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SYSTEMATIC REVIEW OF SCRATCH AS A MEDIA FOR TEACHING COMPUTATIONAL THINKING IN MATHEMATICS

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ABSTRACT

The use of Scratch software has become the focus of research in the context of mathematics learning. This study focuses on analyzing the effect of using Scratch on students' computational thinking skills. Methods This research uses the SLR (*Systematic Literature Review*) using the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) for the topics *of Computational Thinking* (CT) and Scratch media. The literature search was carried out thoroughly and systematically using various academic databases, namely Erick Jurnal. Research shows that the use of Scratch is effective in improving students' CT skills, especially when integrated into various subjects, one of that mathematics. Integrating Scratch is also effective in improving students' CT skills in elementary level, more effective with another approach like m-block, python, STEAM, and VEE. Next deep research is needed to support CT learning through Scratch programming.

Keywords : Computational Thinking, Scratch, Impact.

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PRELIMINARY

Mathematics is a discipline that plays a central role in human life, serving as a fundamental basis for understanding and advancing science and technology (Widana et al., 2024). However, in the context of classroom learning, mathematics is often perceived as a difficult subject due to its abstract nature, which is dominated by formulas and complex calculations. This perception has led many students to become reluctant to engage actively in mathematics learning (Haryati & Pranata, 2024). In fact, mathematical thinking is not only essential for solving academic problems but also constitutes a critical component of broader mental activities, such as critical thinking, decision-making, and problem-solving. These three processes are closely interrelated and form the core of computational thinking skills, which are increasingly recognized as essential competencies in addressing the challenges of the 21st century (Sari & Yahfizham, 2024). Therefore, it is imperative for educational systems to design mathematics instruction that goes beyond procedural fluency and fosters logical, systematic, and reflective modes of thinking.

In line with the importance of mathematical thinking in supporting 21st-century skills, computational thinking is also recognized as a vital component of the problem-solving process. Wing defines computational thinking as a problem-solving approach that applies logic in a continuous and systematic manner (Ardianti, 2024). These abilities reflect the analytical skills that underlie effective problem-solving, enabling students to address complex and ambiguous challenges more efficiently (Memolo, 2022). Furthermore, Tang et al., as cited in Huda (2023), state that computational thinking involves the mental process of formulating and solving problems, with the resulting solutions effectively represented by information-processing agents. Accordingly, computational thinking is not only closely linked to problem-solving mindsets but also demonstrates a logical connection to the use of digital technologies as tools for modeling, simulating, and executing solutions. This underscores that integrating technology into the learning process is not merely supplementary, but rather a crucial strategy for cultivating computational thinking in a contextual and practical manner.

A concrete example of technology integration in education that supports the development of computational thinking skills is the use of visual programming platforms such as Scratch. Scratch offers a variety of benefits for learners, including helping them learn the basics of coding, understand problem-solving strategies, design creative works, and communicate ideas in a visual and interactive manner. These benefits contribute significantly to the cultivation of computational thinking skills from an early age (Wulandari, 2021). Although originally designed for children aged 8 to 16, Scratch is accessible to users of all age groups, including adolescents and adults. Through this platform, users can create programs in the form of interactive stories, educational games, animations, and various types of digital media that support contextual learning (http://scratch.mit.edu). Another notable advantage of Scratch is its ease of use. As Sarifah (2023) notes, Scratch is highly user-friendly for beginners, including teachers who may not yet be proficient in operating computers. Therefore, Scratch serves as a promising tool for integrating technology into mathematics instruction in an engaging and meaningful way.

The integration of computational thinking (CT) and Scratch presents significant opportunities for enhancing mathematics learning. Scratch provides a platform for students to engage with mathematical content in an interactive and creative manner while simultaneously fostering their CT skills. For instance, students can develop mathematical simulations using Scratch, such as dynamic models to explore geometric or algebraic concepts. They can also design programs to solve problems systematically—calculating the area of geometric shapes, creating visual representations of equations, or developing solutions to complex mathematical tasks. This dual approach not only deepens students' conceptual understanding of mathematics but also cultivates essential skills in problem-solving and computational thinking, which are increasingly vital in today's digital society. As such, the integration of CT through tools like Scratch serves as both a pedagogical strategy and a means to equip learners with future-ready competencies.

Based on the literature review and the focus on integrating computational thinking (CT) with the Scratch platform in mathematics learning, this study aims to address several key research questions.

1. What types of research have emerged on the topic of CT and Scratch?
2. How much research has been done on the topic of CT and Scratch?
3. How does the use of this Scratch application affect learning?
4. What is the impact of using Scratch on learning?

METHODS

The methodology used in this study is *a Systematic Literature Review* (SLR) using the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) method for the topics *of Computational Thinking* (CT) and Media Scratch.

1. Planning:

The first step in applying the PRISMA method is to plan a clear and detailed literature review. This includes determining the research question, developing the research protocol, and assessing the feasibility and relevance of the topic. PRISMA is a minimum item rule for reporting in systematic reviews and meta-analyses based on evidence. The PRISMA protocol helps researchers identify study outcomes that have accurate literature according to the objectives of the study through three processes, including identification, screening and eligibility (Gillath & Karantzas, 2019).

2. Literature Search:

The literature search was carried out thoroughly and systematically using various academic databases, namely Erick Jurnal. Keywords relevant to the research topic are used in the search, abstract and research year i.e. the last 5 years. Then English is a language that has been used during the process of searching for articles using the following string of keywords: ("*computational thinking*" OR "CT" AND "SCRATCH" AND "*Mathematic Education*". Based on these keywords, a total of 99 articles have been obtained.

3. Admission and Rejection Criteria

In conducting this systematic literature review, a rigorous article selection process was implemented to ensure the relevance and quality of the included studies. Only articles that met specific admission criteria were considered for analysis. These criteria focused on publication period, type of publication, language, and accessibility. Conversely, articles that did not meet these standards were excluded based on clearly defined rejection criteria. This process ensures that the review is both current and comprehensive, providing reliable insights into the integration of computational thinking and Scratch in mathematics education.

Table 1. Admission and Rejection Criteria

Admission	Rejection
Articles published from 2020 to 2024 to ensure that the articles are relevant and appropriate to the current situation.	Articles published in 2020 and below.
Articles that have full open access so that they can be researched and analyzed.	Articles that have not open full access.
Articles published in English.	Articles published other than in English.
Selected articles in the form of "Journal Articles"	Selected articles are not in the form of "Journal Articles."

4. Analysis and Synthesis:

Based on the acceptance criteria and rejection criteria, as many as 10 articles are suitable and feasible. Throughout the screening process, article suitability was identified by analyzing the topic, keywords, and abstract of the article, followed by reading the full article. A total of 10 articles were then studied and researched through a thematic analysis process for the purpose of classifying articles by theme. The following is the Journal Selection Flow.

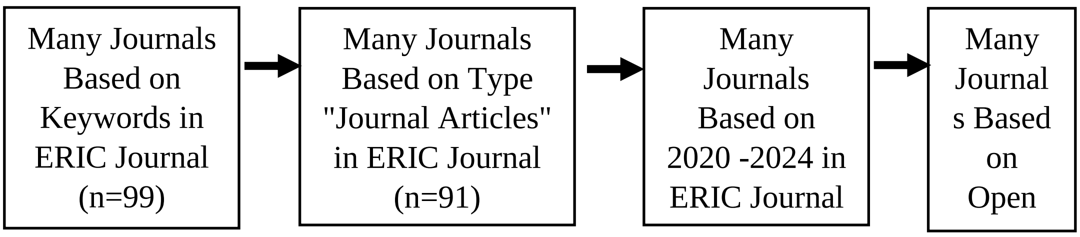

Table 2. Journal Finding

Code Author	Author	Heading	Year
[1]	William H. STEWART1 and Kwanwoo BAEK	*Analyzing Computational Thinking Studies in Scratch Programming: A Review of Elementary Education Literature*	*2023*
[2]	João PIEDADE and Nuno DOROTEA	*Effects of Scratch-Based Activities on 4th-Grade Students' Computational Thinking Skills*	*2023*
[3]	Ulaş Ilic	*The Impact of Scratch-Assisted Instruction on Computational Thinking (CT) Skills of Pre-Service Teachers*	*2021*
[4]	Wei-Ling Tan, Muhad Ali Samsudin, Muhad Urfi Ismail, Noor Jahan Ahmed, Korina Abdul Talib	*Exploring the Effectiveness of STEAM Integrated Approach via Scratch on Computational Thinking*	*2021*
[5]	Janne FAGERLUND Päivi HÄKKINEN, Mikko VESISENAHO , Jouni VIIRI	*Assessing 4th Grade Students' Computational Thinking through Scratch Programming Projects*	*2020*
[6]	İbrahim Çetin, Tarik Otu	*The Effect of the Modality on Students' Computational Thinking, Programming Attitude, and Programming Achievement*	*2023*
[7]	Abdullah Koray, Eda Bilgin	*The Effect of Block Coding (Scratch) Activities Integrated into the 5E Learning Model in Science Teaching on Students' Computational Thinking Skills and Programming Self-Efficacy*	*2023*
[8]	Raquel Hijón Neira, Miguel García-Iruela, Cornelia Connolly	*Developing and Assessing Computational Thinking in Secondary Education Using a TPACK Guided Scratch Visual Execution Environment*	*2021*
[9]	Adelmo ELOY , Camila F. ACHUTTI, Cassia FERNANDEZ, Roseli de Deus LOPES	*A Data-Driven Approach to Assess Computational Thinking Concepts Based on Learners' Artifacts*	*2022*
[10]	Manargul Mukasheva from Aisara Omirzakova	*Computational Thinking Assessment at Primary School in the Context of Learning Programming*	*2021*

RESULT AND DISCUSSION

Computational Thinking (CT) has become popular in recent years and has been recognized as an essential skill for everyone in the digital age[1], trend in education in many countries and several initiatives have been developed for its inclusion in school curricula[2]. Abdul Mut'i, the Minister of Basic and Secondary Education (Mendikdasmen), stated that by 2025 the implementation of topic Coding and AI will be applied in Indonesia and is currently in the harmonization stage. Reviewing the implementation of the types of topics and how they are in other countries, the following data was obtained:

Table 3. Research result

Code Author	Main Topic	Educational Target	Country
[1]	CT research in primary education with Scratch	Elementary school students	Korea Selatan & AS (global literature)
[2]	The influence of Scratch-based activities on the computational thinking of fourth-grade student	(ages 6-12) 189 fourth-grade	Portugal
[3]	The influence of Scratch-based learning on pre-service teachers	students 33 pre-service teacher	Turki
[4]	The integrated STEAM approach using Scratch towards the CT sub-dimension	students 59 students (29 boys, 30 girls),	Malaysia
[5]	Assessment of 4th grade students' CT through Scratch projects	57 fourth-grade	Finlandia
[6]	The influence of programming approaches (Scratch, mBlock, Python) on CT, attitudes, and programming achievements.	students Sixth graders (around ages 11-12) 105 students	Turki
[7]	Integration of Scratch in the 5E learning model in science lessons	Sixth-grade students, 22 Students	Turki
[8]	Development and assessment of CT using Scratch and the TPACK framework	(two cohorts: club & regular school)	Spanyol and Irlandia
[9]	Automated CT assessment based on Scratch projects in MOOC	MOOC participants (varied ages, mostly K-12 students)	Brasil
[10]	Assessment of CT development in elementary school students using Scratch	Elementary school students (102 students)	Kazakhstan

Furthermore, Scratch can be more successful by integrating it into courses such as mathematics and science [7], it was stated that the use of Scratch software could contribute to students of all grades from preschool to higher education [3], actually in elementary. Based on research [1][2][5][6][7][10], scratch has proven to be effective in enhancing students' computational thinking skills at that level. More than that, the design of various types of projects besides Scratch [5] can be maximally enhanced, such as m-block, python [6] and Science Technology Engineering Art. Mathematic (STEAM) [4] with gender.

Scratch research from a gender perspective is closely related to computational thinking. Male students have a higher average score compared to female students, and the difference is greater in the experimental group [2]. Furthermore, the integrated STEAM approach through Scratch has successfully supported five subconstructs of CT skills for both male and female students. Both male and female students showed an improvement in CT skills [4], although other studies indicate otherwise, showing no significant correlation between CT levels and gender [3]. However, it emphasizes that its findings contradict the findings of other studies. All of the discussion by this result:

Table 4. Variables related to the use scratch in computational thinking

Variables measured	Sources	Frequency
Grade	[1], [2], [5], [6], [7], [10]	6
Gender	[2], [3], [4]	3
Assessment	[8], [9], [10]	3
Achievement	[4], [7]	2
science	[2], [4]	2
perception	[4], [8]	2
Attitude	[6], [7]	2
Motivation learn	[1]	1
Creativity	[1]	1
Teaching methods	[1]	1
Educational taxonomy	[10]	1
Type of projects	[6]	1
Online engagement	[9]	1
Coding patterns	[5]	1
Student involvement in programming	[5]	1
VEE experience	[8]	1
Self-efficacy in programming	[7]	1
Programming concepts	[8]	1

Another important variable related to computational thinking is how to assess computational thinking itself. Studies note that it is difficult to find tools or methods that can be used to assess the level of development of computational thinking. The content analysis by Kalelioglu (2018) states that only 6 out of 65 studies focused on evaluating computational thinking skills [10]. using the Technological Pedagogical Content Knowledge (TPACK) framework that is guided and integrates a Visual Execution Environment (VEE) with Scratch for middle school students shows an increase in knowledge about computational concepts and programming, as well as encouraging them to translate (not transfer) their computational thinking experiences into reality. [8], Second applying an approach to automatically assess computational thinking in Massive Open Online Courses (MOOCs) regarding, that is, the dropout rate of participants while working on projects. Additionally, there is no significant difference between the profiles of participants who drop out and computational thinking [9]. Therefore, it is very important to increase research on the assessment of computational thinking

CONCLUSION

This research provides and expands understanding of the impact of Scratch Integration on computational thinking, both in terms of grade and gender. Additionally, it offers insights to educators on various strategies that can be used in learning by integrating with other projects such as m-block, python, MOOC, and VEE. The author's hope and dream is that math learning can be integrated with AI or IoT according to the school curriculum to create more innovative and relevant learning for future needs.

The author finds that there is still limited research on how to assess computational thinking skills themselves, as only 3 out of 10 articles were found discussing the assessment of computational thinking. Therefore, more in-depth research on assessing computational thinking is needed.

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