Indonesian Journal of Teaching in Science

IJOTIS

Computational Thinking in Mathematics Learning: Systematic Literature Review

M. Mitrayana*, Elah Nurlaelah

Department of Mathematic Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229 Bandung 40154, Indonesia
*Correspondence: E-mail: mitrayana671@upi.edu

A B S T R A C T

Computational Thinking (CT) has contributed to changing curricula around the world and is needed by everyone. This study aims to determine the research focus related to Computational thinking in mathematics learning and its novelty. The method used in this study is the method with systematic literature review (SLR). The data taken comes from the Google Scholar and Scopus databases. The moderator variables involved in this study were the year of publication, level of education, research class, research methods, and research instruments. All of the data obtained is presented in a quantitative descriptive manner. The results of the research show that 2022 is the highest peak for publication. This research was dominantly conducted at the junior high school level. And the class that is widely used in research is class XI. The study is dominated by descriptive research methods with a qualitative approach. Instruments that are widely used are tests and interviews.

A R T I C L E   I N F O

1. INTRODUCTION

Computational Thinking (CT) is a way to find solutions to problems from the input data using an algorithm by applying a technique used by software in writing programs Cahdriyana and Richardo, (2020) and a statement from researchers that is that CT is a thinking process involved in formulating a problem in such a way that the solution can be expressed as a computer-like computational step to be performed such as decomposition, pattern recognition , abstraction , and algorithms (Fajri & Utomo , 2019 ; Ansori , 2020 ; Supiarmo & Susanti, 2021). CT has contributed to changing curricula around the world. In the digital era, everyone needs skills (Nasiba, 2022).

CT ability is a thinking process that is involved in such a way that computers, humans, or machines can work effectively (Wing, 2006). Aspects of CT include solving problems, designing systems, and understanding human behavior or traits using the basic concepts of computer science (Dian, 2020). CT is breaking down a problem that looks difficult or complex into a problem that is easy to understand and has a known solution, whether using reduction, insertion, transformation, or simulation. CT can enhance and strengthen intellectual skills (DiSessa, 2018). Integrating computing can engage students from all backgrounds (Lee *et al.,* 2020). CT is not limited to the field of computer science but can be implemented in various other disciplines, such as Natural Sciences, Engineering, and Mathematics (Lee *et al.,* 2020). The statement (Veronica *et al.,* 2022) CT skills are very important in learning mathematics.

Mathematics is a knowledge that is very necessary for the development of technology as a support. Mathematics is the knowledge that if there is a problem there will be a solution. Mathematics decomposes something complex into simpler parts so that it can be understood easily. Mathematics is also a way of thinking to find a solution to a given problem in the simplest way (Ragadhita & Nandiyanto, 2022; Reskianisa *et al.,* 2022).

Research on CT has been widely published , like research conducted by Fajri and Utomo, 2019, Mawardi *et al. (*2020), Kamil, (2021), Saad & Zainudin, 2022) and other research, thus it is necessary to study in depth the statistical methods used in analyzing the results of research, to determine the focus of research and research updates. One method that can be used is a systematic literature review (SLR). SLR is a research method that aims to find and synthesize comprehensive research that refers to specific questions , each step in the process using an organized , transparent , and replicated procedure (Kek & Huijser , 2011 ; Juandi, 2021).

The data collected is in the form of research results related to CT in learning mathematics, then extraction is carried out according to the research question, namely how to describe the ability of CT based on the year of publication, level of education, class, research methods, and research instruments. This study aims to describe CT abilities in terms of the year the article was published, level of education, class or semester, research methods, and research instruments.

2. COMPUTATIONAL THINKING

CT is defined as a series of abstract mental activities that include reasoning processes such as abstraction, decomposition, pattern mapping, pattern recognition, algorithmic thinking, automation, modeling, simulation, assessment, testing, and generalization (Città *et al.,* 2019). CT processes involve a variety of skills and techniques that can train students to formulate problems by breaking down these problems into small parts that are easy to solve, thus making students creative (Angeli & Giannakos, 2020; Wing, 2006). Lee *et al.* (2020) stated that there are four CT skills which are presented as follows :

(i)   Decomposition. Decomposition is defined as the process of simplifying a complex problem so that it is easy to understand, solve, develop, and evaluate separately. Decomposition is also a cognitive activity carried out to break down problems into small parts that are easy to solve, to make it easier for students to solve the problems they face.

(ii)   Pattern recognition. Pattern recognition is the stage of finding different or similar characteristics to determine a solution to a problem. In addition, this stage is also carried out to find out how the methods used solve various types of life problems. This step helps students solve problems and build solutions to problems found.

(iii)   Abstraction. Abstraction is a fast method for solving new problems that are used to solve problems through the experience of similar problems. Abstraction is done by filtering important information or finding conclusions by eliminating elements that are not needed when carrying out a settlement plan.

(iv)   Algorithmic thinking. Algorithmic thinking is the stage of taking a solution to a problem through a definition that is following the facts. Algorithmic thinking is also the steps used to find a logical and structured solution.

3. METHODS
3.1. Systematic Literature Review

This study uses the SLR method with a survey-based quantitative descriptive approach. The survey was conducted on secondary data, namely the results of research on the ability of CT in mathematics learning. The stages of the research started with data collection, and data analysis and ended with concluding (Tamur & Juandi, 2020). Data is collected from primary research results published in Google Scholar and Scopus. The extraction of all found articles aims to select articles that are relevant to the inclusion criteria (Juandi, 2021; Al- Husaeni & Nandiyano, 2022).

3.2. Inclusion Criteria

In this study the inclusion criteria used, namely (1) research on CT skills in learning mathematics; (2) Research in Indonesian and English (3) Research samples ranging from Elementary School (SD) to Higher Education (PT) levels; (4) The research must include classes from the sample education level; (5) Research has been published in 2019 to April 2023; (6) Research must include the approach or method used; (7) the research must contain the research instruments used.

3.3. Research Instrument

This study uses research instruments in the form of protocols related to inclusion and exclusion criteria from primary research, which was based on year publication, level of education, research class, research method, and research instrument. The primary study selection process went through four stages namely; identification, screening, eligibility, and inclusion (Tamur & Juandi, 2020).

3.4. Population and Sample

The population in this study is research on CT skills in learning mathematics that has been published in indexed journals. Publications taken from the Google Scholar and Scopus databases from 2019 to 2023 were analyzed using an SLR. The stages of data collection started with identification, screening, eligibility, and inclusion (see **Figure 1**).
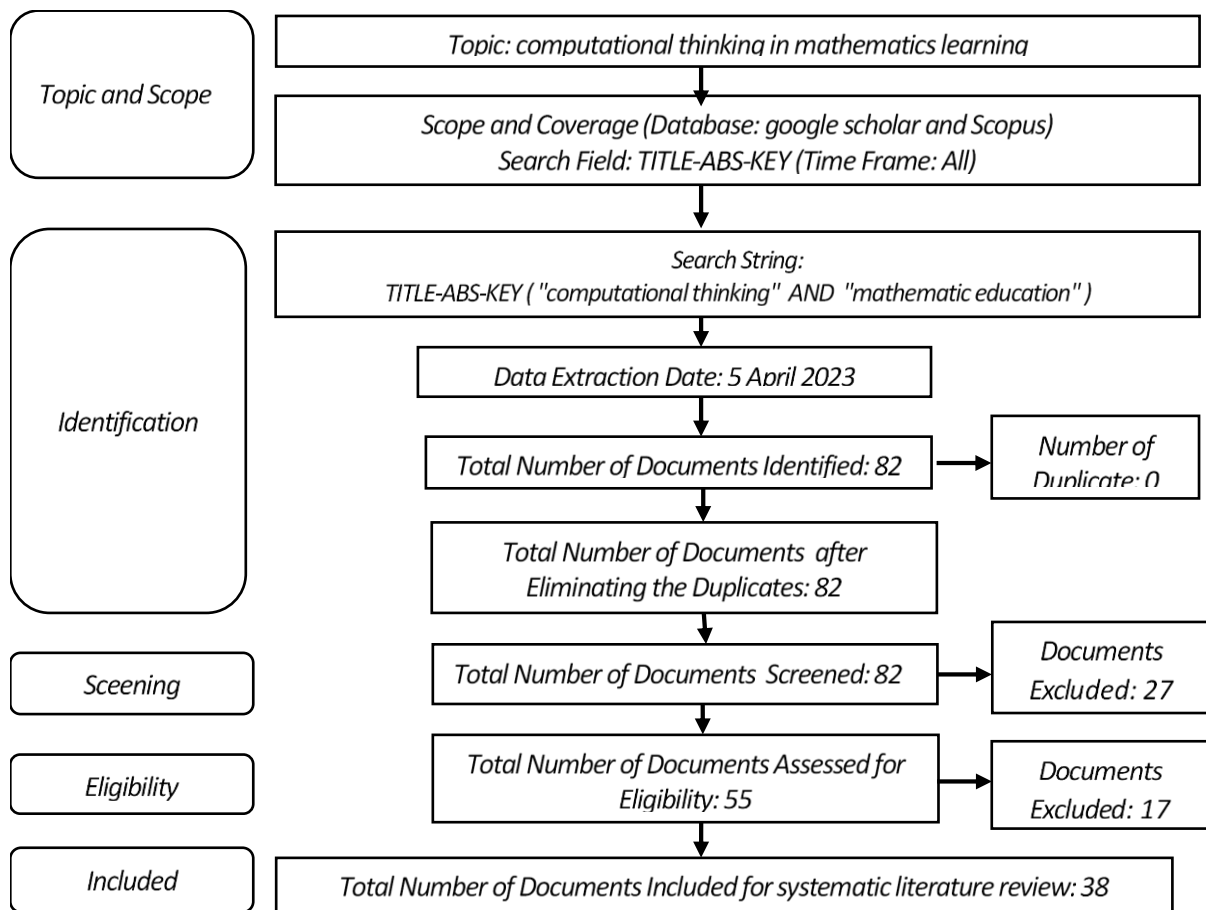
Topic and Scope	Topic: computational thinking in mathematics learning
	Scope and Coverage (Database: google scholar and Scopus) Search Field: TITLE-ABS-KEY (Time Frame: All)

Search String:
TITLE-ABS-KEY ("computational thinking" AND "mathematic education")

Data Extraction Date: 5 April 2023

Identification

Total Number of Documents Identified: 82 → Number of Duplicate: 0

Total Number of Documents after Eliminating the Duplicates: 82

Sceening

Total Number of Documents Screened: 82 → Documents Excluded: 27

Eligibility

Total Number of Documents Assessed for Eligibility: 55 → Documents Excluded: 17

Included

Total Number of Documents Included for systematic literature review: 38

Figure 1. Data of collection process.

Identification is done by entering keywords according to the research theme to be studied. This study discusses CT in learning. For this reason, the researchers entered the keywords "Computational thinking" and "Mathematic education" in the Google Scholar database and the Scopus database. Data were obtained for 82 publications according to the criteria, namely publications in the form of articles and publications in Indonesian and English. the data of publications was then examined whether there were duplicate data or not. Because there was no duplication of data, 82 publications could proceed to the next stage.

Screening is carried out to select publications from the first stage, publications must meet the following criteria, namely titles and abstracts containing the words of CT and learning mathematics. After the screening, 27 articles were discarded and did not proceed to the next stage. A total of 55 who meet the next criteria will be carried out in the eligibility stage.

Eligibility is carrying out the eligibility from the 55 data of documents from the previous stage. It will be seen whether these documents meet the inclusion criteria. after feasibility, 38 publications that met the criteria were obtained which could be continued at the inclusion stage.

4. RESULTS AND DISCUSSION
4.1. Temperature

The inclusion criteria in this study were the year of publication, level of study, class or semester, research methods, and research instruments, which is shown in **Table 1**.

Table 1. Data of research based on criteria.

Characteristic study	Criteria	Frequency
Year of Publication	2019	1
	2020	8
	2021	8
	2022	16
	2023	5
Education level	Elementary school	5
	JUNIOR HIGH SCHOOL	14
	SENIOR HIGH SCHOOL	11
	College	4
	Teacher	4
research class	IV	1
	V	4
	VII	5
	VIII	6
	IX	3
	XI	8
	XII	3
	3rd semester	2
	5th semester	2
	Elementary School teacher	3
	High school teacher	1
research methods	Quantitative	9
	Qualitative	10
	Development research	5
	mixed method	1
	Descriptive	13
research instruments	Test	30
	Interview	19
	Questionnaire	5
	Observation	7
	Documentation	5
	Student worksheet	1
	literature review	1
	Validation	3

4.2. Research Based on Year Publication

The trend of research-related publications from 2019 to 2023 is shown in **Figure 2**. From **Figure 2**, it can be seen that 2022 is the year with most the publications about this research. Research of CT in mathematics learning continues to increase, especially from 2021 to 2022, namely from 8 studies in 2021 increasing to 16 studies in 2022 (Husnah *et al.,* 2021; Marasabessy, 2021; Hashim *et al*., 2021).

4.3. Research Based on Education Level

Research based on educational levels, namely elementary school, junior high school, high school, university, and teachers, is shown in **Figure 3**. In **Figure 3**, it can be seen that research related to CT in mathematics learning is the most researched and published at the level of junior high school, namely 37% or as many as 14 studies. While research on teachers is still small, namely 10%, research is conducted and published. This is something that needs

attention because CT is an important ability to be developed in learning mathematics. Teachers as educators are important to know and apply CT in learning aspects. CT is one of the necessary thinking skills in the 21st century (Kurniasi *et al.,* 2022).
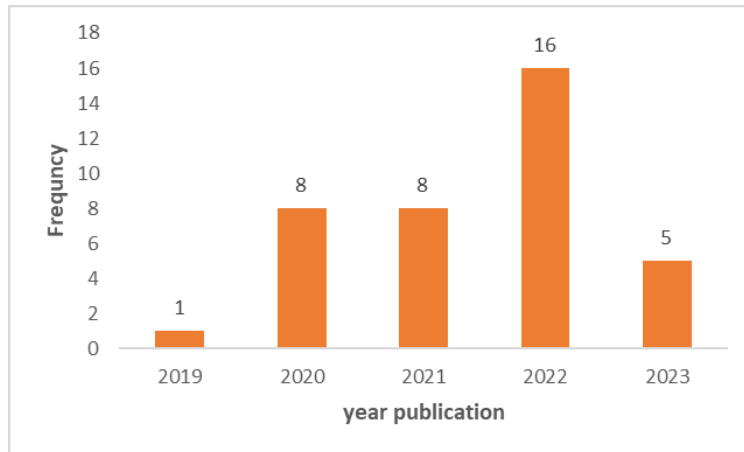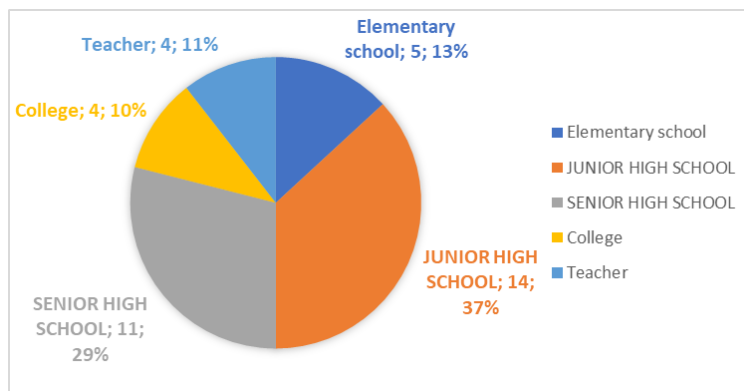

Figure 2. Data of year publication.

Figure 3. Data based on level of education.

4.4. Research Based on Research Class

Research related to CT based on research classes is shown in **Figure 4**. From **Figure 4**, it can be seen that the most research conducted and published in class XI is as many as 8 studies. And there is still little research being conducted and published, namely in class IV as much as 1 research and research on high school teachers is also still a little researched and published.
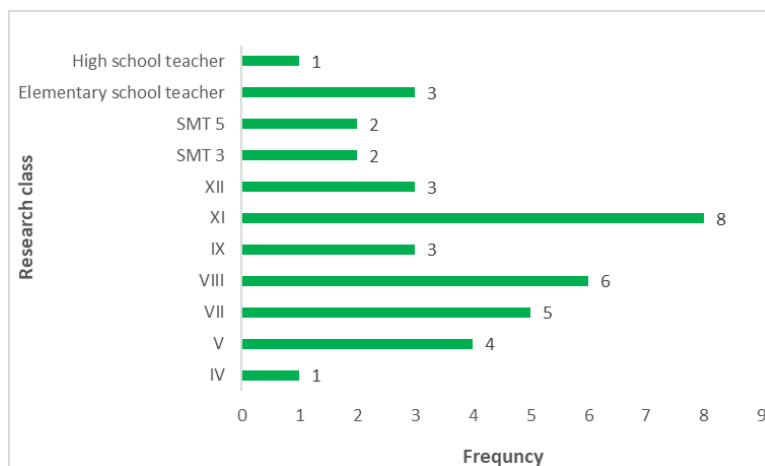

Figure 4. Data based on research class.

4.5. Research Based on Research Methods

CT research in learning mathematics based on the method is shown in **Figure 5**. From **Figure 5**, it can be seen that the method used the most is the descriptive method, whereas for development research and mixed method methods only a few have been carried out and published. From the review studies conducted, it was found that the Qualitative method and the Qualitative method related to research on CT are still balanced. This means that research on CT in mathematics learning methods that vary widely. Research is more dominant using descriptive research methods with a quantitative approach.
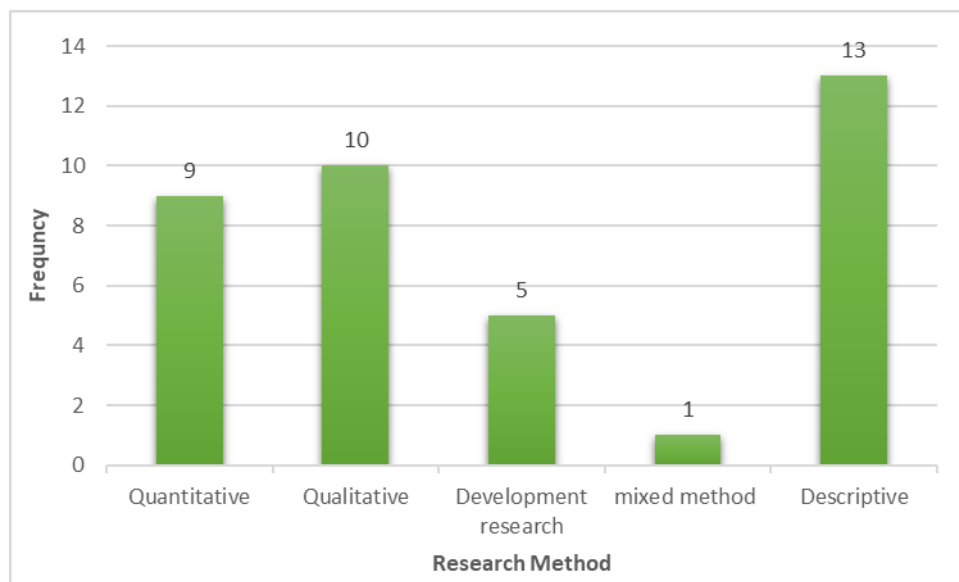

Figure 5. Data based on research methods.

4.6. Research Based on Research Instruments

CT research in learning mathematics based on research instruments is shown in **Figure 6**. From **Figure 6**, it can be seen that the research instruments used varied, from one instrument to four instruments in one study. The most widely used instruments are tests and interviews such as research conducted by researchers (Supiarmo & Susanti, 2021; Fauzi *et al.,* 2022).
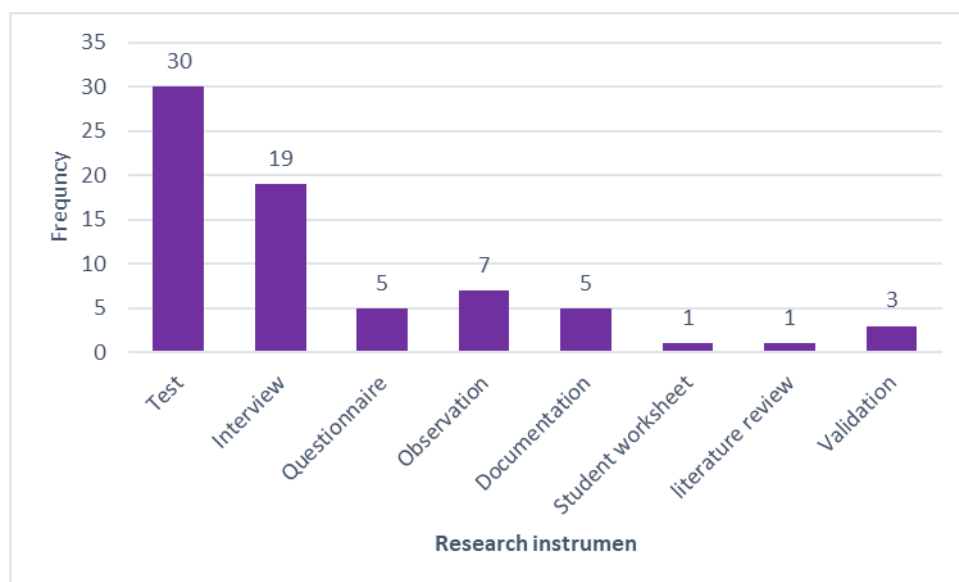

Figure 6. Data based on research instruments.

5. CONCLUSION

CT research in mathematics learning has received good attention, especially from 2020 to 2023 and most research will be in 2022. This research is dominantly conducted at the level of junior high school and the class that is widely used in research is class XI. Research is more dominant using descriptive research methods with a qualitative approach. Instruments that are widely used are tests and interviews. Suggestions for educators or researchers to be able to research CT in mathematics learning for teachers and prospective teachers using research methods other than descriptive methods.

6. ACKNOWLEDGMENT

7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

8. REFERENCES

Al Husaeni, D. F., Nandiyanto, A. B. D. (2022). Bibliometric computational mapping analysis of publications on mechanical engineering education using vosviewer, *Journal of Engineering Science and Technology,17*(2), 1135-1149.

Angeli, C., and Giannakos, M. (2020). Computational thinking education: Issues and challenges. *Computers in Human Behavior*, *105*, 1-7.

Ansori, M. (2020). Pemikiran komputasi (computational thinking) dalam pemecahan masalah. *Dirasah: Jurnal Studi Ilmu Dan Manajemen Pendidikan Islam*, *3*(1), 111-126.

Cahdriyana, R. A., and Richardo, R. (2020). Berpikir komputasi dalam pembelajaran matematika. *Literasi (Jurnal Ilmu Pendidikan)*, *11*(1), 50-56.

Città, G., Gentile, M., Allegra, M., Arrigo, M., Conti, D., Ottaviano, S., and Sciortino, M. (2019). The effects of mental rotation on computational thinking. *Computers and Education*, *141*, 1-11.

Dian, M. (2020). Aspek-aspek kemampuan berpikir komputasional dalam penyelesaian masalah matematika. *Widya Warta*, *2*(02), 147-153.

DiSessa, A. A. (2018). Computational literacy and "the big picture" concerning computers in mathematics education. *Mathematical Thinking and Learning*, *20*(1), 3-31.

Fajri, M., and Utomo, E. (2019). Computational thinking, mathematical thinking berorientasi gaya kognitif pada pembelajaran matematika di sekolah dasar. *Dinamika Matematika Sekolah Dasar*, *1*(1), 1-18.

Fauzi, F. A., Ratnaningsih, N., and Lestari, P. (2022). Pengembangan digibook barisan dan deret berbasis anyflip untuk mengeksplor kemampuan berpikir komputasional peserta didik. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *6*(1), 191-203.

Hashim, S., Masek, A., Mahthir, B. N. S. M., Rashid, A. H. A., and Nincarean, D. (2021). Association of interest, attitude and learning habit in mathematics learning towards enhancing students' achievement. *Indonesian Journal of Science and Technology*, *6*(1), 113-122.

Husnah, A. U., Hidayat, M. A., and Jannah, M. (2021). The journey of a math: As a mathematics learning innovation. *Indonesian Journal of Multidiciplinary Research, 1*(1), 129-136.

Juandi, D. (2021). Heterogeneity of problem-based learning outcomes for improving mathematical competence: A systematic literature review. *Journal of Physics: Conference Series*, 1722(1), 1-7.

Kamil, M. R. (2021). Analisis kemampuan berpikir komputasional matematis Siswa Kelas IX SMP Negeri 1 Cikampek pada materi pola bilangan. *AKSIOMA: Jurnal Matematika dan Pendidikan Matematika*, *12*(2), 259-270.

Kek, M. Y. C. A., and Huijser, H. (2011). The power of problem-based learning in developing critical thinking skills: Preparing students for tomorrow's digital futures in today's classrooms. *Higher Education Research and Development*, *30*(3), 329-341.

Kurniasi, E. R., Vebrian, R., and Arsisari, A. (2022). Development of student worksheets based computational thinking for derivatives of algebra function. *Jurnal Teori dan Aplikasi Matematika*, *6*(1), 212-222.

Lee, I., Grover, S., Martin, F., Pillai, S., and Malyn-Smith, J. (2020). Computational thinking from a disciplinary perspective: Integrating computational thinking in K-12 science, technology, engineering, and mathematics education. *Journal of Science Education and Technology*, *29*, 1-8.

Saad, A., and Zainudin, S. (2022). A review of project-based learning (PBL) and omputational thinking (CT) in teaching and learning. *Learning and Motivatio*n, *78,* 101802.

Marasabessy, R. (2021). Study of mathematical reasoning ability for mathematics learning in schools: A literature review. *Indonesian Journal of Teaching in Scienc*e, *1*(2), 79-90.

Mawardi, A. V., Yanti, A. W., and Arrifadah, Y. (2020). Analisis proses berpikir siswa dalam menyelesaikan soal hots ditinjau dari gaya kognitif. *JRPM (Jurnal Review Pembelajaran Matematika)*, *5*(1), 40-52.

Nasiba , U. (2022). Brankas rahasia : Media pembelajaran numerasi berbasis berpikir komputasi untuk meningkatkan kemampuan pemecahan masalah . *Jurnal Didaktika Pendidikan Dasar*, *6*(2), 521-538.

Ragahita, R., and Nandiyanto, A. B. D. (2022). Computational bibliometric analysis on publication of techno-economic education. *Indonesian Journal of Multidiciplinary Research, 2*(1), 213-220.

Reskianissa, A., Sakti, A. W., Azizah, N. N. (2022). TikTok platform to train middle school students' computational thinking skills in distance learning. *ASEAN Journal of Educational Research and Technology, 1*(1), 79-86.

Supiarmo, M. G., and Susanti, E. (2021). Proses berpikir komputasional siswa dalam menyelesaikan soal pisa konten change and relationship berdasarkan self-regulated learning. *Numeracy*, *8*(1), 58-72.

Tamur, M., and Juandi, D. (2020). Effectiveness of constructivism based learning models against students mathematical creative thinking abilities in Indonesia: A meta-analysis study. *Pervasive Health: Pervasive Computing Technologies for Healthcare*, *1*, 107-114.

Veronica, A. R., Siswono, T. Y. E., and Wiryanto, W. (2022). Hubungan berpikir komputasi dan pemecahan masalah polya pada pembelajaran matematika di sekolah dasar. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *5*(1), 115-126.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.