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# Exploring Technology, Role, and Components of Computational Thinking in Mathematics Learning: A Systematic Literature Review

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**ABSTRACT**

Computational thinking as a 21st century skill has attracted the attention of researchers, including in mathematics education. This research identifies the use of technology, the role and components of computational thinking in mathematics learning. This study uses a sysematic literature review with procedure consisting of planning the review, conducting the review, and reporting the review. The articles used came from the Scopus database in the 2010-2024 publication time range. Based on the PRISMA protocol involving criteria such as type of publication, language, field of study, publication stage, and accessibility to the article, 11 articles were obtained with the most research conducted in Spain. The research conducted involved many students and teachers as the object of research, including pre-service teachers. The reviewed studies also revealed that most of the computational thinking research used qualitative methods where the role of computational thinking in the research was mostly as a process or activity or tools used in learning, either using technological devices or in the form of unplugged activites. In addition, the results of the review of selected articles also reveal that the components of decomposition, pattern recognition, abstraction, and algorithm are still dominating as the main components studied in computational thinking.

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## A. INTRODUCTION

The development of technology has had an impact on learning that occurs in the classroom, including in mathematics learning. The development of information and communication technology (ICT) and its integration in mathematics learning causes a major transformation so that mathematics learning is not only about transferring mathematical knowledge, but accommodating the abilities needed by students to be able to use ICT (Irawan et al., 2024). With the development of ICT, one ability that must be possessed by students is Computational Thinking (CT) (Li et al., 2020; Park & Kwon, 2022; Weintrop et al., 2016).

The term Computational Thinking first refers to Papert (1980) statement that "computer languages that simultaneously provide a means of control over the computer and offer new and powerful descriptive languages for thinking will undoubtedly be carried into the general culture" (pp.98). The statement shows that computer language can be one of the things that facilitate the occurrence or development of the thinking process. Computational thinking is very close to computers, as Berland and Wilensky (2015) stated that CT is the ability to think through computers as a tool. However, Wing (in Kallia et al., 2021) states that CT is a skill for everyone and not only for computer scientists, besides CT has become the center of attention of educational researchers. Thus, CT is not only always related to the use of technology such as computers, but can also be done in other contexts without having to use computers.

Computational thinking is a cognitive process that involves formulating problems and presenting solutions as performed by computers or machines (Wing, 2017). Belmar (2022) stated that CT includes thinking skills that are specific to problem solving. However, in CT, logical thinking is very important because it involves analyzing situations to decide on a course of action. In CT, there are fundamental components that can vary according to experts. However, from several opinions, there are at least some common components, namely decomposition, pattern recognition, abstraction, and algorithm (Dong et al., 2019; T. Y. Lee et al., 2014; Shute et al., 2017; Wing, 2006; Yadav et al., 2017). The researcher summarized the definitions of the four components above as presented by Lee et al. (2014) and Shute et al. (2017) i.e: (1) decomposition as the process of breaking down a large problem into smaller or more detailed sub-problems; (2) pattern recognition as relating a situation, required action or event to a similar phenomenon so that it can be used to make predictions, in this case, the act of recognizing similar parts is performed; (3) abstraction as the process of extracting or distilling the essence of a (complex) system or the essential parts of a problem; and (4) algorithm as the logical steps required to construct a solution to a given problem.

Similar to the previously described CT components, Kalelioğlu et al. (2016) developed a framework for CT that includes several CT components, namely: (1) problem identification as a form of abstraction and decomposition; (2) collecting, representing, and analyzing data as a form of collecting data, analysis, pattern recognition, conceptualizing, and data representation; (3) generating, selecting, and planning as a form of mathematical reasoning, algorithms, and procedures; (4) implementing solutions as a form of automation, modeling, and simulation; and (5) assessing solutions and continuing improvements as a form of testing, debugging, and generalization.

The learning process involving CT has provided a new paradigm in mathematics learning. Computational thinking can be seen as a tool as well as an object in learning (Wu & Yang, 2022). Through the integration of CT in mathematics learning, it provides an opportunity for students to be able to improve their mathematical thinking skills while fostering problem solving skills (Khoo et al., 2022; Kynigos & Grizioti, 2018; Ramaila & Shilenge, 2023; Wu & Yang, 2022). Through key elements in CT in the form of algorithms and abstractions, students can understand and build a system of understanding so that students' mathematical abilities can improve. In addition to being beneficial to students' mathematical abilities, integrating CT in mathematics learning also has other positive impacts on mathematics learning itself. Weintrop et al. (2016) stated that there are three benefits obtained by integrating CT in mathematics learning, namely: (1) the establishment of a relationship between CT and mathematics; (2) improving teachers' skills and overcoming practical problems; and (3) making mathematics learning in line with current professional practices.

Several studies have investigated the implementation of CT in mathematics learning through various potential ways (Alonso-García et al., 2024; T. Y. Lee et al., 2014; Rodríguez-Martínez et al., 2020; Zurnacı & Turan, 2024). Nonetheless, some literature shows that CT in learning is still problematic. In the context of curriculum, Kite et al. (2021) stated that CT has the opportunity to cause obstacles in the learning process. One of the obstacles encountered is the difficulty of teachers in integrating CT with curriculum or instructional practices, such as the selection of learning models (Çiftçi & Topçu, 2023; Kite et al., 2021). On the technical aspect, integrating CT in learning requires qualified resources, including time. On the other hand, on the student aspect, the demand for rapid adaptation to the shift in learning paradigm can be an obstacle in itself. However, Irawan et al. (2024) stated that the integration of CT in mathematics learning will continue to grow.

Studies on CT are still growing, but some studies also state that there is limited consensus on how CT should be operationalized in learning (Grover & Pea, 2013; Román-González et al., 2017). Thus, while it is believed that the study of CT will continue to evolve including the diversity of theoretical interpretations, the study of CT remains challenging as there are still many practical issues that need to be further explored. Some scholars state that these practical issues include what activities and approaches can be used to integrate CT effectively and how CT is assessed in new contexts (Grover & Pea, 2013; Shute et al., 2017; Tang et al., 2020). Based on the results of relevant studies related to CT, a comprehensive exploration specifically in mathematics learning of the development of CT research, technological tools used in mathematics learning, the role of CT in mathematics learning, and the components of CT is very important to know. Therefore, it is necessary to know how these things are in mathematics learning by involving CT, so that the development of mathematics education curriculum becomes comprehensive and supports the demands of 21st century skills. Therefore, in this study, the researcher conducted a literature review on CT through a Systematic Literature Review with the research objectives, namely: (1) to know the distribution of CT research, both from the geographical aspects of CT research locations, respondents involved in CT research, and research methods carried out; (2) to know the technology applications used in CT research in mathematics learning; (3) to know the position/use of CT as a research variable in the studies conducted; and (4) to know the CT components that are the focus of research from the articles reviewed.

## B. METHODS

This research was used Systematic Literature Review (SLR) research with the aim as expressed by Juandi (2021) to find, select, and evaluate and analyze research results. Studies through SLR are useful for conducting future research based on previous research results (Kitchenham et al., 2009). The systematic literature review procedure carried out refers to the process proposed by Xiao and Watson (2019) as Figure 1.

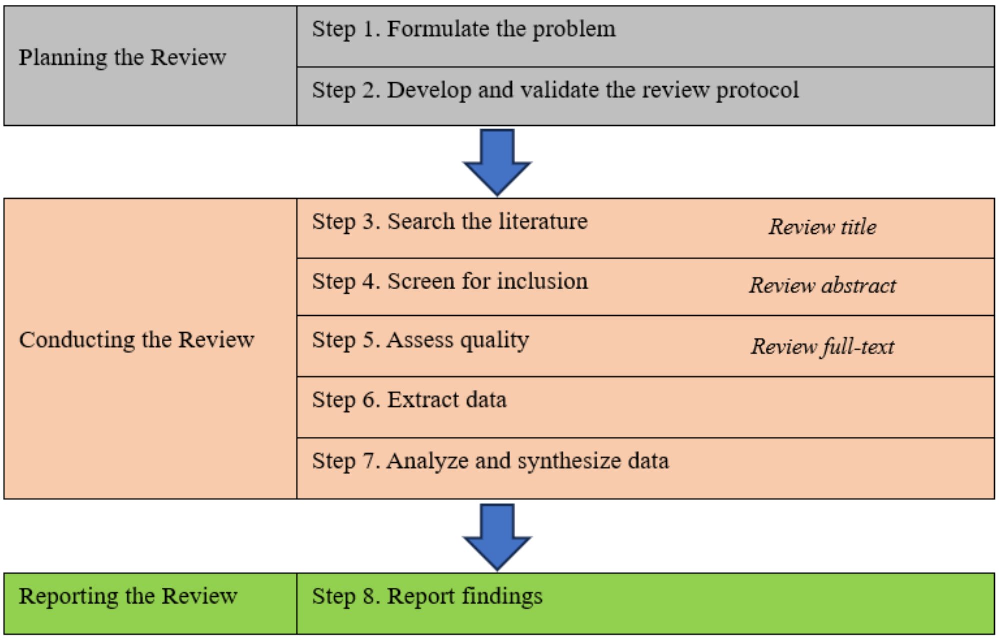


**Figure 1**. Steps of Systematic Literature Review

## 1. Planning the Review

In the planning the review stage, the process of identifying the needs for conducting the review process is carried out, including developing specific research questions and protocols that will be used in the review process (Xiao & Watson, 2019). In the first stage, the researcher formulated the research questions as presented at the end of the introduction. Furthermore, in the second stage, researchers developed a review protocol that included three main things as stated by Khizar et al. (2023), namely determining keywords, selecting databases, and inclusion and exclusion criteria used for protocol review. Researchers determined the keywords used to identify articles related to CT in the scope of Mathematics Education and Mathematics Learning. Next, the database used for the article search process was selected, namely the Scopus database. The Scopus database was chosen because it is the most comprehensive database to be used as an academic database (Phuong et al., 2023). In addition, Gao et al. (2022) stated that the Scopus database is a database that provides information that is relevant and reliable to the study being conducted, extensive data coverage, provides information on all authors cited in the reference, and makes it easy to download data directly so that it can be processed by software. Finally, the researchers developed inclusion and exclusion criteria to ensure that the articles used were relevant to the stated research objectives as presented in Table 2.

## 2. Conducting the Review

At the conducting the review stage, the stages carried out begin with searching the literature on a predetermined database, namely the Scopus database, inclusion screening, data extraction, and analyzing and synthesizing data. Data collection was carried out on September 19, 2024 on the Scopus database using a query string, namely (TITLE-ABS-KEY (computational AND thinking) AND TITLE-ABS-KEY (mathematics AND education) AND TITLE-ABS-KEY (mathematics AND learning)). In addition, the focus of the search was also limited to the publication period of the scientific papers in question, namely between 2010 and 2024 (as of

September 19, 2024). The search started in 2010 on the basis that it was the phase where CT had been integrated in Mathematics education as a 21st century skill. In addition, the search process was conducted using English terms, including English abstracts as one of the considerations. The inclusion and exclusion criteria of this study are presented in Table 1 to ensure the quality of the literature and its significance.

**Table 1.** Inclusion and Exclusion Criteria

| Aspects | Inclusion | Exclusion |
|---|---|---|
| Type of Publication | Journal Article | Review, editorial, conference proceeding, and others |
| Language | English | Other |
| Field of Article Study | Mathematics Education | Other |
| Publication Stage | Final | Article in press |
| Accessibility | Full-text articles or open acces | Preview articles or articles requiring a payment |

The article search in the conducting review process used the PRISMA protocol as presented in Figure 2. In the initial stage, the initial search resulted in 460 articles from the Scopus database using predetermined keywords. After that, an export was made into a Microsoft Excel file to check for duplication and completeness criteria for article identity. The results of the check obtained 31 articles that did not meet the eligibility in this initial section. Furthermore, from 429 articles selected in this initial section, screening was carried out based on the inclusion criteria in the form of Document type, Publication stage, Language, and Accessibility so that 99 articles were obtained. The next stage, researchers reviewed the 99 articles that had been selected based on several inclusion criteria that had been submitted to specify the search for articles in the form of verification of the study area, namely research conducted in the Mathematics Education study area. Based on this verification, 77 articles were excluded so that 20 articles remained.

Shute et al. (2017) provided another guideline to emphasize the selection of articles to be used in the systematic review process, one of which was the specific involvement of CT. As a final step, the remaining 20 articles were sorted again based on the research questions that had been compiled, resulting in 11 articles. The 11 selected articles were then subjected to qualitative analysis to answer the research questions. Qualitative analysis was carried out with the stages of collecting literature through the PRISMA protocol, extracting data relevant to the research objectives, identifying (coding) keywords or important concepts and categorizing themes based on the identification stage. The coding process began with preparation by reviewing the 11 selected articles, then manual coding on paper/spreadsheet referring to the research questions or research objectives. Finally completed with interpretation and reporting. A schematic overview of the screening process is provided in Figure 2.

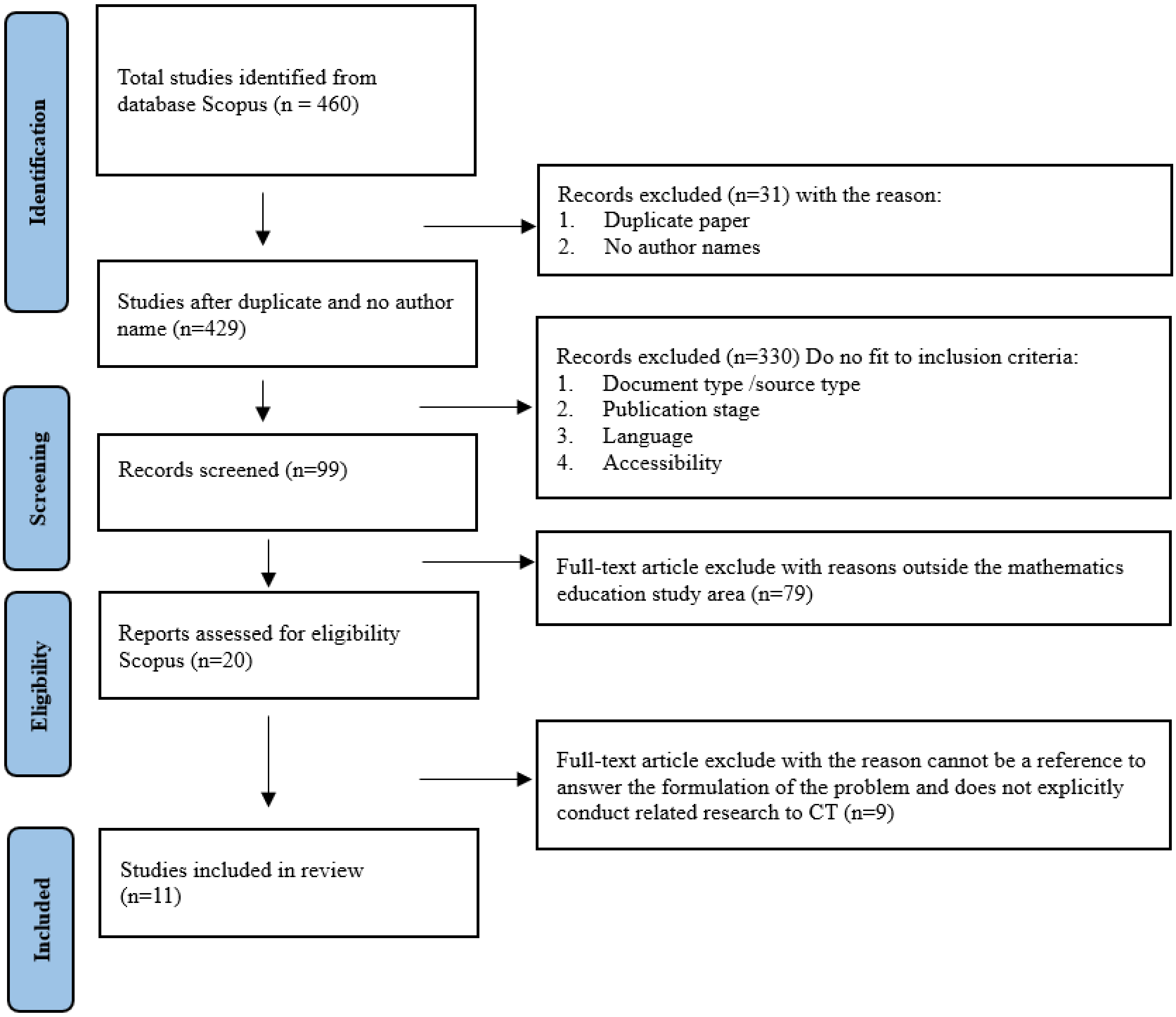


**Figure 2**. PRISMA Protocol (Source: Authors' own elaboartion)

The identities of the 11 articles used for further analysis used in this study are presented in Table 2.

**Table 2.** Overview of the 11 Articles Included Studies

| Authors | Title | Journal |
|---|---|---|
| Reichert et al. (2020) | Computational thinking in K-12: An analysis with mathematics teachers | Eurasia Journal of Mathematics, Science and Technology Education |
| Özçakir Sümen (2022) | Teaching the order of operations topic to fourth-graders using Code.org | Milli Eğitim Dergisi |
| Molina-Ayuso et al. (2022) | Introduction to computational thinking with scratch for teacher training for Spanish primary school teachers in mathematics | Education Sciences |
| Moon et al. (2023) | Developing preservice teachers' intuitions about computational thinking in a mathematics and science methods course | Journal of Pedagogical Research |

| Authors | Title | Journal |
|---|---|---|
| Mumcu et al. (2023) | Integrating computational thinking into mathematics education through an unplugged computer science activity | Journal of Pedagogical Research |
| Humble and Mozelius (2023) | Grades 7–12 teachers' perception of computational thinking for mathematics and technology | Frontiers in Education |
| Dahshan and Galanti (2024) | Teachers in the loop: Integrating computational thinking and mathematics to build early place value understanding | Education Sciences |
| Moreno-Palma et al. (2024) | Effectiveness of problem-based learning in the unplugged computational thinking of university students | Education Sciences |
| Purwasih et al. (2024) | How do you solve number pattern problems through mathematical semiotics analysis and computational thinking? | Journal on Mathematics Education |
| Molina-Ayuso et al. (2024) | Computational thinking with scratch: A tool to work on geometry in the fifth grade of primary education | Sustainability |
| Nordby et al. (2024) | Computational thinking in primary mathematics classroom activities | Frontiers in Education |

### 3. Reporting the Review

The last stage was reporting the review, where the researcher presents a report on the findings of the literature search and selection process that has been carried out, including a quality assessment (Noordzij et al., 2009). The results of the review that has been carried out are presented descriptively based on the results of the analysis, namely quantitative descriptive based on literature profiles as well as based on qualitative literature analysis and critical reviews.

## C. RESULT AND DISCUSSION

The following presents the results of the review of 11 articles reviewed in this study based on the topic of the research question posed. The 11 publications included in this systematic literature review were published from 2020 to 2024 as presented in Figure 3.

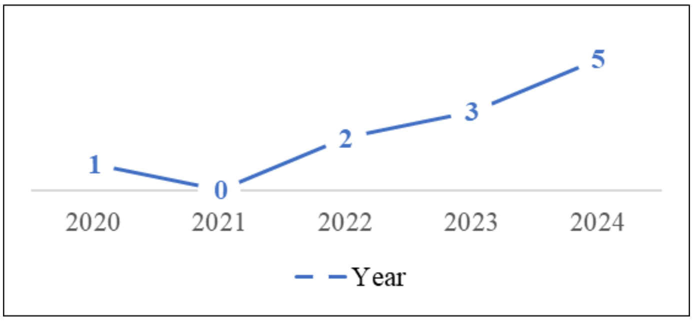


**Figure 3**. Distribution of Computational Thinking-related Research by Year
(Source: Authors' own elaboartion)

Based on Figure 3, in 2020 there was only 1 article, but in 2021 no articles on CT were obtained. However, starting in 2022, there was an increase in the number of research articles on CT until 2024 with 5 articles. In this context, it should be underlined that the absence of articles in 2021 does not mean that no research on CT has been conducted, but that none of them meets specifically in the field of mathematics education according to the predetermined inclusion criteria. However, Navarro and de Sousa (2023) stated that it is possible that in the estimated year the CT literature is still developing as a study in a particular field of study, including the definition of CT integrated with the context of Mathematics education is still limited.

1. **Geographical Distribution of Locations and Respondents Involved in Computational Thinking Research Sub Title**

The results of the review of 11 articles on the aspect of geographical distribution of research on CT are presented in Figure 4.

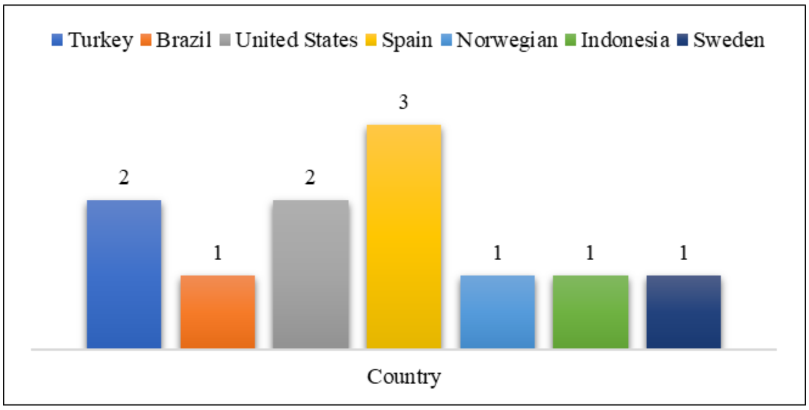


**Figure 4**. Geographic Distribution of Computation Thinking Research Locations
(Source: Authors' own elaboartion)

Based on Figure 4, it is found that the 11 articles reviewed come from seven countries. Spain dominates the geographical distribution of research locations on CT with 3 articles (Molina-Ayuso et al., 2022, 2024; Moreno-Palma et al., 2024), followed by Turkey with two articles (Mumcu et al., 2023; Özçakir Sümen, 2022) and the United States with two articles (Dahshan & Galanti, 2024; Moon et al., 2023). While the remaining one article each from Brazil (Reichert et al., 2020), Norway (Nordby et al., 2024), Indonesia (Purwasih et al., 2024), and Sweden (Humble & Mozelius, 2023). The results of the study further presented the distribution of respondents involved in CT research from the 11 articles reviewed as shown in Figure 5.

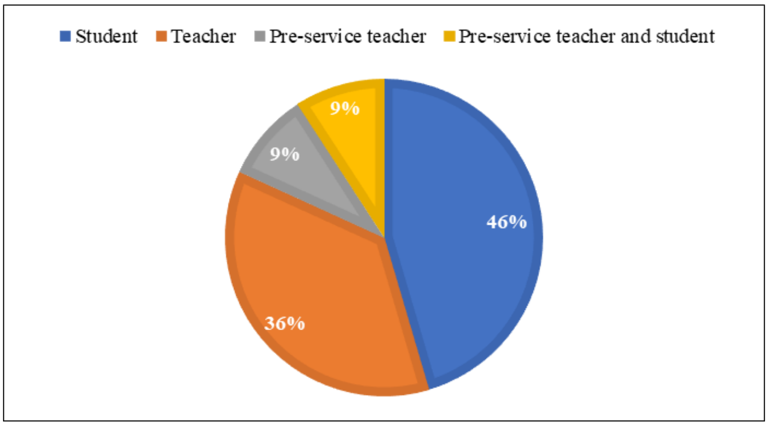


**Figure 5**. Geographic Distribution of Research Respondents
(Source: Authors' own elaboartion)

Based on Figure 5, CT research conducted is dominated by student respondents as much as 46%, followed by research involving teachers as much as 36%, and the remaining 9% each involving pre-service teachers and collaboration between pre-service teachers and students. However, 46% of the students involved in CT research from the 11 articles reviewed consisted of several levels of education, namely primary to university level education where the percentage for students in primary education was 20%, students in secondary education was 40%, and students in university degree was 40%. In line with the distribution of respondents for students, research respondents, namely teachers, also consist of several levels of education, namely Mathematics Teacher in K-12, Teacher in Early Childhood Education, Teacher in Primary School, and Mathematics Teacher in Grade 7-12.

However, looking more broadly, the study of the 11 articles can be said that 50% of the respondents were students and the remaining 50% were teachers and pre-service teachers. However, of the 50% of student respondents, 40% are students in university degrees who are students with majors related to education. The composition of the selection of respondents or CT research subjects which still involves a lot of teachers or pre-service teachers in CT research from 11 articles reviewed shows that the development of CT is still relatively new, so that the research conducted related to CT is still at the introduction stage. This shows that the development of CT still has limitations, where consensus on how CT should be operationalized in learning is still limited (Grover & Pea, 2013; Román-González et al., 2017).

## 2. Research Methods used in Computational Thinking Research

The research methods used in CT research are certainly in line with the research objectives set by the researcher. The review of the 11 articles shows the diversity of research methods used, both those explicitly and in detail stated in the article and those that are only mentioned in general terms. The following Table 3 shows the distribution of research methods used in the 11 articles reviewed.

**Table 3.** Distribution of Computationl Thinking Research by Research Method

| Research Method | Research Design | Frequency | Total |
|---|---|---|---|
| Qualitative | Case Study | 2 | 6 |
| | Exploratory | 1 | |
| | Deductive Analytical | 1 | |
| | Phenomenological | 1 | |
| | - (*not explicity*) | 1 | |
| Research and Development | Experience First Model | 1 | 1 |
| Mixed Method | Sequential Explanatory (Qualitative Process to Quasi-Experimental) | 2 | 2 |
| Quantitative | Quasi-Experimental (Pre-test and Post-test) | 1 | 1 |
| Design and Development Research | Type 1 Product and Development Study | 1 | 1 |

Based on Table 3 above, the research conducted is dominated by research using qualitative methods, which is 55%, followed by mixed methods as much as 18%, and the remaining 9% each are studies using research and development methods, quantitative with quasi-experimental, and design and development research. The difference in research methods used is certainly inseparable from the objectives of each researcher conducted. In studies that use qualitative methods, the research objectives achieved include analyzing and describing and interpreting the mathematics learning process to achieve CT (Sümen, 2022), analyzing teachers' initial perceptions of CT (Reichert et al., 2020), looking at teacher collaboration to explore and critique integrated CT-based learning activities (Dahshan & Galanti, 2024), investigating CT in learning (Nordby et al., 2024), and exploring CT in specific mathematics content (Purwasih et al., 2024).

The dominance of qualitative methods in the 11 articles reviewed, either by using case study design, exploratory, deductive analytical, or phenomenological is inseparable from the research objectives to be achieved from each study to strengthen the argument that CT as something relatively new. Research conducted on CT is still at the introduction stage in the learning process, especially in mathematics learning. This is shown by several studies on CT still being in the aspect of introducing CT and its understanding to teachers specifically and more deeply, including pre-service teachers. As revealed by Grover and Pea (2013) as well as Román-González et al. (2017) that the development of CT still has limitations, where consensus on how CT should be operationalized in learning is still limited.

However, some of the articles reviewed also used other research methods, namely mixed methods such as Ayuso et al. (2022) and Ayuso et al. (2024), research and development, namely Moon et al. (2023), design and development research namely Mumcu et al. (2023), and quantitative with quasi-experimental namely Moreno-Palma et al. (2024). There is still limited research on CT using research methods other than qualitative, especially those related to how learning activities or approaches should be carried out in integrating CT. This shows that there are still limitations, as expressed by several experts (Grover & Pea, 2013; Shute et al., 2017; Tang et al., 2020) that there are still practical problems in CT research, one of which relates to how activities or approaches can be used to integrate CT effectively. This certainly provides a challenge as well as an opportunity for other researchers to be able to formulate effective learning activities or activities to integrate CT, especially in mathematics learning.

### 3. Technology Applications in Computational Thinking Research

Computational thinking refers to the process of thinking by adopting the language used in computer programs. Thus, in some studies conducted, many use technological devices including computers and other supporting technological applications. Based on the results of a review of 11 articles, it was found that there were several technological applications used either using only one application or a combination of several applications. Sümen (2022) used the Code.org application, while other studies, namely Molina-Ayuso et al. (2022), Dahshan and Galanti (2024), Ayuso et al. (2024), and Reichert et al. (2020) in their research using the Scratch program. Apart from using only one application or one program, the research conducted by Nordby et al. (2024) used a combination of several technology applications, namely Codespark, Bee-Bot, ScratchJr., Bit:Bot, and Scratch.

Based on several applications used, the Scratch program is one of the program applications that are widely used in research. Scratch is educational software used as a visual programming language that can be used to support the development of mathematical reasoning or problem solving processes including building a positive learning environment (Calao et al., 2015). Scratch is not only a simple resource to provide interactive activities, but it can also create constructions for students that allow students to work creatively (Molina-Ayuso et al., 2024). In addition, the use of Scratch as educational software in CT is inseparable from the components of CT that can shape programming skills (Babazadeh & Negrini, 2022).

However, as Wing (in Kallia et al., 2021) stated that CT is not only related to computers, but can also be a study in other fields. This shows that CT does not always have to be related to computers, but can also be done without computers. The results of the review of 11 articles also show that without using a computer, it is called unplugged activites. The studies referred to are the research of Moreno-Palma et al. (2024), Mumcu et al. (2023), and Reichert et al. (2020). In addition, of the 11 articles reviewed, there were also studies that did not use or explicitly mention the technology applications used, namely Humble and Mozelius (2023), Moon et al. (2023), and Purwasih et al. (2024).

Unplugged activites are described as “learning computer science without a computer” (Bell et al., 1998). Similar to Bell et al., Reichert et al. (2020) in their research stated that unplugged activities are activities without using a computer. Currently, “unplugged” refers to an activity or strategy used in learning through indoor or outdoor games, including using mechanical toys, cards, puzzles, or others (Brackmann et al., 2017; Caeli & Yadav, 2020). In line with previous opinions, Moreno-Palma et al. (2024) in their research stated that unplugged relates to an approach in exploring computer-related concepts, but does not depend on technology. Thus, the strategies or activities built remain focused on processes based on CT components so that students are still encouraged to think critically even though they are not doing activities with technology or computers.

The unplugged activity in CT learning has been selected based on several considerations, in addition to its advantages. Moreno-Palma et al. (2024) stated that the unplugged approach was chosen because it still introduces CT so that the research conducted remains unaffected by technological devices such as computers. Unplugged activities are very useful in educational environments that have limited technological resources without having to lose activities that lead to CT (Caeli & Yadav, 2020). In addition, Moreno-Palma et al. (2024) stated that the selection of unplugged activites can also be based on students' lack of ability in programming. Nevertheless, students will not lose the opportunity to do activities that are closely related to CT.

## 4. The Role of Computational Thinking in Research

The role of computational thinking in a research process referred to is the use of CT in the research conducted, namely whether it is played as a performance outcome to be measured in a study or as a process used in learning, either as an approach or learning flow or learning process used in the study. The first role refers to whether CT is used as a skill or ability to be measured or as a learning outcome, while the second role as an approach or process used in learning, which refers to the use of CT components as a learning activity carried out.

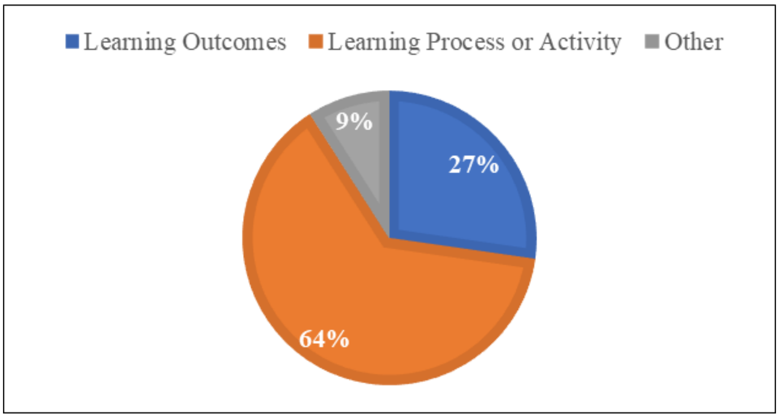


**Figure 6**. The Role of CT in Research Activites (Source: Authors' own elaboartion)

Figure 6 shows that of the 11 articles reviewed, 64% of CTs were used in research activities as a process in the learning that was carried out. Computational Thinking is used as a series of activities in mathematics learning by making the components of CT as stages or processes in mathematics learning. In addition to being an activity in learning, 27% of the studies made CT also as a learning outcome. In this case, CT components are used as indicators to assess student learning outcomes so that it can be seen how the ability or CT skills of students or research respondents. In addition to these two roles, the results of the review of 11 articles also found that 9% of studies made CT in another role (other), namely as an object in the research itself. In this case, the research in question refers to research conducted with the aim of seeing how the perception or view of the research subject is related to CT itself.

Based on the results above, the use of CT in the research conducted mostly makes CT an activity or process carried out in the learning process. The CT learning process is carried out by using CT components as activities carried out by students. The CT components in question are *decomposition, pattern recognition, abstraction,* and *alghorithm*. In addition to the four components above, the research conducted also applied several other CT components as revealed by Kalelioğlu et al. (2016), Kallia et al. (2021), and Shute et al. (2017). However, 64% of the articles reviewed did not explicitly state the learning model or approach used. Through learning activities conducted involving CT components, it can provide an overview of how to organize an effective learning flow involving CT components. This is because there are still practical issues that include what activities and approaches can be used in integrating CT effectively (Grover & Pea, 2013; Shute et al., 2017; Tang et al., 2020).

Referring to the role of CT used as a learning activity in mathematics learning, it is expected to provide meaning to the concepts learned. The application of CT components in mathematics learning as part of the learning activities carried out provides several positive impacts as presented in several articles reviewed (Dahshan & Galanti, 2024; Molina-Ayuso et al., 2022; Moon et al., 2023). In addition, learning by involving activities from CT in learning activities plays a very important role because it can improve skills in mathematics. Zuod and Namukasa (2023) stated that through CT activities, it is possible for students to use mathematical concepts in different situations so as to improve the ability to understand mathematical concepts. Furthermore, (Suarsana et al. (2024) stated that through the application of CT as an activity in mathematics learning in particular and in general in the curriculum has an important role in developing 21st century skills. In addition to being related to students' cognitive abilities, learning using CT activities provides the possibility of developing affective aspects, one of which is student disposition (Ramaila & Shilenge, 2023). In addition, studies show that the integration of CT in the mathematics learning process allows for a variety of learning approaches in a variety of contexts (Nordby et al., 2022), both using technological devices or computer programs and unplugged activites.

## 5. Components of Computational Thinking

In the review of 11 articles, it was found that there was a diversity in the use of CT components. Identification of CT components in each article was done manually by reading each article. The following Figure 7 presents a map of the use of CT components from the 11 articles reviewed.

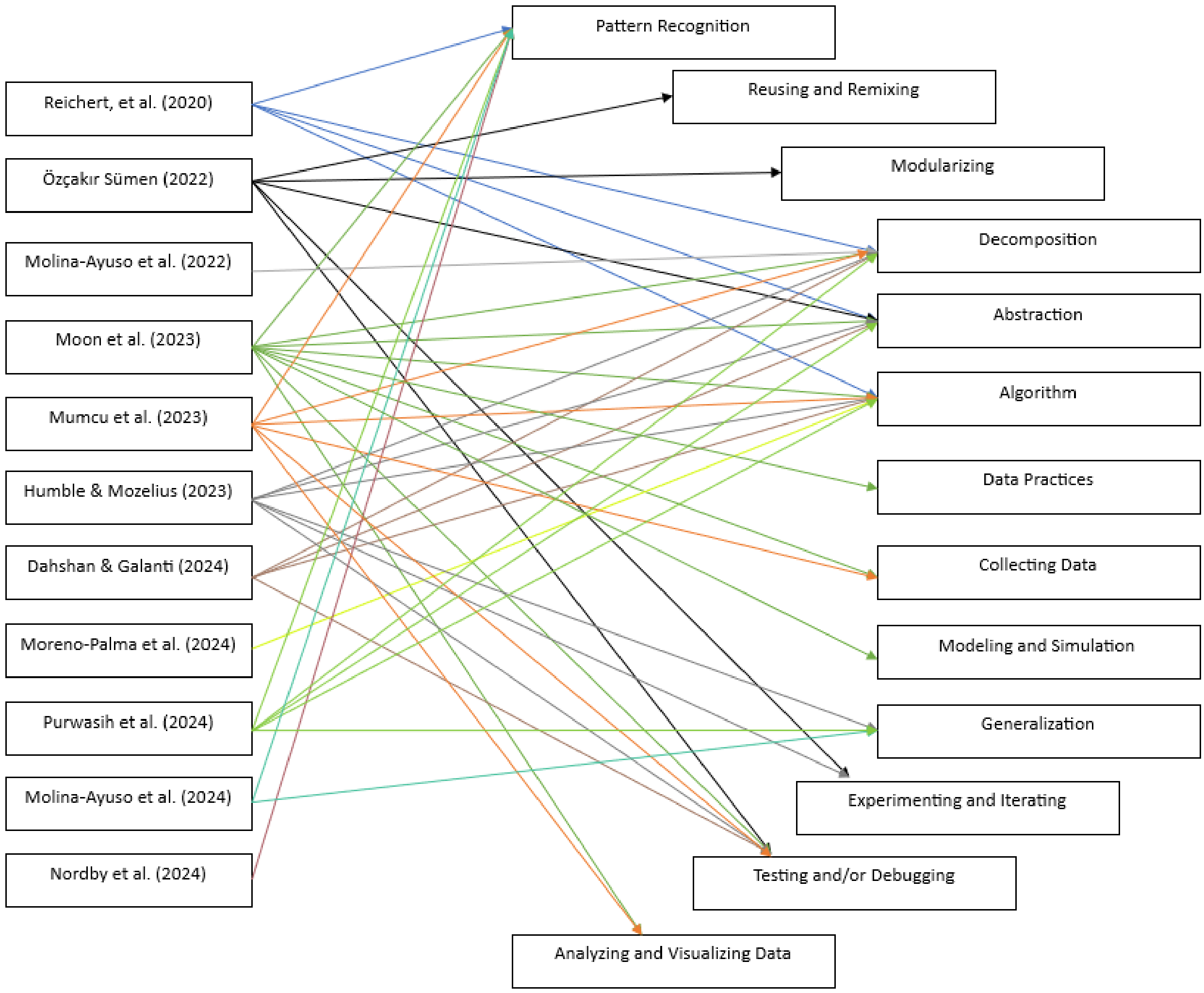


**Figure 7**. The Use of Computational Thinking Components in Research Activites
(Source: Authors' own elaboartion)

Figure 7 shows that the CT components most involved in research are *decomposition, pattern recognition, abstraction,* and *algorithm*. The number of studies using the four CT components arises because according to Dong et al. (2019) that these four components are important components in CT. The four components of CT provide an opportunity to form logical reasoning that can be used in developing higher-order mathematical skills such as problem-solving skills. Shute et al. (2017) stated that *decomposition* refers to breaking down large problems into smaller problems. From these small problems, it is possible to observe the existence of patterns or relationships (*pattern recognition*). *Abstraction* as a process of extracting a complex system that allows the process of data collection, pattern recognition, including modeling (Shute et al., 2017), while the *algorithm* refers to the preparation of a logical and orderly design that can be a way to obtain a solution to the problem. In addition to the four CT components, there is another component that has also become a focus in many studies, namely *testing and debugging* where Shute et al. (2017) stated *debugging* as the process of detecting and identifying errors and fixing the errors that occur.

The differences in CT components in the reviewed articles can be broadly classified into four CT categories based on their taxonomy as expressed by Weintrop et al. (2016), namely *data* *practices, modeling and simulation practices, computational problem solving practices,* and *systems thinking practices*. CT components such as *collecting data, analyzing,* and *visualizing data* are part of *data practices*, so the research conducted by Moon et al. (2023) and Mumcu et al. (2023) refer to the taxonomy of *data practices*. The category of *modeling and simulation practices* by Weintrop et al. (2016) related to the preparation or assessment of the model, so that the CT components included in this second taxonomy include *modularizing, testing,* and *modeling and simulation*, so that the research conducted by Özçakir Sümen (2022), Dahshan and Galanti (2024), and Humble and Mozelius (2023) involves CT components in the category of *modeling and simulations practices.* Furthermore, the category of *computational problem solving* is related to the CT process in problem solving, where Weintrop et al. (2016) stated several iterative processes from this category including *decomposition, pattern recognition, abstracting, debugging, programming, algorithm,* and *generalizing.* Referring to Figure 7, several studies related to CT above such as Moon et al. (2023), Purwasih et al. (2024), and Reichert et al. (2020) involves many components that fall into the category of *computational problem solving*. This supports the ability of problem solving specifically as one of the skills in the 21st century.

The diversity of the use of one or several CT components in research shows that CT components are not a hierarchy, but are separate from one component to another (Dong et al., 2019). Some experts also have different views on CT components (Angeli et al., 2016; Barr & Stephenson, 2011; Lee et al., 2011; Wing, 2006, 2008). Thus, researchers have the freedom to choose CT components in accordance with the research objectives to be achieved without being bound by the CT component hierarchy or other rules. In addition, the diversity of the use of CT components in research shows that CT continues to be dynamic and has a variety of underlying theories.

## D. CONCLUSION AND SUGGESTIONS

The results of the review of the 11 articles used show an increase in the number of publications on CT every year, starting from 2022 to 2024. The distribution of CT research across countries shows that Spain has the highest number compared to other countries in the articles studied, namely Turkey, United States, Indonesia, Brazil, Norway, and Sweden. In addition, the results of the review also reveal that research on CT involves many students and teachers as research respondents, including pre-service teachers with qualitative research methods.

In the process of implementing learning by involving CT, the results of the study reveal that the learning carried out involves several technological applications such as educational software i.e Code.org application, Scratch program, Codespark, Bee-Bot, ScratchJr., Bit:Bot, that allows the facilitation of the emergence of CT components. However, the results of the study also reveal the existence of a learning process by integrating CT without involving the use of technological devices called unplugged activites. This is also in line with the results of the study on the role of CT in research which also shows that CT is played as an activity or tool in the learning process, in addition to being a product or learning outcome. In addition, the results of the study also revealed that the studies conducted used a variety of CT components, where the components of decomposition, pattern recognition, abstraction, and algorithm were the most widely used or researched components in the study.

However, regarding the results of the study conducted, the research we conducted still has limitations. The limitations we mean are in using databases, where we only use the Scopus database in the 2010-2024 period. For this reason, it is hoped that further research can add or use other credible databases so that it is hoped that broader study results will be obtained and provide other findings. Apart from that, referring to the results of the study obtained, research on CT is still at the exploration and introduction stage of CT, so it is hoped that in the future there will be research related to more in-depth exploration including the development of instructional design for learning that integrates CT, both as a learning activity and as a result learning.

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