This is in line with research on other mathematics skills, such as mathematical literacy skills which are mostly also conducted on the Java Island (Rum & Juandi, 2022) and students' error due to lack of mathematics skills are mostly conducted in Java Island (Aswin & Juandi, 2022). Therefore, computational thinking research in mathematics education must be handled in other provinces in Indonesia so that computational thinking skills are evenly distributed to all students in Indonesia and teachers know various ways to improve computational thinking skills.

### **Study by Research Methods**

Furthermore, research on computational thinking in mathematics learning has been carried out using various methods. The number of studies, based on the research method used, can be seen in Figure 5 below:

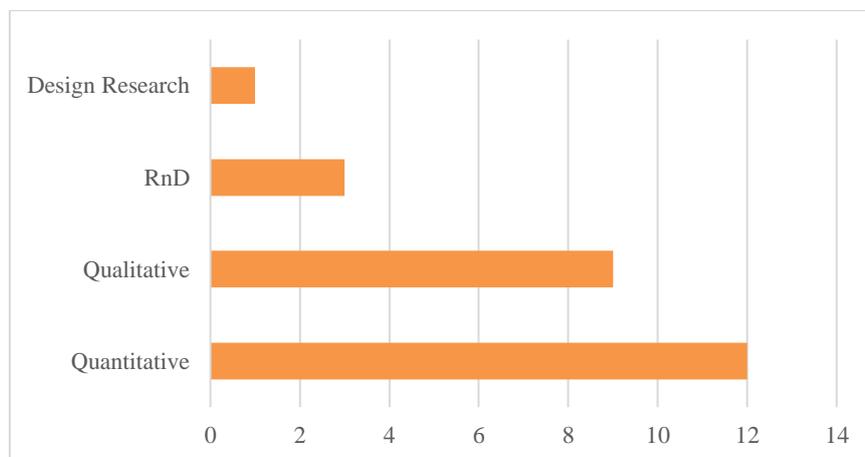


Figure 5. Study by the Research Method

Based on Figure 5, the research method that is often used in researching computational thinking in learning mathematics is the quantitative research method, there are 12 studies using this quantitative method. This is because computational thinking is a thinking skill so that in order to teach it, teachers must carry out certain activities that aim to discuss and improve computational thinking (Zahid, 2020). Meanwhile, there were 9 studies using qualitative methods, 2 studies using the research and development method, and 1 other study using the design research method.

### **Implementation of Computational Thinking on Mathematics Learning Research**

Based on the 25 research articles analyzed, some studies have implemented the aspects of computational thinking completely. the implementation of computational thinking in mathematics learning is presented in Table 1. Based on Table 1, it can be concluded that, in implementing computational thinking in mathematics learning, students are able to carry out the abstraction process and the algorithm process. However, students in performing the algorithm are still not perfect so that students still have difficulty in answering the problems given. In the decomposition process, students have not been able to identify and simplify the information provided. Meanwhile, in the pattern recognition process, students still have difficulty in recognizing various patterns. Therefore, a special stimulus is needed to train students to recognize various patterns.

Table 1. Implementation of Computational Thinking on Mathematics Learning

<b>No</b>	<b>Researcher(s)</b>	<b>Year</b>	<b>Implementation</b>
1	Angraini, L. M., Arcat, and Sohibun	2022	Four aspects of computational thinking, namely: decomposition, pattern recognition, abstraction, and algorithm, have been carried out and the results showed that there was an increase in the ability of computational thinking ability of students who are taught using interactive multimedia-based teaching materials
2	Kadarwati, S., Suparman, and Astutik, K.	2020	The application of the computational thinking and problem based-learning model using four aspects of computational thinking, namely: decomposition, pattern recognition, abstraction, and algorithms effectively improves student creativity and learning outcomes.
3	Kuswanto, H., Rodiyanti, N., Kholiso, Y. N., and Arianti, B. D. S.	2020	This research has applied four aspects of computational thinking, namely: decomposition, pattern recognition, abstraction, and algorithms. The results showed that there is no significant relationship between computational thinking ability and math ability in elementary school-age children.
4	Marchelin, L. E., Hamidah, D. and Resti, N. C.	2022	From the answers of 3 students presented, only one answer of the third student was able to fulfill the computational thinking indicator. Meanwhile, the first student's answer has not been able to identify the information asked (decomposition) and the second student's answer has been able to

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<b>No</b>	<b>Researcher(s)</b>	<b>Year</b>	<b>Implementation</b>
			identify information and draw conclusions from the patterns found in the given problem (abstraction) but the algorithm used is not perfect so that students have not been able to recognize the characteristics of problem solving which causes the problem to not be answered (resolved).
5	Nurmuslimah, Hilda	2019	The results of this study show that students overall have the ability to design algorithms and abstraction. However, special stimulus needs to be given to train students in recognizing patterns, processing data, and especially in problem solving.
6	Wardani, S. S., Susantri, R. D., and Taufik, Marhan	2022	This study involved 10 students, the use of jungle adventure games in learning computational thinking influenced problem solving skills with an average of 60% of students said to be good at decomposition, 70% said to be good at pattern recognition, 80% said to be good at abstraction, and 90% at algorithm.

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## **CONCLUSION**

Based on this systematic literature review, it was found that computational thinking research in mathematics learning in Indonesia has received considerable attention. This was indicated by the increasing number of studies conducted each year. As much as 32% of computational thinking research was carried out at the university level and 48% of it was carried out using quantitative methods. Because of the importance of computational thinking for students' futures, it is suggested for future researchers to carry out mathematics learning that integrates computational thinking starting from the elementary school level. Meanwhile, the implementation of computational thinking research in mathematics learning has not been evenly distributed throughout Indonesia. Dominant computational thinking research was conducted on Java Island. Students are able to perform abstraction and algorithm processes. However, they still have difficulty in performing the decomposition and pattern recognition processes. So that, this can be a consideration for future researchers to try to integrate computational thinking in mathematics learning that is carried out in all regions of Indonesia, not only limited to Java Island, and focuses on improvement of decomposition and pattern recognition process.

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