

Systematic Literature Review (SLR) Computational Thinking Learning Science in the Period 2012 - 2021

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Abstract—The study review of the literature systematic displays an overview of research on computational thinking in learning science in the period 2012 to 2021. In the process of selection of data in this study using a flow diagram of a Prism that can show the activity of the inclusion and exclusion of the search results data. The search is performed through the database of Springer to establish some inclusion criteria. The research variables analyzed include the distribution of publications per year, the frequency of the emergence of the term “computational thinking” in the title of the document. The number of authors publishes computational thinking year, the country's most productive research in computational thinking, as well as the number of citations in the research. The results show the publication of the study of computational thinking, the frequency of the emergence of the term computational thinking on the title of the study as well as the author of the most there in 2020, whereas in the period 2012 to 2021 the state the most to contribute in the research of computational thinking, i.e. the USA as well as publisher of research in computational thinking the most is Journal of Science and Technology which has published research in computational thinking by 56 times in one decade.

Keywords: Systematic literature review (SLR), research trends, systematic analysis, computational thinking learning

1. INTRODUCTION

The characteristics of the 21st century are different from previous centuries. In this 21st-century technology develops, the relationship between the nation stronger, changes the way of life, as well as the interaction of citizens getting closer to the citizens of other countries. In addition, the system of 21st-century learning is a rite of passage of learning in which the curriculum developed at this time demanding the school to change the approach to learning that is centered on the teacher (teacher-centered learning) into an approach to learning that is centered on learners (student-centered learning).

Education in the 21st century encourages teachers to build the skills and competence of students following the needs of the industry that puts technological progress and economic development, (Ananiadou & Claro, 2009). The skills and competence of students of the 21st century include skills learning and innovation skills life and career, as well as the skills of information literacy and media, are expected to be useful for future students and can be implemented in the environment of the community (Care, 2018). The development of 21st-century skills in students can be done by applying a variety of methods, approaches, and models of learning that are integrated with the topics of the subject matter in class. In addition to making the learning becomes more meaningful, the use of methods, approaches, and learning model is also able to demonstrate the ability possessed by students (Salomone & Kling, 2017).

One of the competencies required in 21st century learning namely computational thinking (CT). The concept of CT is not new, computational thinking was first introduced by Seymour Papert (1980) with the expression thought algorithmic. According to Wing (2008), computational thinking or Computational Thinking is a kind of analytical thinking that uses thinking mathematically as an approach to solving a problem, designing systems, and evaluating a system of large and complex that it can be operated in the real world. This involves computability, intelligence, the mind, and human behavior. Increase learning with computational thinking in middle school (K-12) carries the assumption that these skills become very important for all people because the benefits of the application of computational thinking can be felt by many people, including professionals in the, increased in the last decade.

Based on the results of a study conducted by Polat et al. (2021), the efforts of the development of the skills of Computational Thinking has been done on middle school students and often treat computer science as major subjects, including science, mathematics, engineering, and robotics. Skills Computational Thinking includes the skills of problem formulation, data collection, and data analysis, abstraction, modeling, thought-based algorithms, search for solutions, the use of digital tools, data representation, decomposition, and automation.

There are 4 components of the experience of pedagogy on the skill of Computational Thinking or known by the CTPF (Computational Thinking Pedagogical Framework), which reflect the level of demand cognitive students develop more and more challenging than the experiences of pedagogy that obtained previously (Kotsopoulos et al., 2017).

Not many studies in the literature about computational thinking, but it's getting a lot done in the last few years. For example, Lockwood and Mooney (2018), conducted a study of the literature intending to open a space for educators to intermediate level who are interested to apply CT into their teaching by giving their class options and ideas about how learning is achieved, as well as researchers of education informed by a detailed overview of the teaching of what has been done in the field, as well as bring focus on some of the gaps and potential opportunities for further work there. In addition, the research Hava and Cakir (2017) make the presentation of the results of the literature review systematic about the development of computer games educative and its implementation in the context of learning by researching the impact of duty game design in learning. the results of the' the students. Ioannou and Makridou in 2018 a review of the published literature refers to the intersection of CT and robotics education, in particular with the main focus is the exploitation of robotics education in developing the skills of CT learners in K-12 as well as Dagiene and Stupuriene (2016) examined the introduction of the model Bebras in the cultivation of CT, applying observations and the contest ten years in various countries. As for literature review in systematic is done to complement the results of the study of previous literature which will be more focused on research in computational thinking in learning science in the period 2012 to 2021.

A variety of information such as about the trend of research on computational thinking can help researchers and educators in understanding the development of research in this field and then plan the research in the future. Therefore, a review of the

current literature aims to analyse and provide a broad overview of the research in computational thinking from 2012 until 2021. As for journal articles identified from the database of Springer. As has been known, that Springer is one of the publishers the best international published a lot of scientific documents in a variety of disciplines, one of which in the field of education. Based on the knowledge of the researchers, there has been no research that explores more broadly about research in computational thinking use of systematic reviews until the year 2021. Thus, this study can provide a completer and more accurate to help researchers and educators around the world in conducting research related to computational thinking, as well as being able to publish his writings in the future. To that end, the research questions proposed in this study are:

1. How is the trend of annual publication of research related to computational thinking during 2012-2021?
2. How the frequency of the emergence of the term “computational thinking” in the title of the document from 2012-2021?
3. How has the frequency of the author published computational thinking in the last ten years?
4. Which countries are the most productive in the study of computational thinking?
5. How is the frequency of the publisher publishing research computational thinking?
6. How many citations are in the research?

2. METHODS

2.1 Research Design

Design in this study using a Systematic Literature Review (SLR), which is aimed at identifying, classifying, and presenting the results of studies following the inclusion criteria (Higgins & Green, 2008). In the process of selection of data in this study using a flow diagram of a Prism that can show the activity of the inclusion and exclusion of the search results data (Stovold et al., 2014). The research variables that will be analyzed include the distribution of publications per year, the frequency of the emergence of the term “Computational Thinking” in the title of the document. The number of authors publishes computational thinking per year, the country's most productive research in computational thinking, as well as the number of citations in the research.

2.2 Inclusion Criteria

The search is performed through the database of Springer to establish some inclusion criteria such as journal articles research published in the period 2012 to 2021, the term of the search is “Computational Thinking” which appears in the title, abstract, or keywords. Then select only the parts of the journal articles on the discipline of education with open access, and only speak English. For books or parts of books, conference proceedings, and article previews are not included in the analysis.

2.3 Data Analysis

The term used in the search journal articles is "Computational Thinking" to get the related article. The researchers conducted manually identified on title, abstract, and keywords of the article to ensure that the articles that were obtained were relevant to the purpose of the study. In this study, a sample of the article was only taken from the discipline of Education. Based on a preliminary search, there are 1590 articles scattered in 48 subdisciplines. Researchers then filter the data back, using two subdisciplines

namely Science Education and Educational Technology is finally 291 articles are suitable to the topic being analyzed.

In the selection process, performed the reading of the full text to all articles. To provide a systematic review of the accurate and comprehensive, we discuss the relevance of the manuscript with the question of the main study if they met the inclusion criteria. If there is any doubt whether the document meets the criteria of inclusion or not it will be evaluated independently. As a result, there are a total of 291 articles that met the inclusion criteria and were selected for review. The process of the selection of articles is presented in the diagram of the Prism below.

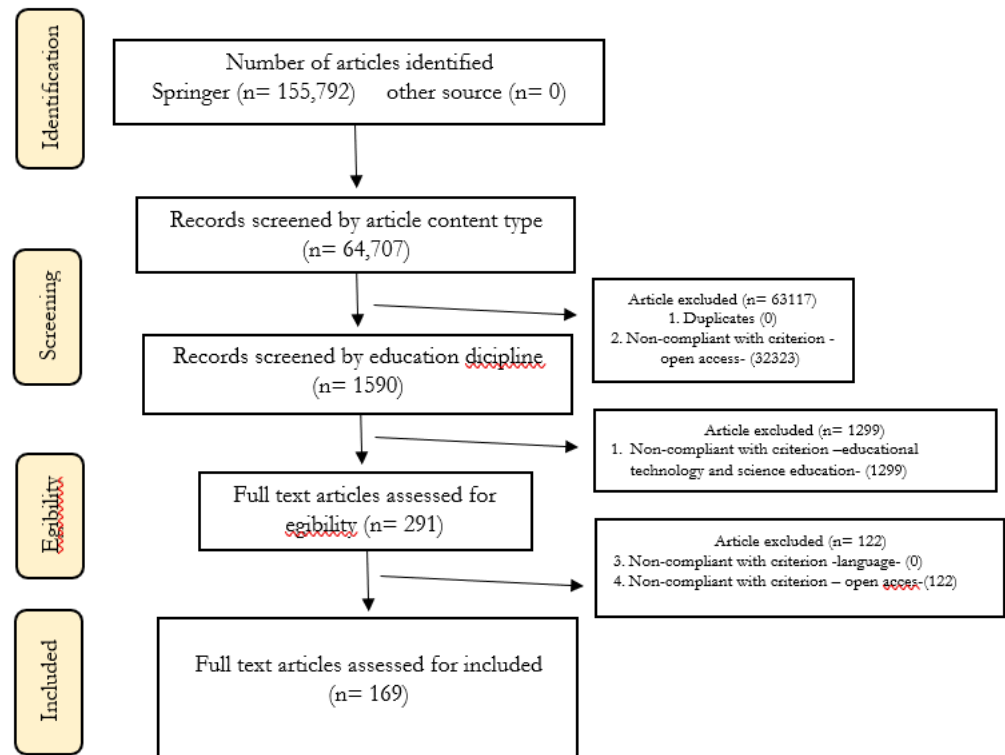


Figure 1. groove selection of journal articles

3. RESULTS AND DISCUSSION

The results of the analysis of the Systematic Literature Review (SLR) on the journal articles found in databases Springer over a while 2012-2021, presented in 6 parts, including covers of publications per year, the frequency of the emergence of the term “Computational Thinking” in the title of the document. The number of authors publishes computational thinking per year, the country's most productive research in computational tinkering, distribution publisher research computational thinking as well as the number of citations in the research.

3.1 Distribution of publications year journal articles related to Computational Thinking

The first variable in this study indicates the distribution of publications, journal articles related to Computational Thinking in the period 2012 to 2021, and is presented in figure 2 below.

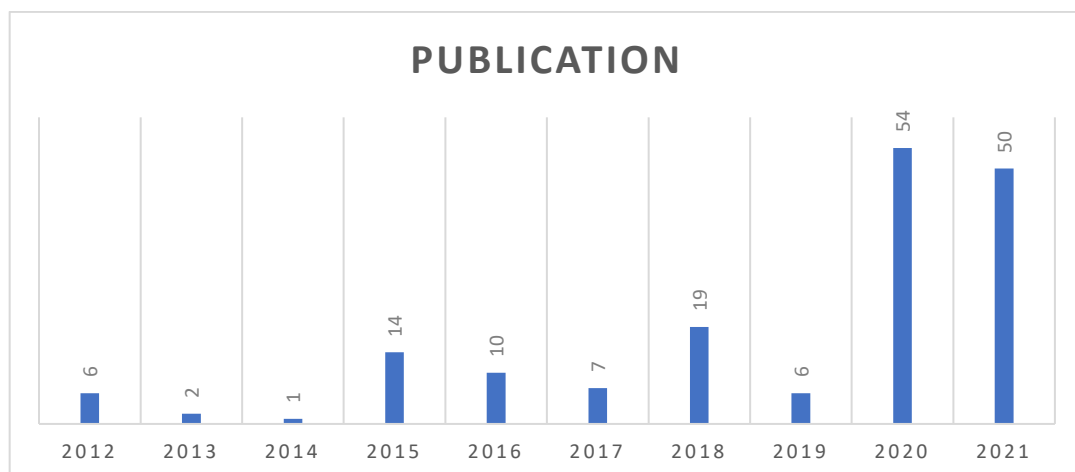


Figure 3. distribution of publications year

Based on the results of the analysis of the distribution of publications per year, it is known to significantly increase the publication in the last 2 years and experience fluctuations in the first 8 years. The number of publications journal articles about computational thinking most noticeable in 2020 as many as 54 journal articles, next highest was found in the year 2021 as much as 50 journal articles. Though visible in the chart is decreased 4 articles in 2021 compared to the previous but the data obtained researcher at the time of collection of the source, the year of 2021 is still ongoing up to this writing on the finish. Researchers estimate that in the year 2021, this trend of research in computational thinking will increase. The presence of the increase in the trend of research in computational thinking, which increased at 2 years in one decade this can occur due to the impact of the pandemic covid19 changing patterns of learning in the whole world is utilizing a computerized technology in learning. This is in line with the research of Abidah (2020) on the impact of the pandemic covid19 in the pattern of learning in Addition, also the research on computational thinking in the field of education has become a new trend that can enhance meaningful learning through a variety of skills corresponding to the needs of students in the 21st century. This research has managed to present an overview of comprehensive studies of previous literature and can help researchers and educators understand the development of research on computational thinking more.

3.2 The frequency of the emergence of the term “Computational Thinking” in the title of the document

The variable further in this study shows the frequency of the emergence of the term Computational Thinking on the title of the document which is presented in figure 3 below:

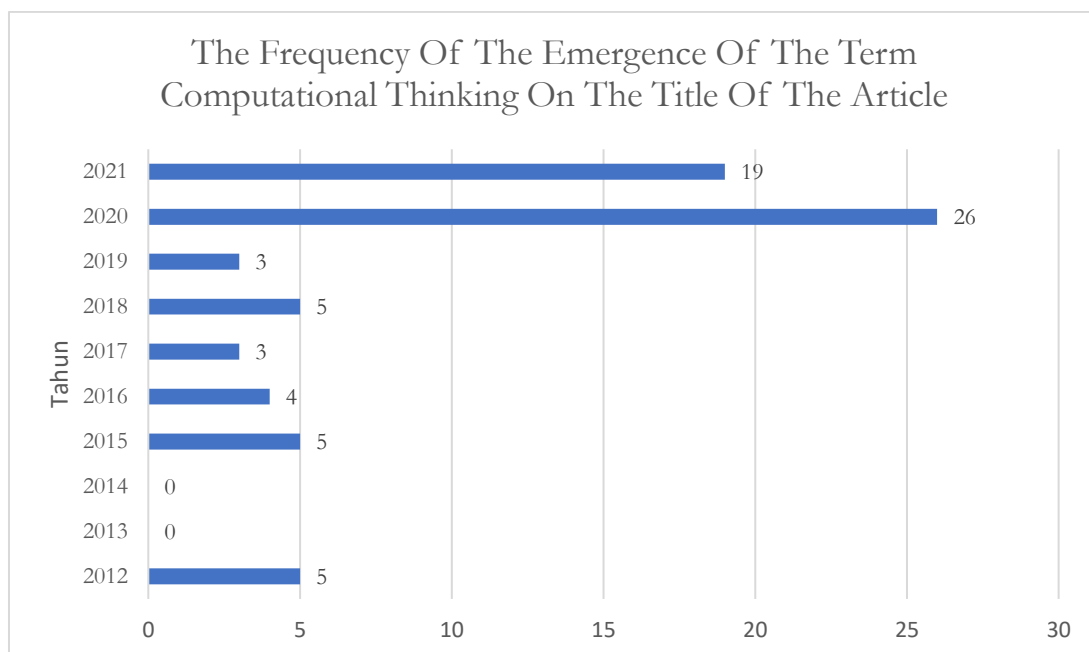


Figure 3. The frequency of the emergence of the term computational thinking on the title of the document

Based on the results of the analysis, the frequency of the emergence of the term “computational thinking” in the title of the document increased from 2020 to 2021. In the year 2020 is the highest frequency of the emergence of the term computational thinking on the title of the articles which amounted to 26 of 54 articles or about 48% of articles in the publication in the year. On the second-order frequency of the emergence of the term computational thinking on the title of the articles, namely in the year 2021 by 19 of 50 articles, or about 38% of articles in the publication in the year. On the third, the frequency of the emergence of the term computational thinking on the title of the articles, namely in the years 2012, 2015, and 2018 which are equally as much as 5 articles but different rates due to several articles in computational thinking which are published in each year is different, namely in the year 2012 at 5 of the 6 article or about 83% of the articles, in the year 2015 at 5 of the 14 article or about 36% of the article as well as in the year 2018 at 5 of 19 article or about 26% of articles in the publication in the year. On the fourth, the frequency of the emergence of the term computational thinking on the title of the articles, namely in the year 2017 dan 2019 which are equally as much as 3 articles but different rates due to several articles in computational thinking which are published in each year is also different, namely in the year 2017 at 3 of the 7 article or about 43% of articles, as well as in the year 2019 at 3 of the 6 article or about 50% of the articles in the publication in the year. However, the article related to computational thinking in 2013 and 2014 does not display the term computational thinking one on the part of the title. This can happen because most of the authors change the terms computational thinking with other terms such as computational design, computational modeling, and others.

3.3 The countries most productive in the study of computational thinking

The variable further in this study indicates the distribution of the Country's most productive in the study of Computational Thinking is presented in figure 4 below.

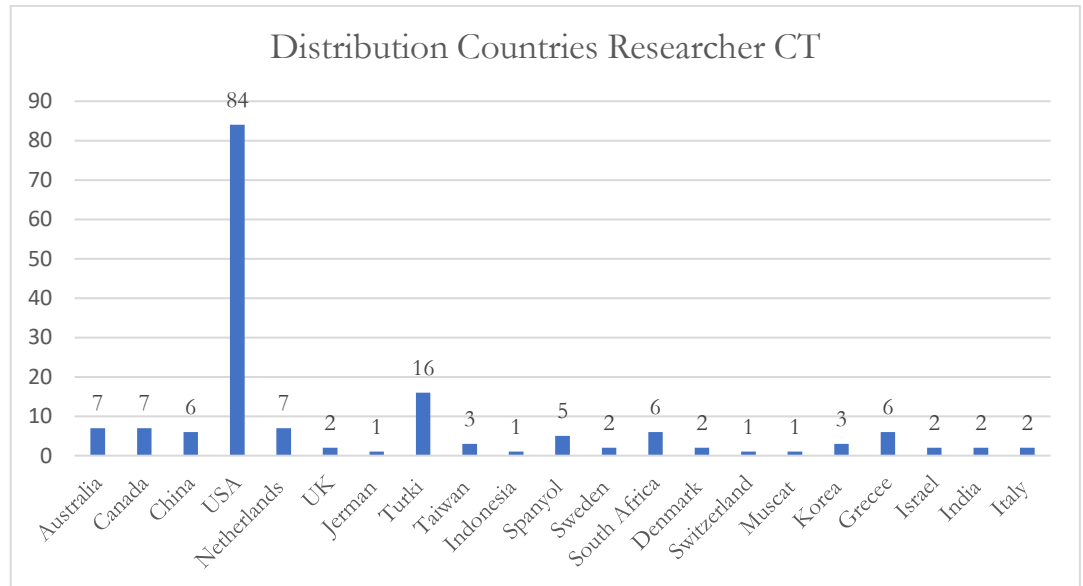


Figure 4. The distribution of the Country's most productive research CT

Based on the results of the analysis can be seen that the USA is a country that is the most productive in the study of computational thinking which amounted to 84 of 169 articles that analyzed or obtain the percentage of 49,70%. Based on these percentages can be concluded for a period of 10 years from 2012 to 2021, research computational thinking a lot published by state USA.

The Turkish state ranks second in the country's productive publish research computational thinking with the amount of 16 articles in the last decade. While Australia, Canada, and the Netherlands rank third by the number 7 of the article. China, South Africa, and Greece rank fourth by the number 6 article while Indonesia ranks last with the publish 1 article in computational thinking. Based on the data that has been analyzed, the show still lacks the authors of the articles in Indonesia that examine the related computational thinking in learning science in school.

3.4 d. The number of authors who publish computational thinking

The variable further in this study indicates the number of authors of journal articles per year, based on 169 journal article that has been analyzed, the results are presented in figure 5 below.

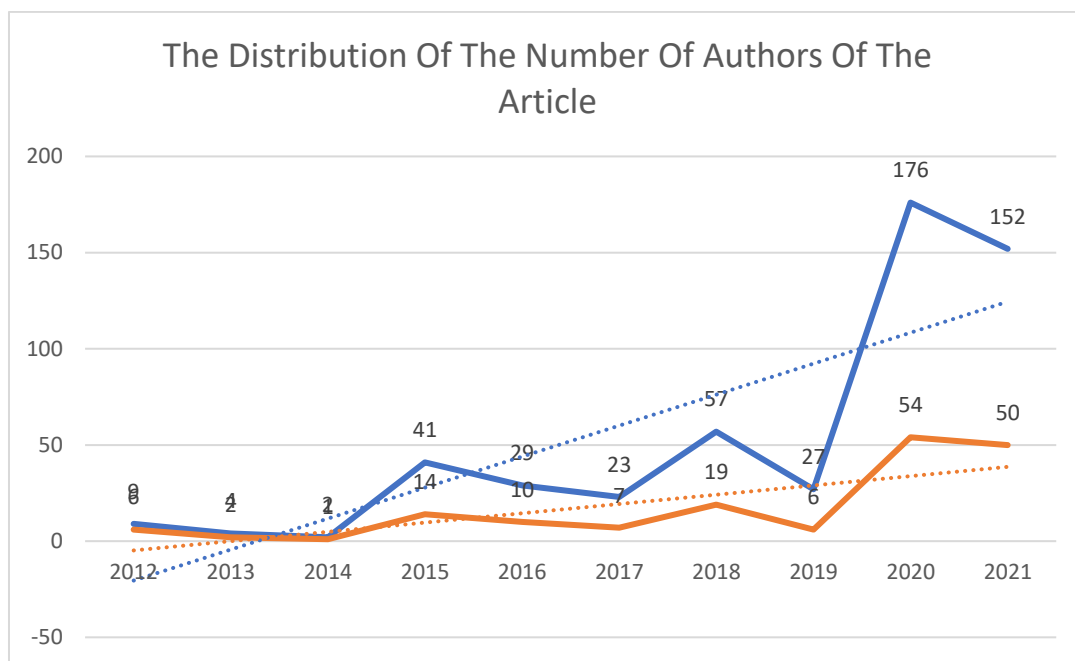


Figure 5. The distribution of the author publishes CT

Based on the results of the analysis that has been done of the Journal of Science and Technology ranks the most in a decade in the published article related to computational thinking with the amount of 56 publications. International Journal of technology and Design Education is in the second position with published 46 articles related to computational thinking in the last decade. Based on the data that has been delivered in figure 6. The visible difference range of the chart is quite prominent by the second publisher that occupies the first position and the second with the publisher also publish articles related to computational thinking.

3.5 The distribution of articles which many in the citation

The last variable in this study shows the number of articles related to computational thinking that in the citation by the reader in the last decade, Based on 169 journal article that has been analyzed, 15 top articles the most cited are presented in figure 7 below.

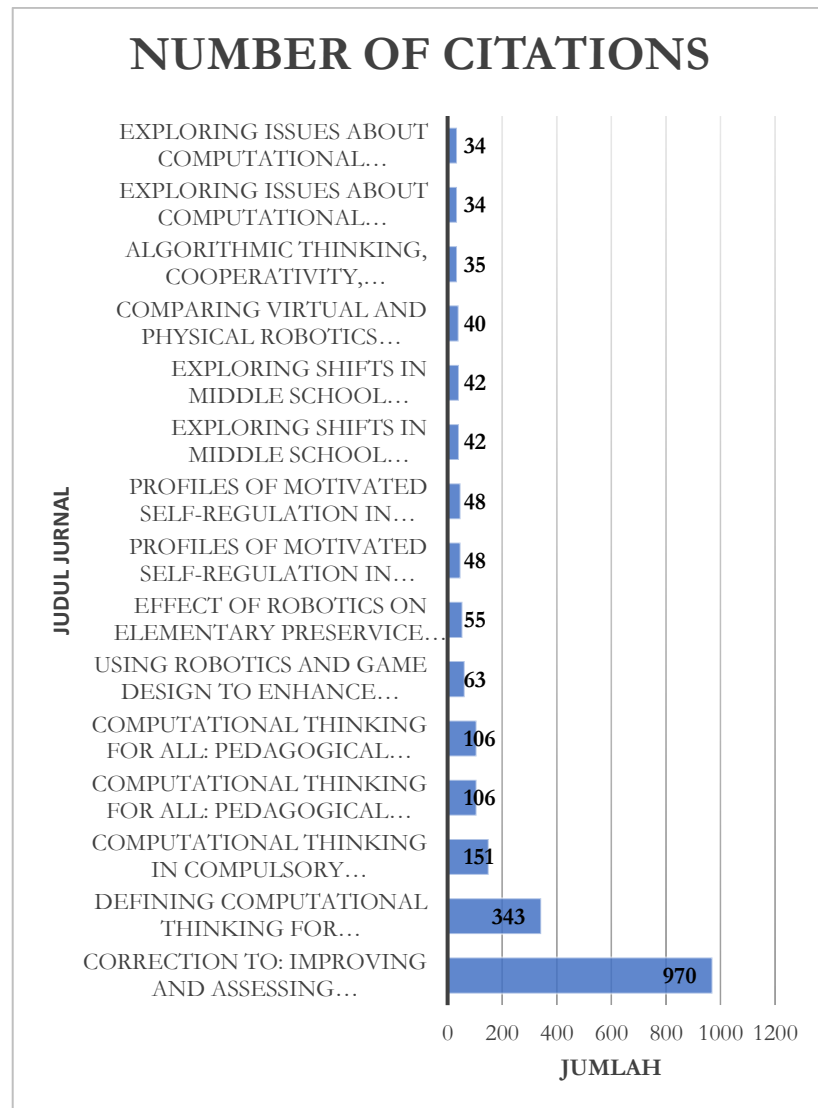


Figure 7. The distribution of the number of citations CT

Based on the results of the analysis that has been done obtained 15 top-ranked articles most often in the citation. The article entitled “Correction to Improving and Assessing Computational Thinking in Maker Activities: the Integration with Physics and Engineering Learning” ranks first with a total citation of as much as 970 citations. The article entitled “Defining Computational Thinking for Mathematics and Science Classrooms” ranks second with a total citation of as much as 343 citations. The article entitled “Computational thinking in compulsory education: Towards an agenda for research and practice” ranks third with total citations total 151 citations. The article entitled “Computational Thinking for All: Pedagogical Approaches to Embedding 21st Century Problem Solving in K-12 Classrooms” and “Computational Thinking for All: Pedagogical Approaches to Embedding 21st Century” both ranks third with a total citation 106. The number of citations of the present article, which occupies the first position until the third shows that the article is qualified and suitable to be used as a primary source on a variety of research in the future.

5. CONCLUSION

Based on the review literature 169 journals systematically published from 2012 to 2021 can be concluded that the research on computational thinking until the current largest conducted by the United States. Although the term computational thinking has been introduced since the 1980s however, the trend to research related to computational thinking graph shows which increased significantly in recent time. In particular, the number of articles most published in 2020 and is followed by the year 2021. Based on the findings of journal articles that use the term computational thinking in the title of his most widely by 26 article title in 2020. There is the fact that journal articles are the most widely published in research in computational thinking is when you are in 2020 with several authors, namely 176 researchers. Based on the results of the analysis of 169 articles, also found the name of the journal's most prolific published research articles about computational thinking, i.e. the journal of Science and Technology with the number of publications total of 56 articles during the years 2012 to 2021 and found an article with the title Correction to Improving and Assessing Computational Thinking in Maker Activities: the Integration with Physics and Engineering Learning the most widely cited by other researchers as much as 970 times. The literature review is expected to be useful for further research as well as future teachers who want to apply computational thinking in learning.

6. LIMITATIONS AND RECOMMENDATIONS

The researchers recommend further research to develop research related to computational thinking in more detail the specific and implement computational thinking research in teaching and learning in schools. This research study has several limitations, which are limited by the keywords search a specific, limited time in review articles that have been published, as well as the database of scientific research that sought. However, the findings that emerged from this article provide an overview of beneficial related trend study of computational thinking in the period 2012 to 2021.

7. REFERENCES

- Abidah, A., H N Hidaayatullaah., R M Simamora., D fehabutar & Mutakinati, L. (2020). The Impact of Covid-19 to Indonesian Education and Its Relation to the Philosophy of “Merdeka belajar”. *Studies in Philosophy of Science and Education Vol 1 no 1*. ISSN: 2721-9267
- Ananiadou, K., & Claro, M. (2009). 21st-century skills and competences for new millennium learners in OECD countries. *OECD Education Working Papers*, 41, 33. <http://dx.doi.org/10.1787/218525261154>
- Arastoopour Irgens, G., Dabholkar, S., Bain, C., Woods, P., Hall, K., Swanson, H., ... & Wilensky, U. (2020). Modeling and measuring high school students' computational thinking practices in science. *Journal of Science Education and Technology*, 29(1), 137-161.
- Care, E. (2018). Twenty-First Century Skills: From Theory to Action. In E. Care (Ed.), *Assessment and Teaching of 21st Century Skills, Educational Assessment in an Information Age* (Assessment, pp. 3–17). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-65368-6_1
- Dagiene, V., & Stupuriene, G. (2016). Bebras – A Sustainable Community Building Model for the Concept-Based Learning of Informatics and Computational Thinking. *Informatics in Education*, 15(1), 25–44.

- Hava, K., & Cakir, H. (2017). A systematic review of literature on students as educational computer game designers. In Proceedings of EdMedia 2017, (pp. 407–419). Washington, DC, USA.
- Higgins, J., & Green, S. (2008). Cochrane Handbook for Systematic Reviews of Interventions. In J. P. H. and S. Green (Ed.), *The Cochrane Collaboration and John Wiley & Sons Ltd.* Wiley-Blackwell. <https://doi.org/10.1109/ISIT.2017.8006970>
- Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Computers & Education*, 126, 296-310.
- Ioannou, A., & Makridou, E. (2018). Exploring the potentials of educational robotics in the development of computational thinking: A summary of current research and practical proposal for future work. *Education and Information Technologies*, 23(6), 2531–2544.
- Irwanto, I., & Prodjosantoso, A. K. (2019). Analyzing the relationships between preservice chemistry teachers' science process skills and critical thinking skills. *Journal of Turkish Science Education*, 16(3), 299-313.
- Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. (2017, August). Students' science process skill and analytical thinking ability in chemistry learning. In AIP Conference Proceedings (Vol. 1868, No. 1, p. 030001). AIP Publishing LLC.
- Kotsopoulos, D., Floyd, L., Khan, S., Namukasa, I. K., Somanath, S., Weber, J., & Yiu, C. (2017). A Pedagogical Framework for Computational Thinking. *Digital Experiences in Mathematics Education*, 3(2), 154–171. <https://doi.org/10.1007/s40751-017-0031-2>
- Lockwood, J., & Mooney, A. (2018). Computational Thinking in Secondary Education: Where does it fit? A systematic literary review. *International Journal of Computer Science Education in Schools*, 2(1), 1–20.
- McCormick, K. I., & Hall, J. A. (2021). Computational thinking learning experiences, outcomes, and research in preschool settings: a scoping review of literature. *Education and Information Technologies*, 1-36.
- Musyaffi, A. M., Rosnidah, I., & Muna, A. (2021). Cloud-Based Learning Management: An Effective Learning during Social Distancing. *Journal of Educational and Social Research*, 11(5), 173-173.
- Musyaffi, A. M. (2022). Learning Management System Sustainability for Accounting Student: The Existence of Self-Efficacy. *Quality-Access to Success*, 23(188).
- Papert, S. (1980). *Mindstorms. Children, computers, and powerful ideas.* New York: Basic Books.
- Polat, E., Hopcan, S., Kucuk, S., & Sisman, B. (2021). A comprehensive assessment of secondary school students' computational thinking skills. *British Journal of Educational Technology*, 52(5), 1965–1980. <https://doi.org/10.1111/bjet.13092>

- Salomone, M., & Kling, T. (2017). Required peer-cooperative learning improves retention of STEM majors. *International Journal of STEM Education*, 4(1). <https://doi.org/10.1186/s40594-017-0082-3>
- Stovold, E., Beecher, D., Foxlee, R., & Noel-Storr, A. (2014). Study flow diagrams in Cochrane systematic review updates: An adapted PRISMA flow diagram. *Systematic Reviews*, 3(1), 1–5. <https://doi.org/10.1186/2046-4053-3-54>
- Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 366(1881), 3717–3725. <https://doi.org/10.1098/rsta.2008.0118>

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