INDONESIAN JOURNAL OF EDUCATIONAL RESEARCH AND REVIEW
Volume 7 Nomor 1 2024, pp 26-35
E-ISSN: 2621-8984; P-ISSN: 2621-4792
DOI: https://doi.org/10.23887/ijerr.v7i1.68202

Computational Thinking in Mathematics Education Across Five Nations

I Made Suarsana[1], Tatang Herman[2], Elah Nurlaelah[3*], Irianto[4], Estrella R. Pacis[5]
[1,2,3] Mathematics Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[4] Mathematics, Rabdan Academy, Abu Dhabi, United Arab Emirates
[5] Mariano Marcos State University City of Batac, Ilocos Norte, Philippines
*Corresponding author: elah_nurlaelah@upi.edu

Abstrak

Computational Thinking (CT) telah dinyatakan sebagai literasi dasar abad ke-21, sama halnya dengan literasi membaca dan literasi numerasi. Kesadaran akan pentingnya ICT telah direspon dengan sangat baik oleh berbagai negara dengan memasukkan CT ke dalam kurikulum sekolah. Penelitian ini bertujuan untuk menganalisis perbandingan integrasi CT dalam pendidikan matematika di 5 negara yaitu China, Singapura, United Kingdom (UK), Kanada dan Amerika Serikat (USA). Penelitian ini menggunakan metode tinjauan literatur sistematis yang dilakukan dengan protokol PRISMA. Penelitian ini dimulai dari mengidentifikasi proses, menilai, dan menafsirkan seluruh bukti penelitian yang ada. Rancangan yang digunakan adalah merangkum, mengulas, dan menganalisis 43 artikel di database Scopus yang sangat relevan dengan objek penelitian. Hasil penelitian menemukan bahwa, sebagian besar penelitian tentang integrasi CT dalam pendidikan matematika telah dilakukan di Amerika. Jenis penelitian yang dilakukan di China didominasi penelitian kuantitatif sedangkan di Kanada cenderung kualitatif. Di Tiongkok, Inggris, Kanada dan Amerika, sebagian besar penelitian dilakukan di tingkat Sekolah Dasar, sedangkan di Singapura dilakukan di tingkat Sekolah Menengah Pertama. Hasil ini menyiratkan wawasan berharga bagi pembuat kebijakan dan pendidik mengenai strategi efektif untuk mengintegrasikan CT dalam pembelajaran matematika.

***Kata kunci**: Berpikir Komputasional, Matematika,* Systematic Literature Review

Abstract

Computational Thinking (CT) has been declared as the basic literacy of the 21st century, as well as reading literacy and numeracy literacy. Awareness about the importance of ICT has been responded very well by various countries by including CT in the school curriculum. This study aimed to analyze the comparison of the integration of CT in mathematics education in 5 countries, namely China, Singapore, United Kingdom (UK), Canada and the United States of America (USA). This study used a systematic literature review method that was carried out with the PRISMA protocol. This study started from identifying the process, assessing, and interpreting all available research evidence. The design used is to summarize, review, and analyse 43 articles in the Scopus database that are very relevant to the research object. The results of the study found that, most research on the integration of CT in mathematics education had been conducted in the USA. The type of research conducted in China was dominated by quantitative research while in Canada and it tended to be qualitative. In China, UK, Canada and USA, most of the research was carried out at the Elementary School level, while in Singapore was carried out at the Junior High School level. This result implies valuable insights for policymakers and educators regarding effective strategies for integrating CT in mathematics learning.

Keywords: *Computational Thinking, Mathematics, Systematic Literature Review*

History:
Received : September 16, 2023
Accepted : March 23, 2024
Published : April 25, 2024

Publisher: Undiksha Press

1. INTRODUCTION

The term of CT was first introduced by study that emphasizes two aspects, namely computation to create new knowledge and computation to improve thinking and patterns of access to knowledge (Papert, 2020). In its development, computational thinking re-popularized CT by offering a new approach, namely CT as an aspect of thinking that is independent of technology and CT as a problem-solving method designed to be executed by humans, computers or both. The idea of CT considered a turning point in awareness of the importance of disseminating computer science skills in various fields including education in schools. In relation to the needs of the world of work, several world experts and organizations also agree to declare CT as one of the future work skills that is as important as public speaking, teamwork, and also leadership (Kittur et al., 2013; Sánchez-Chiappe & Poratelli, 2011; Senter & McClelland, 2015). The Organization of Economic Cooperation and Development (OECD) has also included the CT aspect in measuring mathematical literacy in the 2021 Program for International Student Assessment (PISA) framework. It indicates that the OECD views the importance of developing CT in students as a provision for future competencies.

PISA is a triennial international study organized by the OECD since 2008 on reading literacy, math literacy and science literacy of 15-year-old school students. The minimum competency score set is 500, and of the 77 participating countries, there were 20 countries that achieve it, namely China, Singapore , Macao, Hong Kong, Estonia, Japan, South Korea, Canada, Taiwan, Finland, Poland, Ireland, Slovenia, United Kingdom , New Zealand, Netherlands, Sweden, Denmark, Germany, and Belgium. The achievement of the PISA score can be used as an indicator of the quality of a country education delivery in preparing and equipping the students with 21st century skills including CT. The top 20 countries above have realized early on the importance of integrating CT in their school curriculum. The integration and implementation of CT in the school curriculum in several top 20 countries is an interesting matter to study. UK has introduced computer science in its national curriculum since 2012 and integrated it into the school curriculum since 2014 (Schleicher, 2019; Seow et al., 2019). Meanwhile in Canada, the results of a mapping study in January 2018 showed that several provinces have established CT as a mandatory component in the school curriculum. Korea and Hong Kong have also launched school curricula that integrate CT since 2015 that was carried out as an effort to strengthen the ICT industry in these countries (Chuntala, 2019; Seow et al., 2019). In China, programming and CT materials have been included in the 2017 national curriculum.

Several countries, including Austria, Denmark, Malta, Portugal, and Turkey, use specific CT integration in Informatics learning; Japan even incorporates it into programming lectures. It is used in math education in several other countries, including Finland and France. Differences in a country's regulations undoubtedly influence how researchers and practitioners incorporate CT into mathematics education. This makes it useful to compare the incorporation of CT in mathematics instruction across nations. Identification of existing level of computational thinking integration within mathematics education across these nations, discerning gaps or discrepancies in integration approaches, assessing the efficacy of current methods, and pinpointing areas necessitating further research or development to bridge the disparity between the current and desired states of computational thinking integration. In this case, the focus is on the four Top 20 nations of Pisa and the United States. A systematic literature review (SLR) on CT in mathematics education has been conducted by several researchers in the past. Previous study performed an SLR to describe the implementation of CT in mathematics education in Indonesia (Mukhibin & Juandi, 2023). Other study conducted an SLR to describe mathematics education that develops CT in various countries (Barcelos, 2018). There is also study conducted an SLR to depict the focus of CT research in mathematics education based on the level of education, research class, research methods, and research instruments (Mitrayana & Nurlaelah, 2023). Additionally, there is also study have also conducted an SLR to illustrate how students' CT skills are utilized in facing the 5.0 revolution in mathematics education. However, there has been no specific comparative study of CT research, particularly in the top 20 PISA countries that have integrated CT into their school curricula (Rizqi et al., 2024).

The urgency and novelty surrounding the research is underscored by several critical factors. Firstly, the increasing significance of computational thinking skills in today's digital landscape necessitates swift action to ensure that mathematics education adequately equips students for the demands of the future. Secondly, the potential disparities in computational thinking education among different nations could have profound implications for students' competitiveness and opportunities on a global scale. Additionally, the rapid evolution of technology underscores the need for timely research to inform educational practices, allowing educators and policymakers to adapt and refine strategies effectively in response to shifting technological landscapes. By addressing these urgent concerns, the research aims to enhance educational practices, thereby better preparing students for the challenges and opportunities of the digital age. By conducting this research, scholars and policymakers can gain insights into how computational thinking is currently integrated into mathematics education across different nations, identify gaps or disparities, and determine areas where interventions or improvements are needed. This can ultimately contribute to more effective educational practices and better prepare students for the challenges of the future.

2. METHODS

In this study, the identification, evaluation and interpretation of articles relevant to the object of research were carried out, namely the integration of CT in mathematics education using the Systematic Literature Review (SLR) method. SLR as a methodical and comprehensive process of identifying, selecting, critiquing, and synthesizing relevant literature on a specific research topic (De Jong & Van Joolingen, 1998; Yang et al., 2017). This approach follows a structured methodology, which includes defining clear research questions, establishing criteria for inclusion and exclusion of studies, conducting systematic searches across multiple databases and sources, and appraising the quality of included studies. By synthesizing findings from multiple studies, SLTs contribute to knowledge development, inform practice, and guide future research directions in the field under investigation.

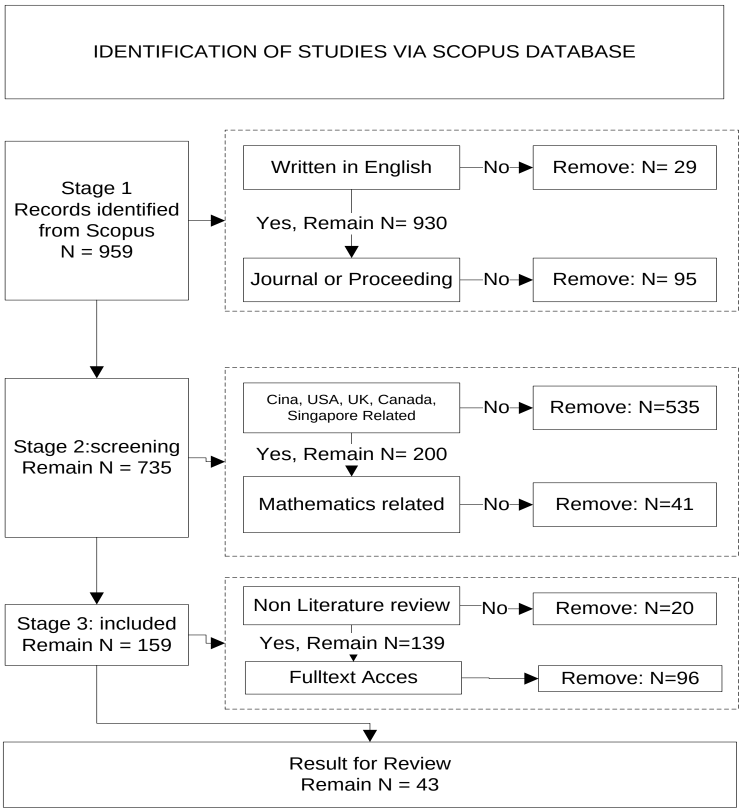

Figure 1. PRISMA Flowchart

The procedure used in this study was the PRISMA protocol (M J Page et al., 2021). PRISMA, which stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses, is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses. It consists of a 3-phase flow diagram, which have been adapted for use by students conducting systematic reviews as part of the course requirements for KIN 4400. The phases are identification, screening, and included as show in Figure 1. The selection process was carried out by including and excluding the literature obtained using the criteria in Table 1.

Table 1. Literature Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Problem/Population	Research on the integration of computational thinking in mathematics education	The research topic is not related to the integration of computational thinking in mathematics education
Intervention	Not using interventions, research can be quantitative, qualitative, and mixed method research	Research results on literature review
Comparation	There is no comparison factor	There is no comparison factor
Outcome	The article explains about CT and its relationship in Mathematics Learning	It does not contain the definition of CT or write down efforts to improve CT in mathematics learning
Published Year	2006 - 2023	Before 2006
Language	UK	Non-UK

Located the instrument used in this study is a guide to analyse literature content so the patterns or trends are obtained to answer research questions. Some basic concepts of classification refer to the following framework. Types of research were categorized based on the method, namely quantitative research, qualitative research and mixed methods research (Fraenkel et al., 2012). Several research designs are in the quantitative research category namely experimental research and non-experimental research (correlation research, comparative causal research, and survey research), while qualitative research types consist of ethnographic research case study history. The selected articles were classified based on the type of research, research subjects, the CT skill framework used and the CT-based learning approaches and tools applied (Kirçali & Özdener, 2022; Ye, 2023). This information was collected by analysing the content provided in the abstract, methods and research results. Furthermore, the data can be presented descriptively.

3. RESULTS AND DISCUSSION

Results

CT Integration Research in Mathematics Education

In this study, the scope of publications on the Scopus database examined the integration of CT in mathematics education covering 5 countries with duration from 2006 to 2023. Through the prism procedure, 139 publications were obtained and only 43 of them could be accessed in full text. The results of publication mapping by country, year, and type of publication were shown in Table 2 and Table 3.

Table 2. Recapitulation of Many Researches by Year

Year	China	Singapore	United Kingdom	Canada	USA
2023	2	0	0	2	2
2022	2	0	0	0	2
2021	3	1	0	1	3
2020	0	3	1	3	2
2019	1	0	1	1	1
2018	0	1	0	0	1
2017	0	0	1	2	1
2016	0	0	1	0	0
2015	0	0	2	0	2
2014	0	0	1	0	0
Total	**8**	**5**	**7**	**9**	**14**

Table 3. Recapitulation of Many Research by Type

Method	China	Singapore	United Kingdom	Canada	USA
Quantitative	5	0	0	0	2
Qualitative	0	2	1	5	3
Mix Method	0	0	1	2	3

CT Integration Research in Mathematics Education Based on Research Subjects

The results of the study in this research showed that research in China, United Kingdom, Canada and the USA was conducted at the elementary level, while in Singapore research on the integration of CT in mathematics education was mostly carried out at the junior high school level. The complete results can be shown in Table 4.

Table 4. Recapitulation of Many Researches by Subject

Subject	China	Singapore	United Kingdom	Canada	USA
Pre School	0	0	1	0	3
Elementary School	4	0	2	3	5
Junior High School	1	3	1	2	2
Senior High School	0	0	0	0	0

CT Skill Framework Used

The results of the computational thinking skill framework study used in 5 countries are shown in Table 5.

Table 5. Recapitulation of Research Based on CT Skill Framework

CT Skill	China	Singapore	United Kingdom	Canada	USA
Testing and debugging,	4	1	2	0	1
Modularizing/Decomposition/Problem reformulation	4	4	3	3	8
Abstraction	4	4	3	3	8
being incremental and iterative	3	0	1	1	1
Reusing and remixing	3	0	0	0	0
Algorithmic thinking	1	4	3	3	8
Pattern recognition	0	3	0	0	0

CT Skill	China	Singapore	United Kingdom	Canada	USA
Generalizing,	1	1	1	3	1
Logical thinking,	3	0	2	0	0
Efficiency	0	0	1	0	0
Innovation	0	0	1	0	0
Automatization	0	0	1	3	8

The CT Skill Framework that is widely referred to in research in China is the definition. According to previous study CT has 3 dimensions, such as computational concepts, computational practices, and computational perspectives. The computational practices dimension is also known as CT Skill that includes several capabilities such as being incremental and iterative, testing and debugging, reusing and remixing (Mukhibin & Juandi, 2023). The framework used in Singapore and the UK mostly adopts 4 CT foundations known as AADP namely abstraction, algorithmic thinking, decomposition, and pattern recognition. For Canada and the USA, CT skills framework, namely abstraction, algorithmic, automation, decomposition, and generalization.

CT-Based Learning Approaches and Tools

In the several intervention studies studied several learning approaches were identified used to measure the effect of CT integration in mathematics learning. The form of the learning approach intervention used in the five countries showed the same trend, namely programming based learning. Several other approaches were also used, namely design based learning, game-based learning, project-based learning, embodied learning, and problem-based learning. While the programming tools used by China, United Kingdom, Canada and USA tend to be the same, namely block programming applications in the form of scratch, while in Singapore they tend to use tangible programming in the form of unplugged Math+C Activities.

Discussion

Computational thinking is used as a research topic for experts not only in the field of computers but also in other fields including education. The results of a systematic literature review conducted by previous study found that research on the integration of CT in education continues to increase from year to year (Kampylis et al., 2023). Furthermore, the results of a systematic literature review conducted revealed that there have been more than 290 studies on the integration of CT in mathematics education conducted since 2006 (Ye, 2023). The results of the study showed that the integration of CT in mathematics education is also a research trend in various countries including the top 20 PISA countries. In relation to the type of CT integration research in mathematics education, other study found that the current trend of the CT integration research in mathematics education is quantitative research, then qualitative and mix-method (Barcelos, 2018; Hickmott et al., 2018). The same trend is shown in trends in the type of research in China, but for Singapore, the United Kingdom, Canada and the USA it shows a different trend, because the type of research is dominated by qualitative research. The findings indicate a global trend towards integrating computational thinking (CT) into mathematics education, particularly in top-performing countries according to the PISA rankings.

Computational thinking inclusion policies in the national curriculum vary widely between countries. Several countries such as Austria, Denmark, Malta, Portugal, Turkey carry out special CT integration in Informatics learning, even Japan packages it in programming lessons. Several other countries such as Finland and France integrate it in mathematics lessons. There are also several countries that combine of the two, namely integrating subjects (mathematics) at a certain level and bringing them up to special subjects (informatics) at a higher level. This variation also influences the tendency of different subjects in the research of the five countries. The results of the study showed the trend of research subjects in research on the integration of CT in mathematics education is elementary school students (Ye, 2023). It is in line with the trend found in China, UK, Canada and the USA, but a different thing is found in Singapore with more research is conducted at the junior high school level. The finding highlights the diverse approaches taken by different countries in integrating computational thinking (CT) into their national curriculum. This variation underscores the absence of a standardized or universally adopted approach to CT education. The countries mentioned in the study, including Austria, Denmark, Malta, Portugal, Turkey, and Japan, demonstrate differing strategies for CT integration, ranging from embedding it within informatics or programming lessons to incorporating it directly into mathematics education.

The definitions of CT given tend to be diverse and divergent. This diversity can be seen from the use of different skill aspects to build CT including testing and debugging, modularizing/decomposition/problem reformulation, abstraction, being iterative and incremental/design process, reusing and remixing, algorithmic design, pattern recognition, generalizing, logical thinking, simulations, and spatial reasoning. The results of previous study showed that the aspects of CT skills that appear most frequently in the literature studied were Testing and debugging (54.76%), decomposition (38.10%), abstracting (16.67%), and being iterative and incremental (14.29%), while reusing and remixing was not examined (Zeng et al., 2023). While USA, Canada and UK research tend to adopt definitions so that the aspects of CT skills that appear most often are abstraction, algorithmic, automation, decomposition, and generalization (J Wing, 2008; Jeannette Wing, 2006). So that the CT skill aspects that appear the most are abstraction, algorithmic, automation, decomposition, and generalization. The aspect of CT skills that is most widely used in research in Singapore showed a different trend because the research mostly adopts the 4 foundations of CT, namely AADP (abstraction, algorithmic thinking, decomposition, and pattern recognition) (Azizah et al., 2022; Palts, 2020).

The use of computers in CT-based learning is not mandatory because it is explicitly agreed that the emphasis on CT is on aspects of thinking not on programming and CT is related to ideas not artifacts (Barbero et al., 2020; Cutumisu, 2019). Even so, the use of technology has proven to be very effective in efforts to develop CT (Bell, 2021; Ruthmann et al., 2010; Scott & Barlowe, 2016). The results of the study showed that the learning approach that is widely used in the integration of CT in learning mathematics is programming based learning (Subramaniam, 2022). These results are in line with research findings that showed the same trend, namely in the five countries that the use of a programming approach in integrating CT in mathematics learning. The programming tool that is widely used in China, UK, Canada and the USA is block-based programming in the form of Scratch, while in Singapore using an unplugged approach using tangible programming, namely unplugged Math+C (del Olmo-Munoz et al., 2020; Fronza et al., 2015). Several studies showed that Scratch as a programming tool is the choice in an effort to facilitate the integration of CT in mathematics learning. The finding suggests that while the use of computers in computational thinking (CT)-based learning is not obligatory, technology has proven to be highly effective in developing CT skills (Tsarava, 2017; Valovičová et al., 2020). This aligns with the notion that CT emphasizes thinking processes rather than programming skills, highlighting the importance of focusing on conceptual understanding rather than mere technological artifacts.

The discussion offers a thorough analysis of how Computational Thinking (CT) has evolved and is currently being integrated into education, with a specific focus on mathematics. CT gained prominence across various fields, prompting increased research into its incorporation into educational curricula. This research, particularly in mathematics education, has shown a consistent upward trend, predominantly utilizing quantitative methodologies, though approaches vary across countries due to contextual factors. National strategies for CT integration differ, influencing research priorities accordingly. Despite the lack of a unified definition, the literature highlights various aspects of CT skills. Additionally, while technology is not obligatory, its effectiveness in CT learning, especially in programming-based methods such as Scratch, is widely acknowledged. Overall, while there is global momentum in integrating CT into education, achieving consensus on its definition and integration approaches remains a priority.

4. CONCLUSION

The research results are obtained based on an analysis of selected articles from five countries that may not be representative of the integration of CT in mathematics learning in those countries. Caution is required in drawing conclusions from the findings obtained. With all these limitations, it can be concluded that several comparisons related to the integration of CT in mathematics learning in five countries are as follows. The type of research on the integration of CT in mathematics education that is mostly carried out in China is quantitative research while in Singapore, United Kingdom, Canada, and USA is qualitative research. Research on the integration of CT in mathematics education in China, the United Kingdom, Canada, and the USA is mostly conducted at the elementary level.

5. REFERENCES

Azizah, N. I., Roza, Y., & Maimunah, M. (2022). Computational thinking process of high school students in solving sequences and series problems. *Jurnal Analisa*, *8*(1), 21–35. https://doi.org/10.15575/ja.v8i1.17917.

Barbero, G., Gómez-Maureira, M. A., & Hermans, F. F. J. (2020). Computational Thinking through Design Patterns in Video Games. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3402942.3409622.

Barcelos, T. S. (2018). Mathematics learning through computational thinking activities: A systematic literature review. In *Journal of Universal Computer Science* (Vol. 24, Issue 7, pp. 815–845). https://www.academia.edu/download/96594322/jucs_24_07_0815_0845_barcelos.pdf

Bell, T. (2021). Computational thinking: Online and offline, plugged and unplugged. In B. M., M. A., & A. M. (Eds.), *16th Workshop in Primary and Secondary Computing Education, WiPSCE 2021*. Association for Computing Machinery. https://doi.org/10.1145/3481312.3488711.

Chuntala, A. D. W. (2019). Scientific approach in 21st century learning in Indonesian language learning vocational school of pharmacy. *International Journal of Active Learning*, *4*(2), 71–77. https://journal.unnes.ac.id/nju/index.php/ijal/article/view/17181.

Cutumisu, M. (2019). A Scoping Review of Empirical Research on Recent Computational Thinking Assessments. In *Journal of Science Education and Technology* (Vol. 28, Issue 6, pp. 651–676). https://doi.org/10.1007/s10956-019-09799-3.

De Jong, T., & Van Joolingen, W. R. (1998). Scientific Discovery Learning with Computer Simulations of Conceptual Domains. *Review of Educational Research*, *68*, 179–201. https://doi.org/10.3102/00346543068002179.

del Olmo-Munoz, J., Cozar-Gutierrez, R., & Gonzalez-Calero, J. A. (2020). Computational thinking through unplugged activities in early years of Primary Education. *COMPUTERS & EDUCATION*, *150*. https://doi.org/10.1016/j.compedu.2020.103832.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). The McGraw-Hill Companies.

Fronza, I., El Ioini, N., & Corral, L. (2015). Students want to create apps: Leveraging computational thinking to teach mobile software development. *SIGITE 2015 - Proceedings of the 16th Annual ACM Conference on Information Technology Education*, 21–26. https://doi.org/10.1145/2808006.2808033.

Hickmott, D., Prieto-Rodriguez, E., & Holmes, K. (2018). A scoping review of studies on computational thinking in K–12 mathematics classrooms. *Digital Experiences in …*. https://doi.org/10.1007/s40751-017-0038-8.

Kampylis, P., Dagienė, V., Bocconi, S., Chioccariello, A., Engelhardt, K., Stupurienė, G., Masiulionytė-Dagienė, V., Jasutė, E., Malagoli, C., & Horvath, M. (2023). Integrating Computational Thinking into Primary and Lower Secondary Education. *Educational Technology & Society*, *26*(2), 99–117. https://www.jstor.org/stable/48720999.

Kirçali, A. Ç., & Özdener, N. (2022). A Comparison of Plugged and Unplugged Tools in Teaching Algorithms at the K-12 Level for Computational Thinking Skills. *Technology, Knowledge and Learning*. https://doi.org/10.1007/s10758-021-09585-4.

Kittur, A., Nickerson, J. V, Bernstein, M., Gerber, E., Shaw, A., Zimmerman, J., Lease, M., & Horton, J. (2013). The future of crowd work. *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, 1301–1318. https://doi.org/10.1145/2441776.2441923.

Mitrayana, M., & Nurlaelah, E. (2023). Computational Thinking in Mathematics Learning: Systematic Literature Review. *Indonesian Journal of Teaching in Science*. https://doi.org/10.17509/ijotis.v3i2.60179.

Mukhibin, A., & Juandi, D. (2023). The Implementation of Computational Thinking on Mathematics Learning Research: A Systematic Literature Review. *Hipotenusa Journal of Mathematical Society*. https://doi.org/10.18326/hipotenusa.v5i1.9007.

Page, M J, Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *Bmj*, *372*. https://doi.org/10.1136/bmj.n160.

Page, Matthew J, McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International Journal of Surgery*, *88*, 105906. https://doi.org/10.1136/bmj.n71.

Palts, T. (2020). A model for developing computational thinking skills. *Informatics in Education*, *19*(1), 113–128. https://doi.org/10.15388/INFEDU.2020.06.

Papert, S. A. (2020). *Mindstorms: Children, computers, and powerful ideas*. Basic books.

Rizqi, N. R., Fauzi, K. M. A., & Syahputra, E. (2024). Systematic Literature Review: The Importance of Computational Thinking Abilities in the Era of Society 5.0 in Mathematics Learning. *Proceedings of Malikussaleh International Conference On Education Social Humanities And Innovation (Miceshi)*, *1*, 4. https://proceedings.unimal.ac.id/miceshi/article/view/309.

Ruthmann, A., Heines, J. M., Greher, G. R., Laidler, P., & Saulters, C. (2010). Teaching computational thinking through musical live coding in Scratch. *SIGCSE'10 - Proceedings of the 41st ACM Technical Symposium on Computer Science Education*, 351–355. https://doi.org/10.1145/1734263.1734384.

Sánchez-Chiappe, I., & Poratelli, A. P. (2011). The world economic forum report, value chains and the creation of wealth in Latin American Countries. *International Business: Research, Teaching and Practice*, *1*, 41–55. https://eprints.lse.ac.uk/88440/.

Sartika, E. (2021). Pemanfaatan Media Digital Pada Pembelajaran Di Masa Pandemi. *Jurnal Bahasa, Sastra, Dan Budaya*, *11*(2), 173–182. https://doi.org/10.37905/jbsb.v11i2.14038.

Schleicher, A. (2019). PISA 2018 Insights and Interpretations. *OECD Publishing*. https://doi.org/10.1787/b25efab8-en.

Scott, A., & Barlowe, S. (2016). How software works: Computational thinking and ethics before CS1. *Proceedings - Frontiers in Education Conference, FIE*, *2016-Novem*. https://doi.org/10.1109/FIE.2016.7757436.

Senter, K. Y., & McClelland, A. (2015). Top ten workplace skills for future organizations. *International Journal of Business Research and Management*, *6*(2), 20–32. https://www.academia.edu/download/77427755/IJBRM-186.pdf.

Seow, P., Looi, C.-K., How, M.-L., Wadhwa, B., & Wu, L.-K. (2019). Educational policy and implementation of computational thinking and programming: Case study of Singapore. *Computational Thinking Education*, 345–361. https://library.oapen.org/bitstream/handle/20.500.12657/23182/1/1006971.pdf#page=341.

Subramaniam, S. (2022). Computational thinking in mathematics education: A systematic review. In *Cypriot Journal of Educational Sciences* (Vol. 17, Issue 6, pp. 2029–2044). https://doi.org/10.18844/cjes.v17i6.7494.

Tsarava, K. (2017). Training computational thinking: Game-based unplugged and plugged-in activities in primary school. In *Proceedings of the 11th European Conference on Games Based Learning, ECGBL 2017* (pp. 687–695). https://www.researchgate.net/profile/Katerina-Tsarava/publication/320491120.

Valovičová, L., Ondruška, J., Zelenický, L., Chytrý, V., & Medová, J. (2020). Enhancing computational thinking through interdisciplinary steam activities using tablets. *Mathematics*, *8*(12), 1–15. https://doi.org/10.3390/math8122128.

Wing, J. (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.

Wing, Jeannette. (2006). Computational Thinking. *Communications of the ACM*, *49*(3), 33–35. https://doi.org/10.1145/1118178.1118215.

Yang, E. C. L., Khoo-Lattimore, C., & Arcodia, C. (2017). A systematic literature review of risk and gender research in tourism. *Tourism Management*, *58*, 89–100. https://doi.org/10.1016/j.tourman.2016.10.011.

Ye, H. (2023). Integration of computational thinking in K-12 mathematics education: a systematic review on CT-based mathematics instruction and student learning. In *International Journal of STEM Education* (Vol. 10, Issue 1). https://doi.org/10.1186/s40594-023-00396-w.

Zeng, Y., Yang, W., & Bautista, A. (2023). Computational thinking in early childhood education: Reviewing the literature and redeveloping the three-dimensional framework. *Educational Research Review*, *39*. https://doi.org/10.1016/j.edurev.2023.100520.