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The Evolution of Computational Thinking in Junior High School Mathematics Learning: A Study of Research Trends 2019-2024

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Abstract

This study aims to analyze articles that meet the criteria of the study of the litelature study of Computational Thinking research trends in Mathematics learning at the elementary level in 2019-2024, the research method uses PRISMA, all articles have been filtered according to the needs of the research. The results of the study revealed that there were two articles that used *CT* in high school Mathematics learning. The results of the first article of the study showed that high school students had a positive attitude towards programming and high self-efficacy. Meanwhile, the results of the second article research show that educational games can improve students' academic achievement. In addition, this learning approach provides a fun learning environment. This study is expected to be a reference for future researchers

Keywords: Trend analysis; SLR; prisma

I. INTRODUCTION

The need for learning in the 21st century requires high qualifications and various skills that must be mastered by students, including critical thinking, problem-solving skills, communication skills, collaboration skills, innovation and creativity skills, as well as good reading skills, emotional awareness, cultural competence, etc. *[1]*. It is important for students to improve their problem-solving skills to solve problems encountered daily and develop 21st century talents, especially with the challenges of having ChatGPT in learning *[2]*. Problem-solving skills include identifying, selecting, evaluating, organizing and considering many alternatives and interpreting information [3], [4], [5]. In practice, learning must be packaged with a selection of diverse learning devices and technology applications, learning strategies combined with pedagogy must also be selected *[6], [7], [8], [9]*. In addition, learning must develop digital professionalism that is not only with theory and practice in learning [10].

The approach that is suitable for solving the problem above is interactive teaching materials based on Computational Thinking (CT) to improve student problem solving with the help of the canva application, CT is one of the innovative learning approaches in the field of mathematics [9], [11], [12]. CT is a thinking process that involves the ability to solve problems using mathematical, logical, and computational concepts [13], [14], [15]. By using the CT approach in mathematics learning, it is hoped that students can be more skilled in solving problems and developing critical thinking skills. Mathematical ability is considered a core factor that predicts students' ability to learn, so CT can improve mastery of number sense material and arithmetic skills influenced by thinking styles, attitudes towards mathematics, and cognitive habits *[16], [17], [18], [19]*.

In mathematics education, CT is necessary to help students understand that mathematics not only finds the right answer to a problem, but also understands the problem and knows that there is no single solution to the problem. Problem-solving involves understanding mathematics in the context of everyday life and not just theoretical mathematics [4], [20], [21], [22]. In this situation, CT emerged as a problem-solving method with the main goal of improving numeracy skills. This will help students of all ages in improving other problem-solving skills [23].

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Based on previous research, computational thinking has an important role, considering that the ability to solve problems is indispensable in facing various daily challenges *[24], [25]*. In line with that, CT thinking is a thinking process that includes the formulation of problems and the delivery of solutions in a way that allows humans and machines to operate effectively and efficiently [26], [27]. CT thinking is the ability to think in innovative ways, observe phenomena in everyday life, and find various practical solutions to the problems being studied. To develop CT, one is required to formulate a problem and then devise a more effective computational solution in the form of algorithms.

Various information such as CT research trends can help researchers and educators understand the development of research in the field and then plan the next research. Therefore, the current literature review aims to analyze and provide an overview of computational thought research from 2019 to 2023. Therefore, this research can provide more complete and accurate information to assist researchers and educators around the world in conducting research related to computer thinking, as well as the possibility of publishing articles in the future.

Thus, the researcher wants to conduct a literature review related to the topic in terms of content, process, product, and learning environment. The purpose of writing this literature review is to obtain a theoretical framework that can petrify to solve the problem being researched, as well as reveal concepts relevant to this case, especially in the context of more in-depth research.

II. METHODS

This review was conducted using PRISMA, which has been developed by [28], with the aim of providing a comprehensive report. PRISMA allows the reader to evaluate the suitability of the method used and therefore can trust the results. In addition, this review presents and summarizes various aspects of the study leading to synthesis, which assists policymakers in assessing the relevance of the findings to their own situation. According Page, PRISMA provides three main benefits. First, it helps formulate the right research questions that form the basis for systematic studies. Secondly, PRISMA assists in developing criteria for including or issuing relevant studies. Third, PRISMA seeks to analyze publications in large scientific databases within a certain period of time. Overall, PRISMA's statement allows for a comprehensive search for terms related to innovative teaching.

III. RESULTS AND DISCUSSION

The implementation of this research has gone through several stages, namely: formulating the problem, searching for literature, selecting the results of the literature search in accordance with *the Quality Assessment*, and analyzing the article.

Stage 1: Formulate the Problem

At this stage, the researcher formulates the problem to be analyzed in more depth, with research questions arranged according to the needs of the chosen topic, namely:

Table 1. Research Question (RQ) 1

Research Question 1	How are journals that discuss *CT* distributed in mathematics learning at the junior high school level?
Research Question 2	How many authors and institutions are in the article about *CT* in mathematics learning at the junior high school level?
Research Question 3	What are the research topics and trends chosen by the researchers about *CT* in mathematics learning at the junior high school level?
Research Question 4	Types of research, data collection techniques and research tools, what subjects are used to research *CT* in mathematics learning at the junior high school level?

Stage 2: Searching for Literature (Identification)

After establishing the topic and formulation of the problem raised, the next stage is to conduct a search for relevant articles, known as the search process. A total of 484 articles were found based on title and abstract identification, 442 of which came from dimensions.ai and 42 from publish or perish. The search results are illustrated in the following chart:

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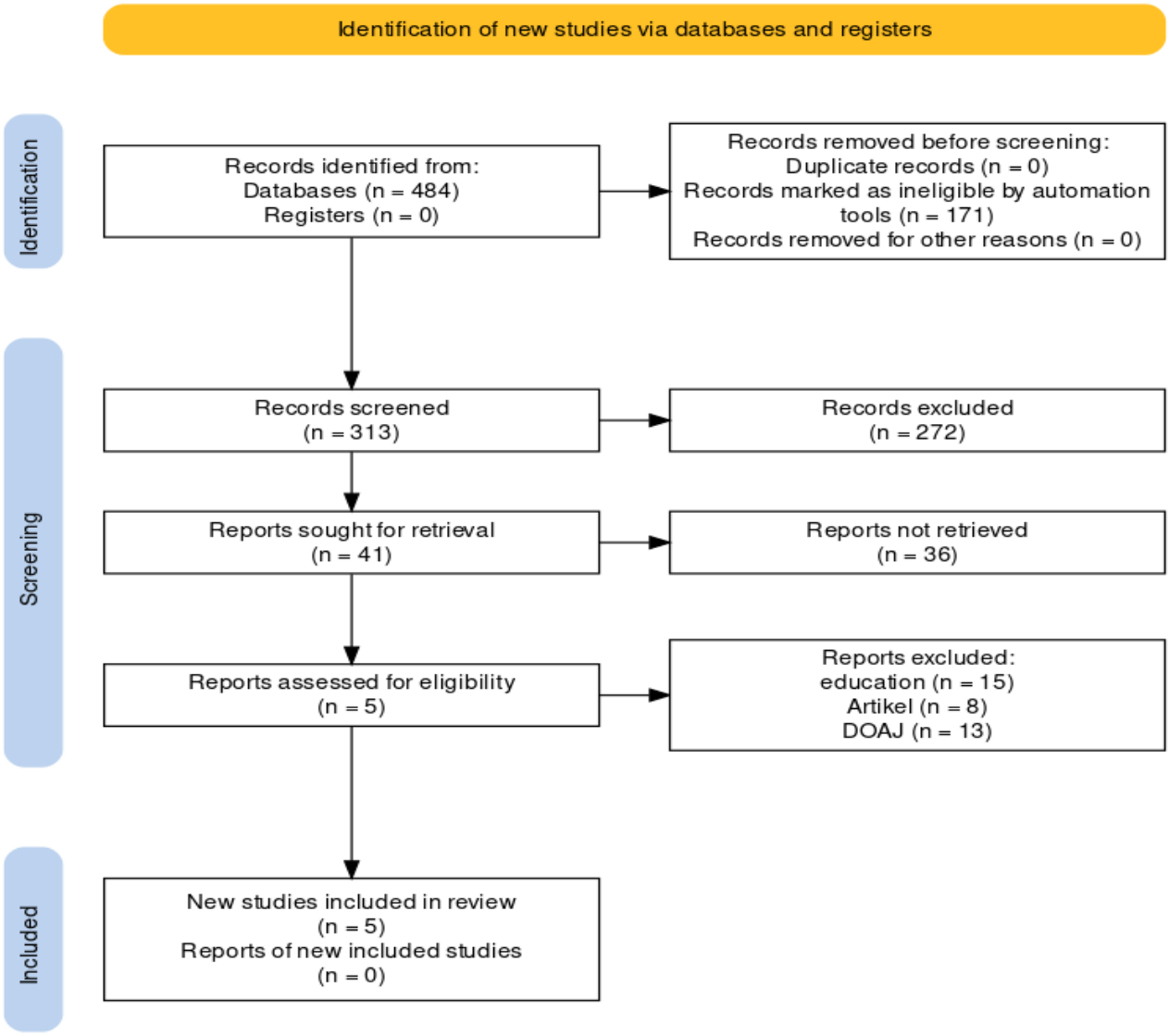

Figure 1. Prisma data

As a result of the first search step, 484 results were found. The findings are still very broad, because they are not limited to years. As a result, researchers narrowed down the literature search to the year limit. From the restrictions based on 2019 - 2023, 313 articles were obtained. Due to the still very broad scope, the researcher limited the search for literature to the period 2019 – 2023 and the field of research (education). From the restrictions based on 2019 - 2023 and files of research (education), 41 articles were obtained. Because it is still very broad, researchers narrow the search for literature with the limitations of 2019 – 2023, files of research (education) and DOAJ Journal List. From the restrictions in 2019 – 2023, DOAJ's files of research (education) and Journal List were obtained article 5.

Stage 3: Select literature search results that are in accordance with *the Quality Assessment* (screening and eligibility)

This stage is carried out to determine inclusion and exclusion criteria using the PICOS approach, so that it can decide on feasible data to be used in SLR research (Budgen and Brereton, 2006). The following table shows the results (Population, Intervetion, Comparison, Outcomes, Study):

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Table 3.1. PICOS Format in Literature Studies 1

Criterion	Inclusion	Exclusion
Population	Study on *CT* on mathematics learning	Unrelated study on *CT* on junior high school math learning
Intervention (Action)	There is an action	No action
Writer's Institution	More than 2 institutions	Less than 2 institutions
Yield (Yield)	How to discuss *CT* in junior high school mathematics learning	-
Study (Study Design)	Using qualitative and quantitative approaches	In addition to using qualitative and quantitative approaches
Year of Publication	Year 2019-2023	Before 2019
Author/Author	More than 3 authors	Less than 3 authors

In this study, the article or journal to be analyzed in depth must meet the quality assessment criteria set as follows:

Table 3.2. Quality *Assessment* (QA) Format 1

***Quality Assessment* (QA)**	**information**
***Quality Assessment* 1**	Does the article contain the results of research on *CT* in junior high school/high school mathematics learning?
***Quality Assessment* 2**	Is the article written by more than 2 authors?
***Quality Assessment* 3**	Are articles written by more than 2 institutions?
***Quality Assessment* 4**	Was the article published in 2019-2023?
***Quality Assessment* 5**	Is the article indexed by Scopus and Google Scholar?

Each paper will be assigned a score based on the answers below for each of the questions asked above.
Y (Yes): for articles that meet the 5 criteria above
T (No) : for articles that do not meet the 5 criteria above

Table 3.3. Quality *Assessment* (QA) Results of Articles

Not	Heading	Writer	***Quality Assessment* (QA)**					**information**	
			QA 1	**QA 2**	**QA 3**	**QA 4**	**QA 5**	**Y**	**T**
1	Elementary Students' First Approach to Computing Thinking and Programming [29]	Linda Mannila, Susanne Kjällander, Anna Åkerfeldt and Fredrik Heintz https://shorturl.at/gdg0B	√	√	√	√	√	√	
2	Design and development of EduPocket A+ [30]	Norfaridatul Akmar , Nur Yasmin Nadhirah, , Ainul Tasneem , Iman Sabrina , Fitrah Nasuha https://ejournal.unikama.ac.id/index.php/momentum/article/view/5700	√	√	√	√	√	√	
3	Mapping the Evolution of Computational Thinking in Education: Bibliometric Analysis of the Scopus Database from 1987 to 2023 [31]	Arif Ainur RAFIQ , Mochamad Bruri TRIYONO , Istanto Wahyu DJATMIKO, Ratna WARDANI , Thomas KÖHLER https://infedu.vu.lt/journal/INFEDU/article/762/info	-	√	√	√	√		√

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4	Introduction to the special edition on "Computational thinking and mathematics teaching and learning. [32]	Max Stephens1 and Chantal Buteau2 Journal of Pedagogical Research, Volume 7, Issue 2, pp. 1-4 https://doi.org/10.33902/JPR.202313362	-	√	√	√	√		√
5	Early grade science, technology, engineering, and math dialogue reading programs: conceptual framework development [33]	Hanrie S. Bezuidenhout https://sajce.co.za/index.php/sajce/article/view/1038/1916		√	√	√	√		√

The results of the Quality *Assessment* show that out of 4 articles that will be thoroughly researched, there are only 2 articles that meet the Qa criteria. Therefore, in this study, we will only discuss these two articles.
From the results of the assessment through the Quality Assessment, it appears that out of 4 articles that will be examined in-depth, only 2 articles have passed the Qa. So based on the table above, this study will discuss only 2 articles.

Stage 4: Article Analysis
This fourth stage analyses from the results of the third stage of screening, so there are only two articles that will be analysed. The following will discuss the results of the analysis of each article that meets the criteria.
The first is in research entitled Design and development EduPocket A+. The Science, Technology, and Mathematics Engineering (STEM) objectives, Digital competencies and programming are actively in the spotlight in the world of education. Both are part of curricula around the world, including the Swedish primary school curriculum. Children are expected to develop computational thinking through programming activities, especially in mathematics—which should be based on proven experience and a scientific basis. Both are lacking in elementary school grades. This article provides a unique insight into student learning during the first programming lesson based on the experiences of a group of Swedish students while entering school. The purpose of this article is to inform educational policies and practices. This large interdisciplinary longitudinal research project studied approximately 1500 students aged 6–16 and their teachers over three years, using video documentation, questionnaires, and focus group interviews. This article reports empirical data collected during the first year in a class with 30 students aged 6–7 years. The multimodal social semiotic theoretical framework "Design for Learning" is used to investigate potential signs of learning in students' multimedia representations. For example, using block programming in primary and secondary transformation units. The results showed that high school students had a positive attitude towards programming and high self-efficacy.
The next analysis, in the second article, shows that educational games can improve students' academic achievement. In addition, this learning approach provides a fun learning environment, increases student engagement in learning, and increases students' interest and motivation in STEM education. However, the study of game-based learning engaging students as educational game designers or inventors is still lacking in Malaysia, especially at the secondary school level. In addition, relatively little research has focused on the development of EduPocketA+. Meanwhile, in the Elementary Students' First Approach to Computational Thinking and Programming research. Digital competencies and programming are actively highlighted in the field of education around the world. They become part of the curriculum around the world, including the Swedish elementary school curriculum, Children are expected to develop computational thinking through programming activities, especially in mathematics which is supposed to be based on proven experience and scientific foundation. Both are lacking in the lower grades of elementary school. This article provides a unique insight into student learning during the first programming lesson based on a group of Swedish students' experiences when entering school. The purpose of this article is to inform educational policies and practices. The large, longitudinal interdisciplinary research project studied approximately 1500 students aged 6–16 and their teachers over three years, using video documentation, questionnaires, and focus group interviews. This article reports empirical data collected during the first year in a class with 30 children aged 6-7 years. Socio-

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semiotic, the multimodal theoretical framework "Design for Learning" is used to investigate potential learning signs in students' multimodal representations when they, for example, use block programming in primary and secondary transformation units. We showed that young students had a positive attitude towards programming and high self-efficacy, and the signs that students were learning in programming were multimodal and often seen in social interactions.

IV. CONCLUSIONS

CT represents a set of skills that should be learned from kindergarten. This article presents a systematic review of the literature with studies published between 2019 and 2023 that discuss *CT* and mathematics education. The results identify the progress and limitations of research in that area. Based on a systematic review, it was found that the most popular tools used to develop *CT* Capabilities according to the findings of this study are coding programs and robotics activities. Different teaching tools that include *CT* in pedagogic materials have an important role in the formation of CT Skills in mathematics education. Furthermore, the results of this study revealed that non-ASEAN countries do most of the research on *CT*. It can be said that the collaboration between these scholars is mostly focused on the national level or neighboring countries. This is because *CT* ability in educational mathematics in ASEAN countries is currently still lacking. *CT* capabilities in ASEAN countries must be strengthened in order to prepare the country for industrialized countries. This is due to the fact that *CT* abilities are at the heart of science, technology, engineering, and mathematics (STEM)

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