

Integration of computational thinking in mathematics learning in Senior Secondary Education from 2019-2023: Systematic Literature Review

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ABSTRACT

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Mathematical thinking is very important for everyone and must be trained from childhood to face and solve everyday problems. To overcome problems and adapt to changes that occur in the era of globalization, changes in the industrial revolution 4.0 The world of education must be able to act quickly and precisely. Computational Thinking (CT), also known as computational thinking, is a process that involves formulating problems and finding solutions, as well as using these solutions to process information effectively to solve problems. The first objective, of this research it is hoped that someone will find it easy to observe problems, find solutions to problems, solve problems, and be able to develop solutions or solutions to problems. Apart from that, computational thinking hones us to think more effectively and efficiently. Second, to obtain a theoretical framework that can help solve the problem being researched to reveal concepts relevant to the case, especially in research that studies more deeply about research. Integration of Computational Thinking in Mathematics Learning in Senior Secondary Education. Stages In this research there are five stages, formulating the problem (1), searching for literature (2), selecting appropriate literature search results (3), analyzing several literature from test results (4), and making conclusions (5). The results show that articles reviewed by researchers regarding Computational thinking are associated with technology namely, from 14 articles referring to 9 articles that passed QA.



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1. Introduction

Mathematical thinking is very important for everyone and must be trained from childhood to face and solve everyday problems [1][2][3]. Because mathematical thinking is the best way of thinking to solve problems in the world today, mathematical thinking can control one's emotions when studying mathematics and solving problems [4][5][6][7]. This way of thinking helps people improve their ability to think critically, logically, and structured and improves their ability to solve problems [8][9][10].

To overcome problems and adapt to changes that occur in the era of globalization, changes in the Industrial Revolution 4.0 [11][12][13]. The world of education must be able to act quickly and precisely. According to the National Science Teachers Association (NSTA) and the US government, the Next Generation Science Standards (NGSS) are educational standards needed to create quality human resources [14][15]. Efforts to teach students according to the NGSS to improve mathematical thinking skills. Making students capable of computational thinking of course starts with the teacher, which is in line with [16] that a teacher's academic abilities are also needed to keep up with developments in technology and information. However, in reality, there are still educational units whose educational staff do not apply mathematical thinking [2].

Computational Thinking (CT), also known as computational thinking, is a process that involves formulating problems and finding solutions, as well as using these solutions to process information effectively to solve problems. Computational thinking helps students solve problems by breaking them down into smaller parts. When solving problems, students find it easier to find problem patterns and solutions [6][17][18].

Based on this description, researchers are interested in conducting research in the form of Integration of Computational Thinking in Mathematics Learning in Senior Secondary Education from 2019-2023: Systematic Literature Review. With the hope that computational thinking will make it easy for someone to observe problems, find solutions to problems, solve problems, and be able to develop solutions or solutions to problems. Apart from that, computational thinking hones us to think more effectively and efficiently. CT abilities are very relevant to the objectives of mathematics learning, namely problem-solving abilities. CT is the ability to solve complex problems by following computer steps [19].

One effort that can be made to see the ability of CT in learning is by implementing learning media that can build computational thinking patterns for students. Technology learned several years ago is starting to be replaced with new technology, including various conventional learning systems [20][21]. The results of research on CT are widely associated with technology, science and mathematics, integrity in a subject, and are also associated with the contribution of CT to intelligence. Previous research findings form the basis for differences with the research to be conducted. The research focuses on mathematics subjects at all levels of education which provides information regarding learning models that insert CT in mathematics learning, materials that insert CT in mathematics learning, and research findings about CT in mathematics learning [22]. This literature study will aim to answer several how do researchers choose the topics regarding the Integrity of Computational Thinking in Mathematics Learning in Senior Secondary Education and Types of research, data collection techniques, and research tools, what subjects are used to research the Integrity of Computational Thinking in Mathematics Learning in Senior Secondary Education.

2. Research Methods

This research was conducted using a literature review research method. This research explains the existing findings and data. The results can be used as an example of other research to organize or discuss the problem to be researched. To make their content or discussion strong, authors obtain data or literature material from articles or journals, as well as references from books. In this research, the content is related to the use of systematic literature analysis methods. Systematic Literature Review refers to a method for finding, evaluating, and interpreting all available research that is relevant to the problem formulation or topic being discussed [23]. This method is used to search and collect journals, draw several conclusions, and then research them thoroughly to achieve good results that meet expectations. The method in this research is to use systematic review and meta-analysis (PRISMA) [24] with the hope that it can guide the implementation and reporting of research carried out. Systematic Literature Review It is useful for synthesizing various relevant research results so that the facts presented are more comprehensive and balanced. The question of this study is to find out research about (CT) in mathematics learning. The criteria for this research are research on CT in mathematics learning which is published in the form of articles in a journal. To search for these articles, the Google Scholar and Scopus databases were used using Harzing's Publish and Perish and grouped and stored in Mendeley. To search for articles as data, use two keywords, computational thinking or mathematical thinking. The data was taken from 2019 to 2023. From Google Scholar Around, Dimensions, and with Harzing's Publish and Perish

2.1 Object of research

The object of this research is an article related to the Integrity of Computational Thinking in Mathematics Learning in Senior Secondary Education

2.2 Stages of Systematic Literature Review (SLR) Research

The stages in SLR research consist of five stages, namely:

Stage 1: Formulating the Problem

At this stage, the researcher writes a problem formulation that will be discussed in depth. This research question was created based on the needs of the selected topic, namely:

Table 1. Research Questions (RQ)

Research Question 1	<i>How is the journal distributed? discussing CT in learning mathematics for middle/high school age (appropriate search engines)</i>
Research Question 2	<i>How is the journal distributed? discussing CT in learning mathematics for middle/high school age (appropriate search engines)</i>
Research Question 3	<i>What are the topics and research trends? selected by researchers on CT on age mathematics learning Middle school/high school?</i>
Research Question 4	<i>What are the topics and research trends? selected by researchers on CT on age mathematics learning Middle school/high school?</i>

Types of research, data collection techniques, and research tools, what subjects are used to research the Integrity of Computational Thinking in Mathematics Learning in Senior Secondary Education?

Stage 2: Searching for Literature (Identification)

After formulating the topic and formulating the problems raised, the next stage is to search for relevant articles, or what is known as the search process.

From the identification results and the author limited the articles from 2019 to 2023, it was found from Google Scholar that around 17,200 articles were found, Dimensions found 1,214 articles and Harzing's Publish and Perish citations were found for 58 articles.

The following are the steps for collecting data from 3 search sources (Search Engines), namely (1) web Google Scholar (2) dimensions <https://dimensions.ai> (3) publish or perish.

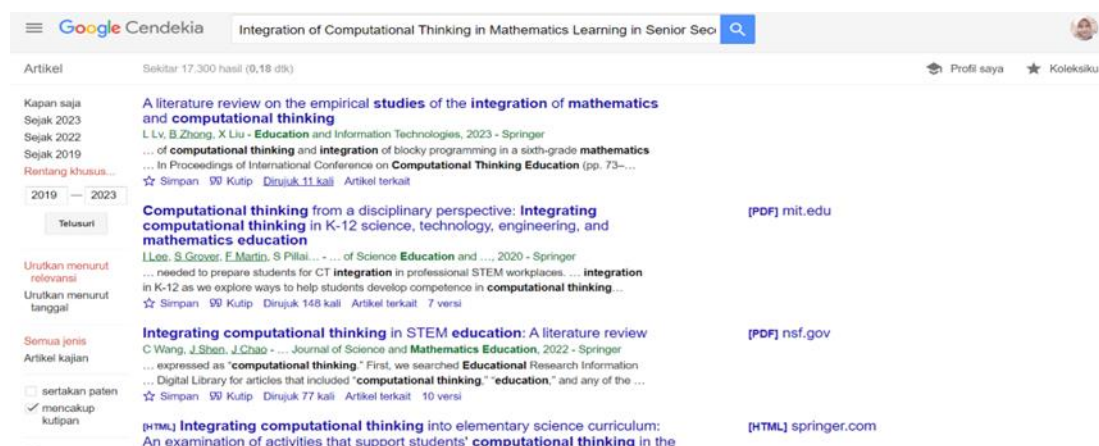


Figure 1. Journal search on the Google Scholar web page

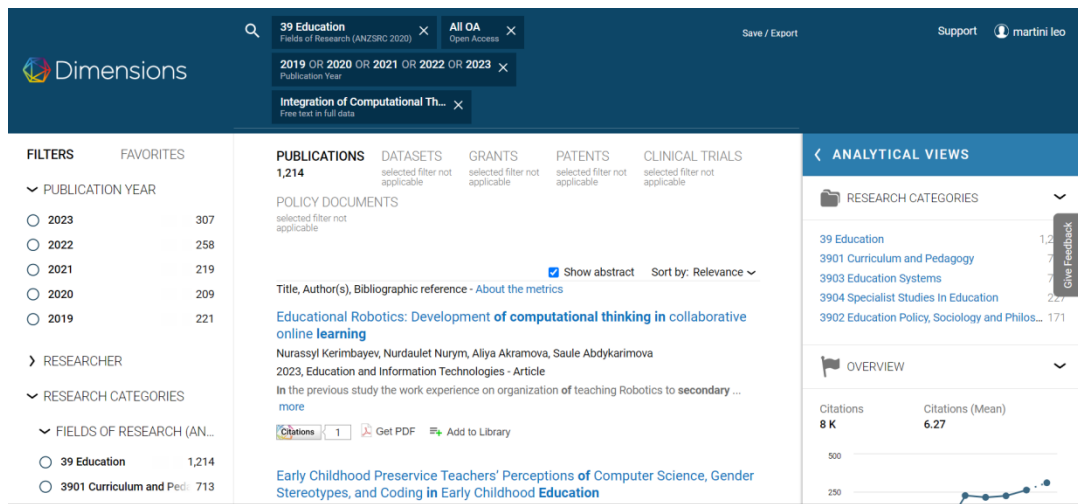


Figure 2. Journal search on the Dimension 1 web page

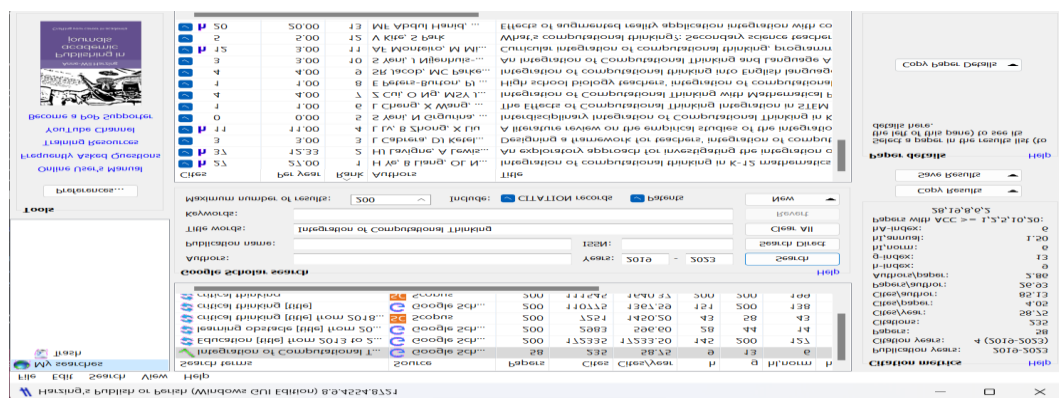


Figure 3. Journal search on the Publish or Perish web page

Stage 3: Selecting literature search results that are by the quality assessment (screening and eligibility)

At this stage, it is carried out to decide whether the data found is suitable for use in SLR research or not. At this stage, Inclusion and Exclusion Criteria are determined using the PICOS approach [25][26][27]. (Population, Intervention, Comparison, Outcomes, Study) which looks like the following **Table 2:**

Table 2. Eligibility format and inclusion criteria

Criteria	Inclusion	Exclusion
Population	Study of CT on learning age math middle/high school	Study of CT on learning age math middle/high school
Writers' institute	More than 2 institutions	Less than 2 institutions
Year of Publication	2019-2023	Before 2020-2021
Author/Author	More than 3 authors	Less than 3 authors

3. Results And Discussion

In this research, articles or journals that will be discussed in depth must meet the following quality assessment criteria:

Table 3. Quality Assessment (QA) Format

Quality Assessment (QA)	Information
Quality Assessment 1	Does the article contain research results on the Integrity of Computational Thinking in Mathematics Learning in Senior Secondary Education?
Quality Assessment 2	Did more than 2 authors write the article?
Quality Assessment 3	Did more than 2 institutions write the article?
Quality Assessment 4	Will the article be published in 2029-2023?
Quality Assessment 5	Is the article indexed by Scopus and Google Scholar?

From each paper, an answer value will be given below for each question above.

Y (Yes): for articles that pass the 5 criteria above

T (No): for articles that do not pass the 5 criteria above

Table 4. Quality Assessment (QA) Results

No	Title	Writer	Quality Assessment (QA)					Information	
			QA1	QA2	QA3	QA4	QA5	Yes	No
1	Early Childhood Preservice Teachers' Perceptions of Computer Science, Gender Stereotypes, and Coding in Early Childhood Education	(Ari, Arslan-Ari, and Vasconcelos 2022) [28]			✓	✓	✓		✓
2	Educational Robotics: Development of computational thinking in collaborative online learning	(Kerimbayev et al. 2023) [6]	✓	✓	✓	✓	✓	✓	
3	Nurturing Secondary School Students' Computational Thinking Through Educational Robotics	(Jawawi et al. 2022) [29]	✓	✓	✓	✓	✓	✓	
4	Computational thinking: early childhood teachers and prospective teachers' preconceptions and self-efficacy	(Avci and Deniz 2022) [30]		✓	✓	✓	✓		✓
5	The Impact of a STEM Inquiry Game Learning Scenario on Computational Thinking and Computer Self-confidence	(Psycharis and Kotzampasaki 2019) [31]		✓	✓	✓	✓		✓
6	The implementation of Computational Thinking on Mathematics Learning Research: A Systematic Literature Review	(Mukhibin and Juandi 2023) [27]		✓	✓	✓	✓		✓

No	Title	Writer	Quality Assessment (QA)					Information	
			QA1	QA2	QA3	QA4	QA5	Yes	No
7	Assessing Computational Thinking: Development and Validation of the Algorithmic Thinking Test for Adults	(Martínez et al. 2022) [32]	✓	✓	✓	✓	✓	✓	
8	Defining Computational Thinking as an Evident Tool in Problem-Solving: Comparative Research on Chinese and Canadian Mathematics Textbooks	(Zhang (张艺美) and Savard 2023) [33]	✓	✓	✓	✓	✓	✓	
9	Exploring Gamification Approaches for Enhancing Computational Thinking in Young Learners	(del Olmo-Muñoz et al. 2023) [34]	✓	✓	✓	✓	✓	✓	
10	Twenty years into the new millennium: How integrated are Mathematics, Physics, and Computer Science at the secondary school level?	(Basson 2021) [35]	✓	✓	✓	✓	✓	✓	
11	Developing Computational Thinking: Design-Based Learning and Interdisciplinary Activity Design	(Wang et al. 2022) [36]	✓	✓	✓	✓	✓	✓	
12	A Study of the Readiness of Implementing Computational Thinking in Compulsory Education in Taiwan	(Hsu 2023) [37]	✓	✓	✓	✓	✓	✓	
13	Learning Composite and Prime Numbers Through Developing an App: An Example of Computational Thinking Development Through Primary Mathematics Learning	(Kong 2023)) [38]		✓	✓	✓	✓		✓
14	Employing Robotics in Education to Enhance Cognitive Development—A Pilot Study	(Kálózi-Szabó, Mohai, and Cottini 2022) [39]	✓	✓	✓	✓	✓	✓	

From the results of the assessment based on Quality Assessment, it can be seen that of the 14 articles that will be reviewed in-depth, only 9 articles passed QA, and 5 articles did not pass QA. So based on the table above, this research will only discuss 9 articles. If depicted in diagram form, stages 1-3 will look like the following image:

4. Conclusions

Articles reviewed by researchers regarding computational thinking are associated with technology. The results of CT research in schools are mostly related to coding and computer subjects at the vocational school level [40]. The next subject that is often associated with CT is mathematics at the high school level. The large number of CT studies found means that the focus of discussion is CT research related to mathematics subjects. The results of this research are presented based on a systematic review of research using computational thinking (CT) in mathematics learning from the Scopus database Harzing's Publish and Perish and Google Scholar. From Google Scholar around 17,200 articles, Dimensions found 1,214 articles, and using Harzing's Publish and Perish found citations for 58 articles it can be seen that of the 14 articles that will be reviewed in depth, there are only 9 articles that passed QA, 5 articles did not pass QA. The results are presented in the following subsections based on the categories described in the methods section.

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