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Research Trends in Teaching Materials to Improve Computational Thinking Skills

A Bibliometric Analysis from 2021 to 2025

[1]Aditya Saputra Dewa*, [1]Edi Kurniawan, [1]Bambang Subali, [1]Ellianawati

Corresponding Author: *adityasaputradewa1706@students.unnes.ac.id

[1] Universitas Negeri Semarang, Semarang, Indonesia

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ABSTRACT

The development of critical thinking as a key 21st-century competency is closely linked to computational thinking (CT), which requires systematic support through appropriate teaching materials. This study aims to analyse research trends in CT teaching materials published between 2021 and 2025 using a systematic review with a bibliometric approach following PRISMA guidelines. Data were collected from Crossref, Google Scholar, Scopus, and Semantic Scholar, resulting in 68 selected articles from an initial pool of 2,050 publications, which were analysed through content analysis and bibliometric mapping using VOSviewer. The findings reveal a significant increase in CT teaching material research in the post-pandemic period, particularly in 2023, with a predominance of empirical and research and development (R&D) studies. Most studies focus on computer science contexts, elementary education, and interactive digital teaching materials, indicating that CT is often positioned as an initial technical competency. In contrast, CT teaching materials for non-computer science subjects, other educational levels, and non-digital or unplugged contexts remain underexplored. Furthermore, existing research primarily emphasises product development and short-term effectiveness, while longitudinal studies examining the sustainability of CT learning outcomes are still limited. These findings highlight the need for pedagogically grounded, context-responsive, and interdisciplinary CT teaching materials, as well as future research employing longitudinal designs to support the equitable and sustainable

development of CT as a core competence in 21st-century education.

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Keywords
21st-Century Skills
Bibliometric Analysis
Computational Thinking
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Introduction

The development of science and technology in the 21st century has had ramifications for the educational environment and society. These include increasingly complex social changes, rapid technological developments, the proliferation of fake news, and the risk of losing control over the development of artificial intelligence (AI) and cyber-physical technology [1], [2]. In this context, education assumes a pivotal role in equipping individuals with the requisite skills and competencies to navigate the increasingly complex and dynamic landscape of Industry 4.0 and Society 5.0. [3]. In this regard, it is imperative for individuals to cultivate essential competencies that will equip them to confront the challenges of this era. These competencies include critical thinking, problem solving, communication, collaboration, creativity, metacognition, and information literacy [4].

In the contemporary era, the pertinence of critical thinking skills lies in their capacity to assist individuals in the critical analysis of information, the judicious decision-making, the effective problem-solving, the discernment of the limitations, biases, and ethical implications of AI, while promoting the judicious and responsible utilization of AI [5], [6]. This process involves the review of established norms, the comprehension of specific situations, and the evaluation of pertinent evidence [7]. Additionally, it encompasses the identification of cognitive biases and the modification of thought processes to facilitate the formation of suitable and rational decisions, thereby ensuring adaptation to contemporary society [8].

The integration of computational thinking (CT) has been identified as a pivotal factor in the development of critical reasoning skills [9], [10]. CT is a problem-solving oriented way of thinking by applying computational concepts [11]. In the field of CT, problem-solving methodologies are informed by the use of computer-based problem-solving techniques. These techniques encompass decomposition, pattern recognition, abstraction, and algorithms [12]. Putri et al [13] explain, students who possess CT will be able to solve problems in a creative, critical, algorithmic, and systematic manner, as well as face complex challenges in various fields. Consequently, computational thinking serves as the foundational framework for cultivating skills and competencies that are pertinent to contemporary challenges.

In light of the pivotal role that CT plays in addressing the challenges of the 21st century, the development of effective teaching materials to nurture students' computational thinking capabilities is imperative. In essence, teaching materials serve as a crucial instrument in the pedagogical toolkit, assisting educators in their mission to facilitate learning. These materials are meticulously and systematically structured, offering a sequential progression that guides students through the educational journey [14]. While instructional materials play a pivotal role in facilitating effective learning, in practice, their utilization remains constrained to printed books provided by educational institutions. This dynamic has been demonstrated to exert a significant influence on the level of interest and enthusiasm exhibited by students [15]. To address these challenges, numerous studies have devised printed and non-printed instructional materials comprising exercises ranging from simple to complex, accompanied by case studies grounded in authentic problems. These materials are characterized by interactivity, engagement, and their capacity to streamline processes such as decomposition, pattern recognition, abstraction, and algorithmic thinking, which are pivotal in fostering computational thinking [15]–[18]. Consequently, a bibliometric analysis is imperative to provide a comprehensive overview and serve as a foundation for developing teaching materials that are more relevant to current learning needs.

The primary objective of this study is to examine research trends on teaching materials to enhance computational thinking in the period 2021–2025. The present study utilizes bibliometric analysis of select articles to identify the direction of research development, ascertain key keywords, and describe the types of teaching materials that can improve CT skills. Based on these objectives, the research questions in this study are formulated as follows.

1. What are the trends and developments in teaching materials to improve CT skills based on the year of publication?
2. Which countries dominate the number of publications related to teaching materials to improve computational thinking skills?
3. What fields of study are most frequently examined in research on the development of teaching materials to improve CT skills?
4. What is the distribution of research on teaching materials to improve CT skills based on the education level of the research subjects?
5. What types of research are used in the study of teaching material development to improve CT skills?
6. What forms of teaching materials are used or developed in research to improve CT skills?
7. What are the keywords/topics that most frequently appear in research on teaching materials to improve CT skills, and how do these keywords form a network map?

Thus, this research is expected to clarify the patterns, focus, and direction of teaching material development that supports computational thinking improvement. It will also provide a basis for developing more relevant and effective teaching materials in the future.

Material and Methods

This study employs a systematic review method with a bibliometric approach for the analysis and mapping of research data, with the objective of comprehending the distribution, trends, and relationships between studies [19]. The study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which encompass four primary steps: The identification, screening, eligibility and inclusion of subjects is a process that has been extensively researched [20].

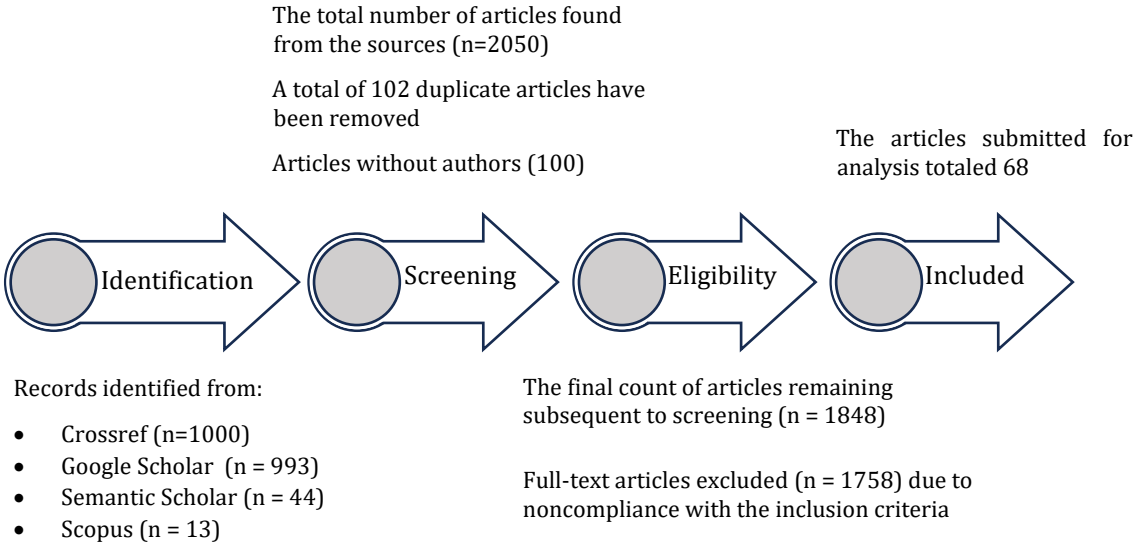


Fig. 1. Research procedure.

In the identification stage, researchers conducted a search for relevant articles. The data sources were obtained from the Crossref, Google Scholar, Semantic Scholar, and Scopus databases, which were searched online using the Publish or Perish (PoP) application. The databases were obtained based on searches using the keywords "computational thinking" and "teaching materials" for the period 2021 to 2025. The number of articles obtained from the Crossref database was 1,000, 993 articles from the Google Scholar database, 44 articles from the Semantic Scholar database, and 13 articles from the Scopus database. Consequently, a total of 2050 articles were identified.

The subsequent screening stage was then performed to remove duplicate articles and those not authored by the relevant parties. Concurrently, the eligibility stage entails a thorough evaluation and selection of articles based on inclusion and exclusion criteria established using the SPIDER approach (Sample, Phenomenon of Interest, Design, Evaluation, and Research

type). The inclusion criteria for the present study are as follows: the research articles under consideration must be of an empirical nature, and must discuss teaching materials or learning related to CT skills. In addition, the articles must involve student subjects, and must utilise a clear research design. Finally, the articles must evaluate or measure computational thinking skills. It is evident that articles which do not align with the specified criteria will be excluded from the analysis. The inclusion and exclusion criteria are outlined in Table 1. The final stage, entitled inclusion, involved the analysis of articles that met all the specified criteria. The analysis was conducted through a content and bibliometric approach, utilising the VOSviewer tool. The VOSviewer tool was utilised to visualise the bibliometric network between keywords, thereby facilitating the comprehension of trends in teaching material research to enhance CT [21].

Table 1. Inclusion and Exclusion Criteria.

Type of Criteria	Inclusion	Exclusion
Sample (S)	Students at pre-school, elementary, junior high, and high school students	Participants other than students
Phenomenon of Interest (PI)	Teaching materials or learning related to CT skills	Topics unrelated to CT or teaching materials
Design (D)	Empirical studies with clear research designs (experimental, R&D, descriptive, mixed methods)	Other
Evaluation (E)	Studies evaluating or measuring CT skills	Studies without evaluation of CT skills
Research Type (R)	Empirical research articles	Non-empirical studies
Publication Type	Journals and conferences	Disertation, book, other
Language	English	Other
Publication Year	2021–2025	Outside the specified period

Results and Discussions

The results of the analysis of scientific articles on the subject of teaching materials research to improve computational thinking skills include the number of articles per year, country of origin, field of study, research methods used, research subjects, types of teaching materials, and frequently used keywords. Scientific articles focusing on the use of teaching materials to improve CT skills from 2021 to 2025 are shown in Fig. 2.

As illustrated in Fig. 2, the number of articles published during the 2021–2025 period exhibits fluctuations. At the onset of the period under consideration, a decline in the number of publications was observed, a phenomenon that was likely associated with shifts in the research context during and following the emergence of the novel Coronavirus (SARS-CoV-2) pandemic. The advent of the SARS-CoV-2 in 2021 precipitated the necessity for educational institutions to adopt online learning modalities, thereby prompting researchers to undertake an examination of the integration of CT in digital learning [22]. This has given rise to a plethora of studies that are exploring the integration of CT through digital approaches, including

storytelling-based learning, games and programming, and robotics [23]–[26]. This surge in publications can be attributed to the growing demand for digital teaching materials in online learning during the pandemic. However, in 2022, there was a decline in the number of publications, as the focus of research shifted to instrument validation and the application of CT in specific contexts, such as comparisons of computer-based and non-computer-based teaching materials [27]–[30].

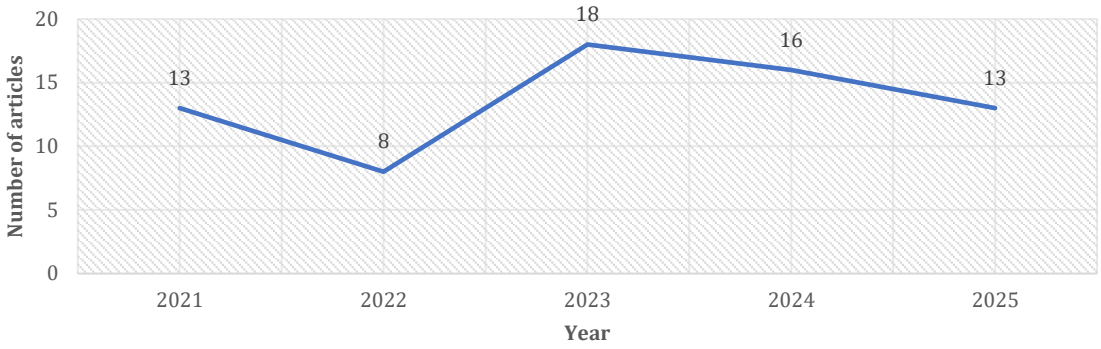


Fig. 2. Number of scientific articles on teaching materials improving CT skills

A substantial surge in article publications was observed in 2023. This finding suggests a notable degree of academic enthusiasm for the development and application of innovative teaching materials aimed at enhancing CT skills. One of the research foci examined was the effectiveness of various teaching materials based on project-based learning, game-based learning, and unplugged activities in improving CT [31]–[33]. Research on analogous subjects has undergone rapid expansion in Indonesia. This finding aligns with the data presented in Fig. 3, which indicates that Indonesia holds the distinction of being the nation with the most significant contribution in this domain.

An examination of the graph depicting the distribution of countries of origin of research (Fig. 3) reveals that Indonesia is the leading contributor to publications concerning the development of teaching materials aimed at enhancing computational thinking skills. It is followed by China and Turkey, which are also significant contributors to this field. A review of the extant scientific literature reveals a focus on the development of digital teaching materials integrated with active learning models and new technology-based learning for CT development in Indonesia. Furthermore, there is a growing inclination to incorporate local wisdom into the design of teaching materials with the aim of enhancing CT. A multitude of factors have contributed to the surge in research on teaching materials for cultivating CT skills in Indonesia. One of these is that conventional learning media have not been effective in stimulating students' CT skills. The demand for the integration of 21st-century learning models, post-pandemic digital transformation, and the Merdeka Belajar policy have also strengthened the use of technology in designing adaptive learning that is relevant to student characteristics.

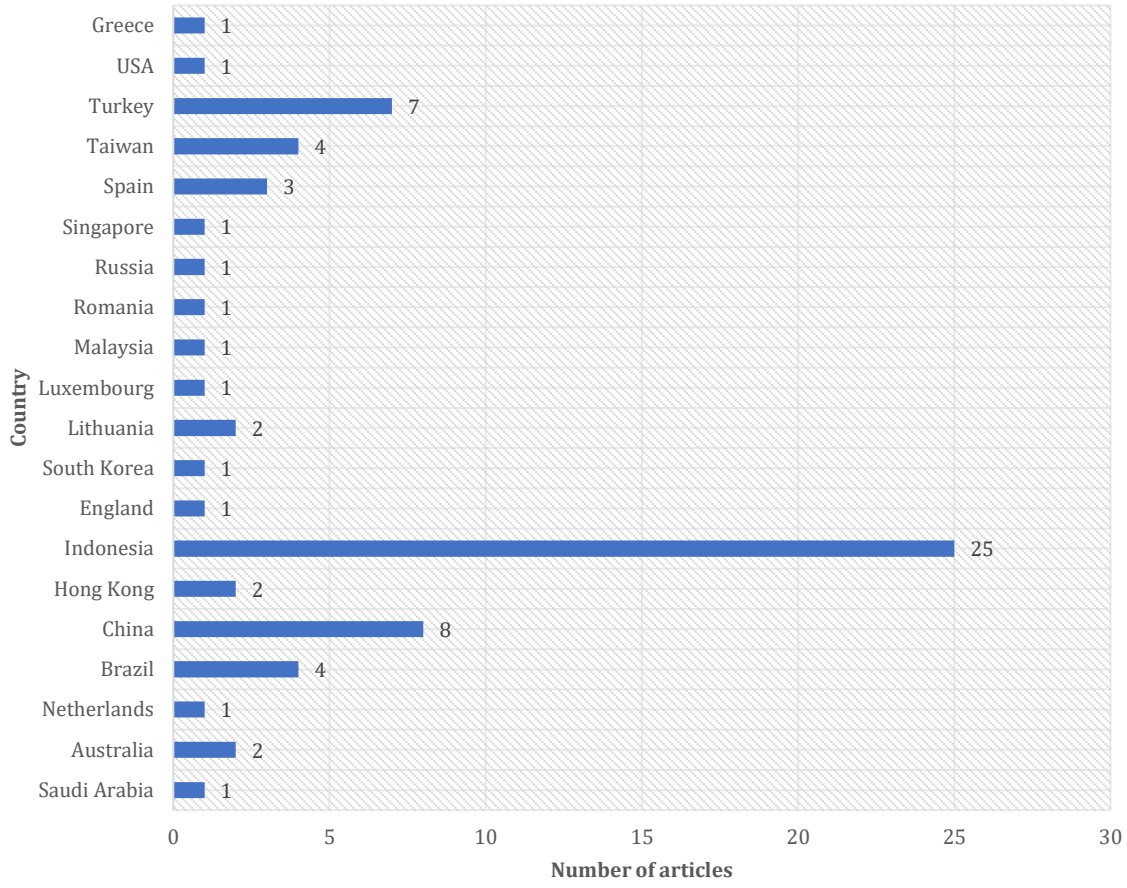


Fig. 3. Number of teaching materials to improve CT skills publications by country

Research in China on teaching materials for computational thinking development focuses on developing innovative learning models based on digital platforms and creative activities (e.g., visual, games, stories, and unplugged) that are tailored to diverse educational contexts. Furthermore, endeavors aimed at equalizing access in rural regions and validating CT assessment instruments have demonstrated that the research focus extends beyond the innovation of teaching materials to encompass the effectiveness, measurement, and inclusiveness of CT education. Concurrently, research in Turkey has centered on the implementation of coding activities (plugged and unplugged) and their impact on students' competencies and self-efficacy. Research conducted in China and Turkey is predominantly characterized by the field of computer science, which has contributed substantially to the increase in the number of publications in the field of informatics, as illustrated in Fig. 4.

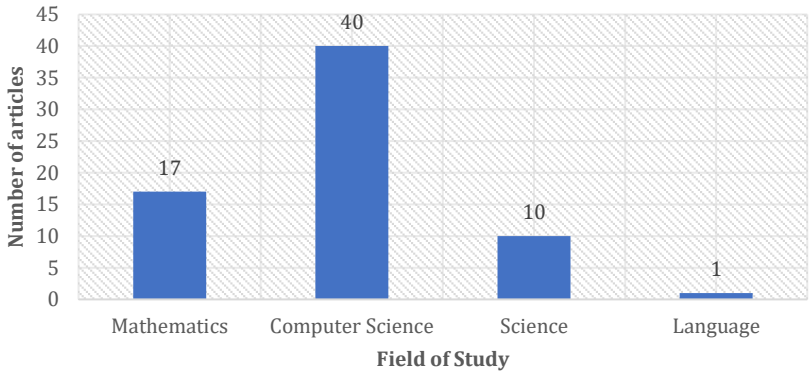


Fig. 4. Number of teaching materials to improve CT skills publications by field of study.

As illustrated in Fig. 4, the research on the development of teaching materials to enhance CT skills in mathematics, science, and language remains comparatively limited in scope when viewed in contrast to the research activity observed within the field of computer science. Mathematics and science are the most prominent fields in Indonesia. This phenomenon may be attributed to Indonesia's substandard performance in science and mathematics as evidenced by international assessments such as the Program for International Student Assessment (PISA). These findings have prompted researchers and educators to devise learning strategies that emphasize logical and systematic thinking through the use of computer-based technology [34]. Research on the development of teaching materials to improve skills in mathematics is predominantly conducted on elementary school students, as illustrated in Table 2.

Table 2. Distribution of Research Based on Research Subjects.

Research Subject	Mathematics	Computer Science	Science	Language	Total Publication
Preschool students	-	3	-	-	3
Elementary school students	9	19	4	1	33
Junior high school students	6	14	3	-	23
High school students	2	7	3	-	12

As illustrated in Table 2, elementary school students are the most frequently researched subjects, with a total of 33 studies, followed by junior high school students with 23 studies, senior high school students with 12 studies, and preschool students with 3 studies. Conversely, elementary school students are frequently utilized as subjects in teaching material research aimed at enhancing CT skills in the domains of computer science, mathematics, and science. A thorough examination of the data presented in Table 2 reveals that elementary school students are the most frequently researched subjects in the context of CT. This finding underscores the significance of incorporating CT integration into the elementary school

curriculum. This tendency aligns with the methodological approach employed, wherein the majority of studies adopt an empirical design, as illustrated in Fig. 5.

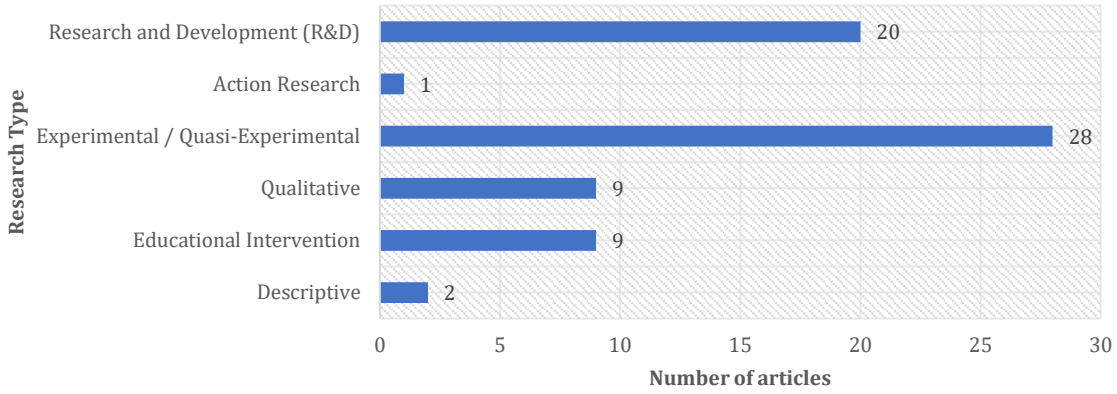


Fig. 5. Distribution of teaching materials based on research type

Preliminary analysis suggests that the majority of research in this field was conducted using an empirical approach. This type of empirical research frequently utilizes experimental or quasi-experimental designs, subsequently accompanied by research and development (R&D) and educational interventions, as illustrated in Fig. 5. A comprehensive review of the extant literature reveals a marked tendency towards experimental and developmental approaches, with a concomitant emphasis on the validation of the efficacy and innovation of teaching materials in facilitating learning. A variety of teaching materials are employed to substantiate the efficacy and innovation in the enhancement of CT skills, as illustrated in Fig. 6.

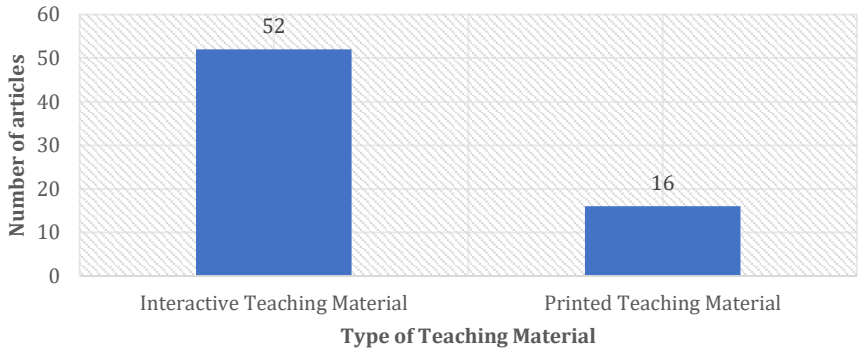


Fig. 6. Distribution of teaching materials based on the type of teaching material.

In the learning process, teaching materials come in various forms that are tailored to the characteristics of the material and media used to make learning more interesting and effective. Astuti & Ismail [35] classify teaching materials into four forms, including printed teaching materials, audio teaching materials, audio-visual teaching materials, and interactive teaching materials. Based on Fig. 6, the dominant form of teaching material used to improve

CT skills is interactive. This type of teaching material includes various digital media such as e-worksheets [36] and e-modules [37]–[39] integrated with the PBL learning model [32], [40], PJBL [31], [41], [42], and linked to local wisdom [13], [17], [43], [44].

A plethora of interactive teaching materials have been developed, including learning animations [29], educational games [26], [33], [45]–[48], Scratch [23], [49], [50]–[53], PowerPoint [54], [55], augmented reality (AR)-based learning media [56], [57], Android-based applications,[58]–[64], learning platform [65], [66] dan programming-based learning media [25], [28], [67]–[76].

In addition to the utilization of interactive teaching materials, the employment of printed teaching materials is also a prevalent practice, particularly in the form of worksheets [24], [77], [78], printed modules [79], and media that facilitate Unplugged activities, including instruction cards, logic boards, and manipulative blocks [27], [30], [80]–[86], as well as questions about the Bebras story type [87]–[89]. Notwithstanding their physical form, these types of teaching materials nevertheless play an important role because they enable active student engagement through exploratory and collaborative activities. The results of this analysis demonstrate a prevailing trend in teaching materials research to enhance CT, characterized by a shift towards digitalization and interactivity. This shift is primarily driven by the objective of increasing student engagement and fortifying higher-order thinking skills. The predominance of interactive teaching materials aligns with the demands of 21st-century learning.

To identify the most dominant keywords and their relevance in teaching material research to improve CT skills, VOSviewer analysis was used, as shown in Fig. 7.

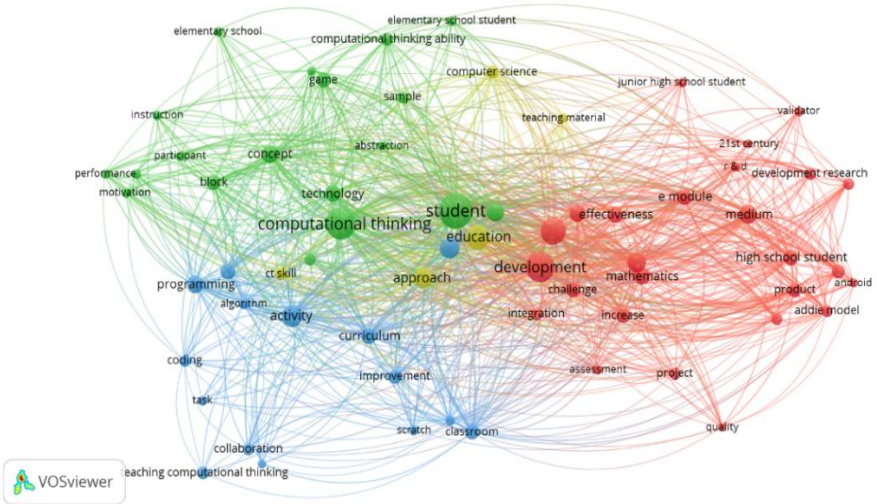


Fig. 7. Visualization of the teaching materials research network (2021-2025)

A subsequent analysis of keyword mapping using VOSviewer in Fig. 7. reveals that the most dominant keywords with the strongest correlation are computational thinking and

student. The prevalence of these two keywords suggests that research on teaching material development consistently prioritizes CT skills as the primary learning objective, with students as the central subject. The strong correlation between these two keywords forms the network core that connects various other research topics, thereby forming an integrated network map structure.

The red cluster signifies the focal point of instructional material development research endeavors aimed at enhancing CT skills. The analysis of dominant keywords reveals a focus on the learning product development process, the selection of development models, and the evaluation of product quality through validity, practicality, and effectiveness tests. Keywords such as "development," "R&D," "ADDIE model," "product," "e-module," "Android," "effectiveness," and "practicality" are indicative of this focus. The interrelationship between keywords in this cluster is formed because instructional material development research generally follows a systematic flow, starting from the design stage, implementation, to the evaluation of learning products.

The green cluster illustrates the relationship between CT skills and learner characteristics and learning contexts. The emergence of keywords such as "student," "elementary school," "junior high school," "instruction," and "motivation" indicates that a significant portion of the research examines the application of teaching materials at various levels of education, particularly primary and secondary education. The interconnectedness of keywords in this cluster is formed because the research focuses not only on the product, but also on how the teaching materials are used in the learning process to increase student engagement, learning motivation, and CT skills.

The blue cluster underscores the integration of CT skills through programming-based learning activities and hands-on experiences. A close examination of the extant literature reveals an intricate interrelationship among the terms "programming," "activity," "curriculum," and "classroom." This observation is primarily driven by the fact that the research in this particular cluster is centered on the integration of computational activities into the existing curriculum and classroom learning practices. The relationship between keywords reflects efforts to develop logical and systematic thinking skills through active and collaborative learning activities.

Concurrently, the yellow cluster signifies pedagogical approaches and scientific domains that facilitate the cultivation of CT competencies. The correlation between keywords such as "education," "approach," "computer science," and "teaching materials" indicates an inherent interconnectedness in the development of CT teaching materials, emphasizing the significance of learning approaches and scientific foundations in this process. The relationship

between keywords in this cluster is formed because CT research is multidisciplinary and combines pedagogical approaches with computer science concepts.

The analysis of the keyword network map reveals a close interconnection among computational thinking skills, learners, teaching material development, and learning approaches. The formation of this network is predicated on the observation of a consistent pattern in research on CT teaching materials. Specifically, the focus of this research has been on the development of learning products, their application to learners, and the evaluation of their impact on computational thinking skills. Utilizing VOSviewer, we are able to obtain an overview of teaching materials intended to enhance CT for the 2021 to 2025 period, as illustrated in Fig. 8.

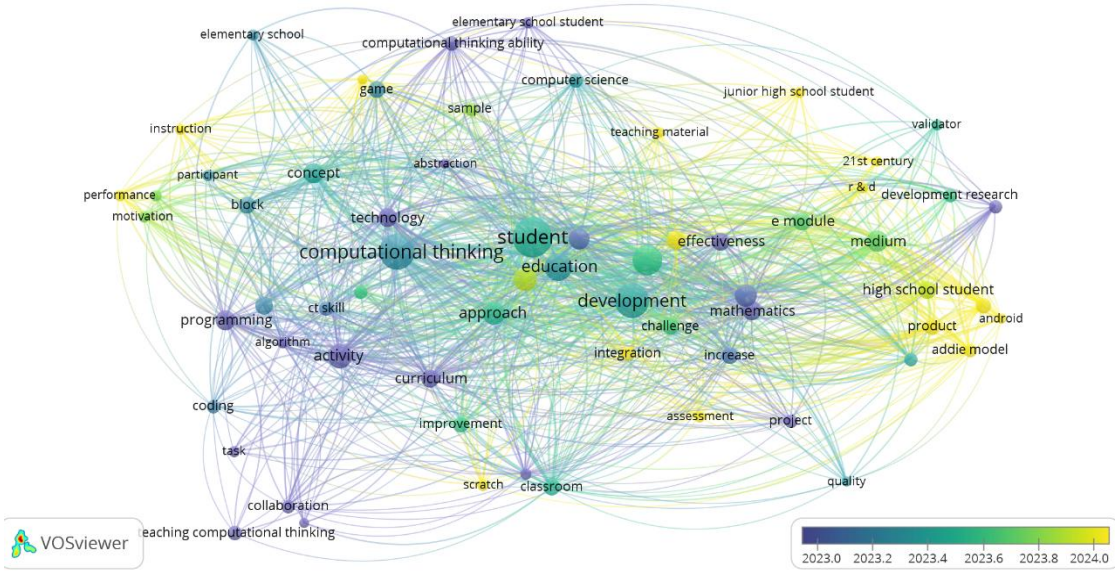


Fig. 8. Visualization of overlapping research on teaching materials (2021-2025)

As demonstrated in Fig. 8, the overlay visualization illustrates the evolution of research on teaching materials designed to enhance computational thinking skills during the period from 2021 to 2025. The blue color represents keywords that were dominant in 2021, such as "programming," "coding," "algorithm," and "activity." These keywords indicate that the initial research focused on introducing the basic concepts of computational thinking through programming activities. As the new academic year began, research shifted its focus to the themes of education, students, curriculum, and integration, indicating an ongoing effort to incorporate computational thinking skills into learning. In the 2023–2024 period, keywords such as "development," "e-module," "mathematics," and "effectiveness" witnessed a marked increase in prevalence, suggesting an escalated emphasis on the development and evaluation of the efficacy of digital teaching materials. Concurrently, from 2024 to 2025, the emergence of terms such as "android," "addie model," "product," and "high school student" signaled the

latest trends in the development of digital products based on research and development (R&D) models. A comprehensive analysis of the data reveals a discernible shift in the direction of research from fundamental activities and programming concepts towards the development of digital teaching materials that are more integrated with technology and applied at various levels of education.

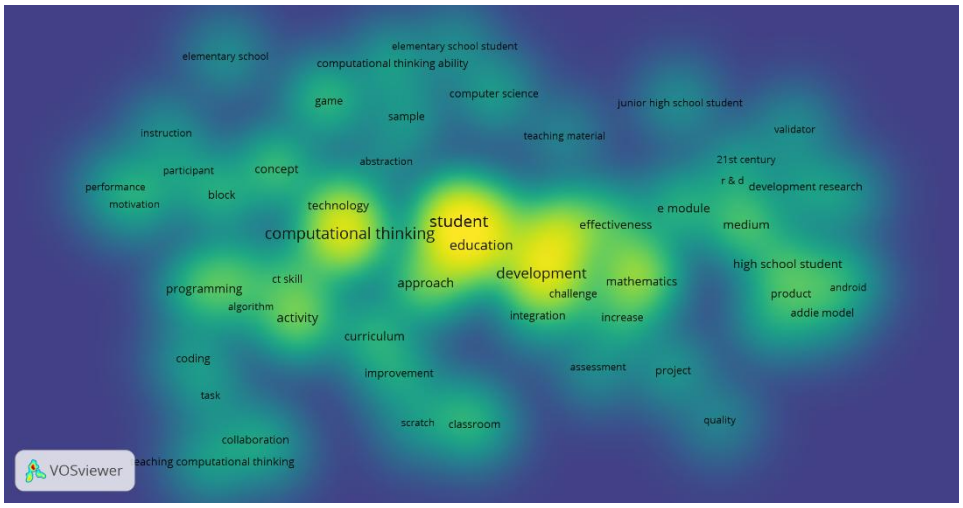


Fig. 9. Visualization of the density of research data on teaching materials (2021-2025)

Based on Fig. 9, research on computational thinking, students, education, and development exhibits the highest density, indicating that this subject is the primary focus in the development of teaching materials to enhance computational thinking skills. Medium density (green zone) is observed in keywords such as programming, activity, curriculum, mathematics, e-module, and effectiveness, which indicate a research focus on the application of learning activities and the development of digital teaching materials to support computational learning. Concurrently, the low density (blue zone) emerges in terms such as "Android," "addie model," "high school student," and "development research," which denote subjects that are in the nascent stages of evolution toward the development of technology-based teaching materials and digital products that are adaptive to the needs of students. A future research direction that merits exploration is the enhancement of teaching material innovation to cultivate computational thinking skills in a contextual manner and in alignment with the diverse characteristics of students across various educational levels.

Implications and Recommendations

A review of research publication trends for the 2021–2025 period reveals a substantial surge in publications following the pandemic, particularly in 2023, which corresponds with the increased demand for digital-based adaptive teaching materials. This condition underscores the necessity for teaching materials to be adapted to changes in the learning situation and the diverse characteristics and environments of learners. The preponderance of

empirical research and development (R&D) signifies a shift in the paradigm of CT teaching materials, which is now characterized by a focus on validating the effectiveness and innovation of learning products. Consequently, the development of future instructional materials must prioritize innovation in learning products that are adaptable to learner characteristics and learning contexts. This encompasses learning environment conditions and resource availability. The emphasis should be on systematic and evidence-based pedagogical design. This approach ensures that instructional materials function not only as learning support tools but also effectively strengthen CT skills, which are pivotal 21st-century competencies.

The focus of CT research is predominantly oriented towards the fields of computer science, elementary education, and the utilization of digital interactive teaching materials. This orientation persists, despite the advancements in other disciplines and the evolution of educational methodologies. This pattern indicates that CT is often positioned as an initial technical competency, while its potential as a cross-disciplinary thinking skill has not been fully utilized. These findings suggest the necessity for curriculum policies and the development of teaching materials that facilitate the integration of CT into non-computer science subjects, such as mathematics, science, and language. Furthermore, these findings emphasize the importance of ensuring the continuity of CT development at higher levels of education, thereby ensuring its progressive development in accordance with students' cognitive development stages. Furthermore, the predominance of digital teaching materials underscores the persistent reliance on technological resources in the implementation of CT. Consequently, the development of CT teaching materials must be accompanied by the enhancement of teacher competencies, the support of learning infrastructure, and the creation of non-digital or unplugged teaching materials as a strategic alternative to ensure the equitable implementation of CT in various learning contexts, not limited to the field of computer science.

Moreover, an analysis of keyword mapping and research trends reveals that the primary focus of CT teaching material research remains centered on product development and short-term effectiveness measurement. Consequently, further research is recommended to adopt a longitudinal design to examine the sustainability of the impact of CT teaching materials on the development of students' CT abilities. Furthermore, there is a need to prioritize the exploration of teaching materials to enhance CT in educational levels that are currently under-researched and in non-computer science subjects. This initiative is crucial to ensure that CT development is not only partial but rather is thoroughly integrated into the education system. Future research is also advised to explore cultural contexts and local wisdom in the development of CT teaching materials, as well as to conduct comparative studies across countries and educational contexts to obtain a more comprehensive picture of best practices.

Conclusion

This bibliometric analysis corroborates the pivotal function of instructional materials in cultivating computational thinking (CT) competencies across diverse educational strata. The findings indicate an escalating trend in research, particularly in 2023, with Indonesia emerging as the predominant contributor to the development of interactive digital teaching materials, including e-modules, educational games, and Android-based applications integrated with project-based learning and problem-based learning models. The field of computer science received the most research attention, with elementary school students being the most prevalent subjects in these studies. The study's findings underscore the pivotal role of technologically advanced, innovative teaching materials in enhancing students' computational thinking abilities. However, it is imperative to note that further research is necessary to assess their long-term efficacy and to determine their integration into 21st-century educational practices.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] O. Erstad, S. Kjällander, and S. Järvelä, "Facing the challenges of 'digital competence,'" *Nordic Journal of Digital Literacy*, vol. 16, no. 2, pp. 77–87, Aug. 2021, doi: 10.18261/issn.1891-943x-2021-02-04.

[2] M. C. Tavares, G. Azevedo, and R. P. Marques, "The Challenges and Opportunities of Era 5.0 for a More Humanistic and Sustainable Society—A Literature Review," *Societies*, vol. 12, no. 6, p. 149, Oct. 2022, doi: 10.3390/soc12060149.

[3] M. Yusuf, *Inovasi Pendidikan Abad-21: Perspektif, Tantangan, dan Praktik Terkini*. Bantul: Selat Media Patners, 2023. [*Eng. Trans.: 21st Century Education Innovation: Perspectives, Challenges, and Current Practices*]

[4] R. H. Mardhiyah, S. N. F. Aldriani, F. Chitta, and M. R. Zulfikar, "Pentingnya Keterampilan Belajar di Abad 21 sebagai Tuntutan dalam Pengembangan Sumber Daya Manusia," *Lectura : Jurnal Pendidikan*, vol. 12, no. 1, pp. 29–40, Feb. 2021, doi: 10.31849/lectura.v12i1.5813. [*Eng. Trans.: The Importance of Learning Skills in the 21st Century as a Requirement in Human Resource Development*]

[5] L. I. González-Pérez and M. S. Ramírez-Montoya, "Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review," *Sustainability*, vol. 14, no. 3, p. 1493, Jan. 2022, doi: 10.3390/su14031493.

[6] Y. Walter, "Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education," *International Journal of Educational Technology in Higher Education*, vol. 21, no. 1, p. 15, Feb. 2024, doi: 10.1186/s41239-024-00448-3.

[7] Darwin, D. Rusdin, N. Mukminatien, N. Suryati, E. D. Laksmi, and Marzuki, "Critical thinking in the AI era: An exploration of EFL students' perceptions, benefits, and limitations," *Cogent Education*, vol. 11, no. 1, Dec. 2024, doi: 10.1080/2331186X.2023.2290342.

[8] B. Thornhill-Miller *et al.*, "Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education," *J Intell*, vol. 11, no. 3, p. 54, Mar. 2023, doi: 10.3390/jintelligence11030054.

[9] P. Meitjing and Y. Fuad, "Berpikir Komputasional Siswa SMP Dalam Menyelesaikan Masalah Matematika," *EduMatSains : Jurnal Pendidikan, Matematika dan Sains*, pp. 104–113, Aug. 2023, doi: 10.33541/edumatsains.v8i1.4976. [*Eng. Trans.: Middle School Students' Computational Thinking in Solving Mathematical Problems*]

[10] S. Binti M. Salleh and R. Omar, "Elements of Computational Thinking Models in Early Childhood Science Literacy: A Recent Comprehensive Structured Review," *International Journal of Research and Innovation in Social Science*, vol. IX, no. II, pp. 1480–1493, 2025, doi: 10.47772/IJRISS.2025.9020121.

[11] F. L. Rahma P, I. A. Putri, M. S. Tanjung, and R. Siregar, "Studi Literatur: Pentingnya Berpikir Komputasional dalam Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik," *Bilangan : Jurnal Ilmiah Matematika, Kebumian dan Angkasa*, vol. 2, no. 2, pp. 17–27, Apr. 2024. [*Eng. Trans.: Literature Study: The Importance of Computational Thinking in Improving Students' Mathematical Problem-Solving Skills*]

[12] K. Park and H. Rim, "Development of mathematics teaching and learning materials using robots to improve computational thinking," *Korean School Mathematics Society*, vol. 26, no. 3, pp. 221–244, Sep. 2023, doi: 10.30807/ksms.2023.26.3.003.

[13] N. E. Putri, D. Rosana, and H. Nuroso, "Development of thermodynamic physics e-book with local wisdom of 'brick making process' to improve computational thinking skills," *THABIEA : JOURNAL OF NATURAL SCIENCE TEACHING*, vol. 8, no. 1, p. 92, Jun. 2025, doi: 10.21043/thabiea.v8i1.29682.

[14] K. D. H. Hasanah, D. A. S. Wahab, J. Nawali, H. I. Savika, and M. Z. N. Yaqin, "Peran Dan Ragam Jenis Bahan Ajar (Cetak Dan Non Cetak) Yang Relevan Dalam Pembelajaran Bahasa Dan Seni Budaya Di SDI Surya Buana Malang," *EBTIDA': Jurnal Pendidikan Dasar Islam*, vol. 06, pp. 361–378, Jun. 2024, doi: https://doi.org/10.33379/ebtida.v4i1.4478. [*Eng. Trans.: The Role and Variety of Relevant Teaching Materials (Printed and Non-Printed) in Language and Cultural Arts Learning at SDI Surya Buana Malang*]

[15] A. T. Prayitno, N. Nurhayati, and A. S. Damayanti, "Pengembangan E-Modul Berbasis Problem Based Learning untuk Memfasilitasi Berpikir Komputasional Matematis Siswa," *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, vol. 5, no. 2, Jun. 2025, doi: 10.51574/kognitif.v5i2.3126. [*Eng. Trans.: Development of Problem-Based Learning E-Modules to Facilitate Students' Mathematical Computational Thinking*]

[16] W. K. Kautsar and I. Rizkianto, "E-Modul Interaktif Berbasis Web Untuk Melatih Kemampuan Berpikir Komputasional Pada Materi Kaidah Pencacahan," *Jurnal Pedagogi Matematika*, vol. 9, no. 2, pp. 82–96, Jul. 2023, doi: 10.21831/jpm.v9i2.19068. [*Eng. Trans.: Web-Based Interactive E-Module for Training Computational Thinking Skills in Counting Rules*]

[17] A. Ratau and H. Bugis, "Efektivitas e-modul interaktif matematika berbasis local issues dengan pendekatan personalized learning terhadap computational thinking," *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, vol. 8, no. 2, p. 311, Sep. 2024, doi: 10.20961/jdc.v8i2.89649.

[18] N. O. Syamsiah, Y. Firmansyah, Y. Mustika, B. Burhanudin, A. Gani, and N. Fitriani, "Pengaruh Edukasi Unplugged Coding Terhadap Kemampuan Computational Thinking Anak Usia Sekolah Dasar," *VOX EDUKASI: Jurnal Ilmiah Ilmu Pendidikan*, vol. 15, no. 2, pp. 365–373, Nov. 2024, doi: 10.31932/ve.v15i2.4048. [*Eng. Trans.: The Effect of Unplugged Coding Education on the Computational Thinking Skills of Elementary School Children*]

[19] A. B. D. Nandiyanto and D. F. Al Husaeni, "A bibliometric analysis of materials research in Indonesian journals using VOSviewer," *Journal of Engineering Research*, Dec. 2021, doi: 10.36909/jer.ASSEEE.16037.

[20] A. Mulyani, H. Hartono, and B. Subali, "Literature Review: A Snapshot of Research on the Argumentation of Bibliometric Analysis in the Period 2015-2023," *International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE)*, vol. 12, no. 2, pp. 451–465, Aug. 2024, doi: 10.23947/2334-8496-2024-12-2-451-465.

[21] I. V. Rossi, J. D. de Lima, B. Sabatke, M. A. F. Nunes, G. E. Ramirez, and M. I. Ramirez, "Active learning tools improve the learning outcomes, scientific attitude, and critical thinking in higher education: Experiences in an online course during the COVID-19 pandemic," *Biochemistry and Molecular Biology Education*, vol. 49, no. 6, pp. 888–903, Nov. 2021, doi: 10.1002/bmb.21574.

[22] S. Maharani, I. T. Yuniahastuti, I. Prastyaningrum, V. D. Susanti, and H. R. Romandoni, "Computational Thinking in Elementary School Students: A Bibliometric Review," *QALAMUNA: Jurnal Pendidikan, Sosial, dan Agama*, vol. 16, no. 2, pp. 1209–1222, Nov. 2024, doi: 10.37680/qalamuna.v16i2.5824.

[23] J. Moreno-León, M. Román-González, R. García-Perales, and G. Robles, "Coding to learn Mathematics in 5th grade: Implementation of the ScratchMaths project in Spain," *Revista de Educación a Distancia*, vol. 21, no. 68, Nov. 2021, doi: 10.6018/red.485441.

[24] M. Rottenhofer, B. Sabitzer, and T. Rankin, "Developing Computational Thinking Skills Through Modeling in Language Lessons," *Open Education Studies*, vol. 3, no. 1, pp. 17–25, Jan. 2021, doi: 10.1515/edu-2020-0138.

[25] A. Scaico, W. P. Ferreira, E. M. Alves, and P. D. Scaico, "Teaching Computational Thinking and Introduction to Programming through Robotics amid the Covid19 Pandemic - An Experience Report," in *2021 XVI Latin American Conference on Learning Technologies (LACLO)*, IEEE, Oct. 2021, pp. 32–37. doi: 10.1109/LACLO54177.2021.00011.
[26] E. V. Soboleva, E. G. Sabirova, N. S. Babieva, M. G. Sergeeva, and J. V. Torkunova, "Formation of Computational Thinking Skills Using Computer Games in Teaching Mathematics," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 17, no. 10, p. em2012, Aug. 2021, doi: 10.29333/ejmste/11177.
[27] V. Critten, H. Hagon, and D. Messer, "Can Pre-school Children Learn Programming and Coding Through Guided Play Activities? A Case Study in Computational Thinking," *Early Child Educ J*, vol. 50, no. 6, pp. 969–981, Aug. 2022, doi: 10.1007/s10643-021-01236-8.
[28] O. Kastner-Hauler, K. Tengler, B. Sabitzer, and Z. Lavicza, "Combined Effects of Block-Based Programming and Physical Computing on Primary Students' Computational Thinking Skills," *Front Psychol*, vol. 13, Jun. 2022, doi: 10.3389/fpsyg.2022.875382.
[29] S.-C. Kong, Y. Hu, and M. Lai, "Computational Thinking Development: Validating an Instrument for Self-regulated Learning Using Animation," in *Proceedings of the 30th International Conference on Computers in Education*, International Conference on Computers in Education., 2022, pp. 675–680.
[30] V. Singhal, "Precoding skills - Teaching computational thinking to preschoolers in Singapore using unplugged activities," Jun. 2022. doi: 10.34641/ctestem.2022.452.
[31] N. K. Findayani, I. N. Suparta, and S. Sariyasa, "Development of Project-based Statistics e-Module with Scratch Assistance to Improve Students' Computational Thinking Skills," *Jurnal Pendidikan MIPA*, vol. 24, no. 3, pp. 516–527, 2023, doi: 10.23960/jpmipa/v24i3.pp516-527.
[32] F. Handayani, Y. Fitria, S. Ahmad, and Z. Zen, "Development of E-Module Based on Problem-Based Learning Assisted with Scratch Applications to Improve Students' Computational Thinking Skills," *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, vol. 9, no. 2, p. 456, May 2023, doi: 10.33394/jk.v9i2.7790.
[33] S.-Y. Huang, W. Tarng, and K.-L. Ou, "Effectiveness of AR Board Game on Computational Thinking and Programming Skills for Elementary School Students," *Systems*, vol. 11, no. 1, p. 25, Jan. 2023, doi: 10.3390/systems11010025.
[34] T. H. Rochadiani, H. Santoso, and H. Mayatopani, "Pengembangan Computational Thinking Melalui IoT Apps Programming Dengan Tinkercad," *Jurnal ABDINUS : Jurnal Pengabdian Nusantara*, vol. 6, no. 1, pp. 230–240, Jan. 2022, doi: 10.29407/ja.v6i1.16007. [*Eng. Trans.: Developing Computational Thinking Through IoT Apps Programming With Tinkercad*]
[35] M. Astuti and F. Ismail, *Studi Inovasi dan Globalisasi Pendidikan Suatu Pendekatan Teoritis dan Riset Dilengkapi Contoh Hasil R&D Bahan Ajar*. Yogyakarta: Deepublish, 2021. [*Eng. Trans.: Study of Innovation and Globalization in Education: A Theoretical Approach and Research Supplemented with Examples of R&D Results in Teaching Materials*]
[36] H. Herlina, A. Arismunandar, and I. Tolla, "Education Character in the Era of Globalization: Facing the Challenges of the Modern World," *International Journal of Engineering, Science and Information Technology*, vol. 4, no. 4, pp. 230–236, Nov. 2024, doi: 10.52088/ijesty.v4i4.649.
[37] W. Andriyani, "Developing Critical Thinking of Students with Hearing Impairment for Computational Thinking in Mathematics with E Module Design," *Psychology and Education Journal*, vol. 58, no. 1, pp. 4613–4621, Jan. 2021, doi: 10.17762/pae.v58i1.1578.
[38] Hapizah, "Interactive e-Module on Exponential Material to Support Computational Thinking," *International Journal of Information and Education Technology*, vol. 15, no. 6, pp. 1226–1234, 2025, doi: 10.18178/ijiet.2025.15.6.2326.
[39] T. K. Nisa', S. Tazkia, N. N. Fildzah, and E. L. W. Palupi, "Developing E-Mowara: An archipelago-insighted electronic module to train middle school students' computational thinking skills," *Jurnal Gantang*, vol. 9, no. 1, pp. 105–116, Oct. 2024, doi: 10.31629/jg.v9i1.6910.
[40] Y. A. Lubis, Asmin, and B. Sinaga, "Development of Macromedia Flash-Assisted Mathematics Learning Media with the Application of Problem-Based Learning Models to Improve Computational Thinking Ability and Self-Efficacy of Class X High School Students," *Journal of Education and Practice*, Dec. 2021, doi: 10.7176/JEP/12-34-03.
[41] Y. P. Selano, L. A. Sutimin, and S. Sumaryati, "Web-Based E-Module with a Project-Based Learning Approach to Improve Computational Thinking Skills of High School Students," *Journal of Education Technology*, vol. 8, no. 4, pp. 763–775, Nov. 2024, doi: 10.23887/jet.v8i4.85248.
[42] E. M. Ulfa, S. Wahyuni, and Z. R. Ridlo, "Development of E-Module-Based PjBL to Develop Computational Thinking Skills Integration with CCR Implementation in Science Education," *JPPS*

(Jurnal Penelitian Pendidikan Sains), vol. 12, no. 2, pp. 176–191, May 2023, doi: 10.26740/jpps.v12n2.p176-191.

[43] H. Bugis and A. Ratau, "Developing an Adaptive E-Module Based on Cognitive Levels and Local Context to Improve Students' Mathematics Computational Thinking Skills in Middle School," *JTMT: Journal Tadris Matematika,* vol. 6, pp. 1–8, 2025, doi: 10.47435/jtmt.v6i1.3227.

[44] A. Ratau, H. Bugis, W. N. Wagola, and J. Hukom, "Development of Interactive Mathematics E-Modules Based on Local Issues with a Personalized Approach to Facilitate Junior High School Students' Computational Thinking Skills," *MATHEMA: JURNAL PENDIDIKAN MATEMATIKA*, vol. 7, no. 1, p. 99, Jan. 2025, doi: 10.33365/jm.v7i1.4670.

[45] W. C. Choi and C. I. Chang, "The Impact of Gamification and Serious Games on Computational Thinking and Learning Motivation in Scratch Programming Education," Aug. 26, 2025. doi: 10.20944/preprints202508.1903.v1.

[46] T.-C. Hsu and T.-P. Hsu, "Teaching AI with games: the impact of generative AI drawing on computational thinking skills," *Educ Inf Technol (Dordr)*, vol. 30, no. 15, pp. 21499–21518, Oct. 2025, doi: 10.1007/s10639-025-13624-3.

[47] X. Ren, T. Cai, H. Wang, and D. Yang, "Research on the Development of Secondary Vocational Students' Computational Thinking Based on Gamification Teaching : —Taking the Secondary Vocational Information Technology Course as an Example," in *2021 2nd International Conference on Information Science and Education (ICISE-IE)*, IEEE, Nov. 2021, pp. 331–334. doi: 10.1109/ICISE-IE53922.2021.00083.

[48] J. V. da Silva, Y. S. Rosa, L. Foss, and S. A. da C. Cavalheiro, "Battleships: A Digital Game for the Development of Computational Thinking in Elementary School," in *Anais do XXXI Workshop sobre Educação em Computação (WEI 2023)*, Sociedade Brasileira de Computação - SBC, Aug. 2023, pp. 373–383. doi: 10.5753/wei.2023.229541.

[49] M. Berlian, N. M. Arsad, D. Hardila, Y. Yovita, and D. N. Nasution, "Development of Scratch Learning Media to Improve Scientific Literacy and Computational Thinking in Primary Education in The Society 5.0 Era," *Journal of Natural Science and Integration*, vol. 7, no. 1, p. 94, Apr. 2024, doi: 10.24014/jnsi.v7i1.30904.

[50] A. Ç. Kirçali and N. Özdener, "A Comparison of Plugged and Unplugged Tools in Teaching Algorithms at the K-12 Level for Computational Thinking Skills," *Technology, Knowledge and Learning*, vol. 28, no. 4, pp. 1485–1513, Dec. 2023, doi: 10.1007/s10758-021-09585-4.

[51] A. Koray and E. Bilgin, "The Effect of Block Coding (Scratch) Activities Integrated into the 5E Learning Model in Science Teaching on Students' Computational Thinking Skills and Programming Self-Efficacy," *Science Insights Education Frontiers*, vol. 18, no. 1, pp. 2825–2845, Sep. 2023, doi: 10.15354/sief.23.or410.

[52] B. M. Quintela, L. O. Esteves, J. de P. Campos, A. C. Verly, and A. Oliveira, "Teaching Computational Thinking to Middle School Students using Rubik's Cube," in *Anais do V Simpósio Brasileiro de Educação em Computação (EDUCOMP 2025)*, Sociedade Brasileira de Computação, Apr. 2025, pp. 404–412. doi: 10.5753/educomp.2025.5329.

[53] T. YILMAZ and S. Izmirli, "Effect of unplugged and plugged coding activities on secondary school students' computational thinking skills," *Journal of Educational Technology and Online Learning*, vol. 6, no. 4, pp. 1180–1193, Dec. 2023, doi: 10.31681/jetol.1375335.

[54] Z. Abidin, T. Herman, and A. Elina Penehafo, "Computational Thinking With An Open-Ended Approach Using Interactive PowerPoint Media: An Experiment In Elementary Schools," 2023.

[55] Z. Abidin *et al.*, "Computational Thinking with a Multi-literacy Model Using Interactive PowerPoint Media: An Experiment in Elementary Schools," *KnE Social Sciences*, Apr. 2024, doi: 10.18502/kss.v9i13.15942.

[56] L. M. Angraini, M. S. Noto, and I. Muhammad, "Augmented Reality–Based Learning Media on Mathematical Computational Thinking Ability," *The International Journal of Science, Mathematics and Technology Learning*, vol. 31, no. 2, pp. 89–118, 2024, doi: 10.18848/2327-7971/CGP/v31i02/89-118.

[57] L. M. Angraini and A. Sthephani, "Differences in Students' Computational Thinking Mathematical Ability Using Augmented Reality Based on Gender," *International Journal of Contemporary Studies in Education (IJ-CSE)*, vol. 3, no. 3, pp. 256–268, Oct. 2024, doi: 10.56855/ijcse.v3i3.1098.

[58] A. Alenezi, "TEACHING COMPUTATIONAL THINKING IN SAUDI ARABIAN SCHOOLS USING SMARTPHONE APPS," *Information Technologies and Learning Tools*, vol. 103, no. 5, pp. 78–88, Oct. 2024, doi: 10.33407/itlt.v103i5.5811.

[59] Alfirahman, D. Irawan, and Nasir Muhammad, "Development of Android-Based Physics Learning Media to Improve Computer Thinking Skills for High School Students," *Journal of Science: Learning Process and Instructional Research (JoSLEPI)*, vol. 3, no. 1, pp. 1–10, 2025.
[60] G. Dietz *et al.*, "StoryCoder: Teaching Computational Thinking Concepts Through Storytelling in a Voice-Guided App for Children," in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, New York, NY, USA: ACM, May 2021, pp. 1–15. doi: 10.1145/3411764.3445039.
[61] S. Fuad, Abdurrahman, A. Suyatna, and D. Lengkana, "Development of Interactive Learning Multimedia Based on Android Integrated with STEM Heat Material to Improve Students' Computational Thinking," *Jurnal Penelitian Pendidikan IPA*, vol. 11, no. 5, pp. 134–143, May 2025, doi: 10.29303/jppipa.v11i5.11106.
[62] D. Murniatiningtyas, I. N. S. Degeng, and N. C. Sitompul, "Developing Instructional Media Android-Based for Building Computational Thinking Skills for High School Students," *Pedagogia : Jurnal Pendidikan*, vol. 13, no. 1, pp. 159–188, Mar. 2024, doi: 10.21070/pedagogia.v13i1.1610.
[63] A. Santika, R. K. Nisa, A. Nasrullah, F. Alfiyanti, M. Aminah, and W. Dwiyanti, "Development of Articulate Storyline 3 Learning Media for Mathematical Computational Thinking Skills," *International Journal of Applied Learning and Research in Algebra*, pp. 35–48, Feb. 2025, doi: 10.56855/algebra.v2i1.1355.
[64] S.-Y. Yang, Y.-C. Lin, and Y.-T. Lin, "Improving Elementary Students' Computational Thinking Skills through an Educational Robot Intervention: A Quasi-Experimental Study," *International Journal of Learning, Teaching and Educational Research*, vol. 23, no. 9, pp. 325–342, Sep. 2024, doi: 10.26803/ijlter.23.9.18.
[65] R. M. Prihandini, D. Dafik, and D. N. U. Iskandar, "Developing smart fractions as a learning media assisted by iSpring Suite 9 and GeoGebra for escalating students' computational thinking skills," *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika*, vol. 5, no. 2, pp. 188–206, Dec. 2023, doi: 10.35316/alifmatika.2023.v5i2.188-206.
[66] H. Wang, "Empirical Research on the Cultivation of Primary School Students' Computational Thinking Based on Visual Programming——Take 'Codemao' Platform Teaching as an Example," *Region - Educational Research and Reviews*, vol. 3, no. 3, p. 35, Oct. 2021, doi: 10.32629/rerr.v3i3.432.
[67] Y. Cao, "Design and Development of Machine Learning Curriculum for Middle School Students' Computational Thinking Development," *Advances in Computer and Communication*, vol. 4, no. 5, pp. 283–288, Nov. 2023, doi: 10.26855/acc.2023.10.004.
[68] A. de O. Costa Junior, E. B. Guedes, J. P. F. Lima e Silva, and J. A. Rivera, "Developing Computational Thinking in Middle School with an Educational Robotics Resource," *J Intell Robot Syst*, vol. 110, no. 2, p. 49, Mar. 2024, doi: 10.1007/s10846-024-02082-7.
[69] E. Erdem and F. Kalelioğlu, "Comparing traditional and flipped classrooms in teaching block-based programming: effects on fifth-graders' self-efficacy towards computational thinking skills, conceptual learning, and their perspectives," *Educ 3 13*, pp. 1–23, Sep. 2024, doi: 10.1080/03004279.2024.2400933.
[70] J. Liu, Y. Bai, and X. Xia, "Research on Developing Computational Thinking of Middle School Students Based on Gamified Text Programming Teaching Activities," in *2023 5th International Conference on Computer Science and Technologies in Education (CSTE)*, IEEE, Apr. 2023, pp. 175–179. doi: 10.1109/CSTE59648.2023.00037.
[71] M. Özmutlu, D. Atay, and B. Erdoğan, "Collaboration and engagement-based coding training to enhance children's computational thinking self-efficacy," *Think Skills Creat*, vol. 40, p. 100833, Jun. 2021, doi: 10.1016/j.tsc.2021.100833.
[72] L. Schwartz, V. Maquil, L. Johannsen, C. Moll, and J. Hermen, "Teaching computational thinking with a tangible development platform: An exploratory field study at school with Kniwwelino," *Educ Inf Technol (Dordr)*, vol. 29, no. 4, pp. 4935–4967, Mar. 2024, doi: 10.1007/s10639-023-11983-3.
[73] N. Ugur and Ü. Çakiroglu, "Implementing Reflective Thinking in Computer Science Unplugged to Enhance Computational Thinking," *International Journal of Technology in Education and Science*, vol. 8, no. 2, pp. 196–218, Apr. 2024, doi: 10.46328/ijtes.515.
[74] F. Wang, L. Chen, and W. Wang, "Design and Effectiveness Analysis of Interactive Strategies for Teaching Graphical Programming Oriented to Cultivate Computational Thinking," in *2023 5th International Conference on Computer Science and Technologies in Education (CSTE)*, IEEE, Apr. 2023, pp. 10–14. doi: 10.1109/CSTE59648.2023.00009.

[75] W. Yang, D. T. K. Ng, and J. Su, "The impact of story-inspired programming on preschool children's computational thinking: A multi-group experiment," *Think Skills Creat*, vol. 47, p. 101218, Mar. 2023, doi: 10.1016/j.tsc.2022.101218.
[76] E. A. Yurdakök and F. Kalelioğlu, "The Effect of Teaching Physical Programming on Computational Thinking Skills and Self-Efficacy Perceptions Towards Computational Thinking," *Journal of Educational Computing Research*, vol. 62, no. 3, pp. 565–595, Jun. 2024, doi: 10.1177/07356331231220313.
[77] S. Alkautsar, Moh. M. Nuryady, H. Husamah, P. Wahyono, and F. J. Miharja, "STEM-PjBL Worksheet : Ways to Improve Students' Collaboration, Creativity, and Computational Thinking," *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, vol. 9, no. 2, p. 681, Jun. 2023, doi: 10.33394/jk.v9i2.7587.
[78] I. M. Matere, C. Weng, M. Astatke, C.-H. Hsia, and C.-G. Fan, "Effect of design-based learning on elementary students' computational thinking skills in a visual programming maker course," *Interactive Learning Environments*, vol. 31, no. 6, pp. 3633–3646, Aug. 2023, doi: 10.1080/10494820.2021.1938612.
[79] S. P. A. Ningsih and Z. Ridlo, "The Development of a Module for Improving Computational Thinking Skills on Science Education based on Google Colaboratory," *ODELIA: Southeast Asia Journal on Open*, vol. 02, no. 02, pp. 57–68, 2024.
[80] L. Hu and H. Wang, "Unplugged activities in the elementary school mathematics classroom: The effects on students' computational thinking and mathematical creativity," *Think Skills Creat*, vol. 54, p. 101653, Dec. 2024, doi: 10.1016/j.tsc.2024.101653.
[81] Y. Jung, E. Choi, and N. Park, "Educational Aids for Teaching Hacking Principles to Strengthen Computational Thinking Skills to Elementary," *Webology*, vol. 19, no. 1, pp. 4527–4536, Jan. 2022, doi: 10.14704/WEB/V19I1/WEB19299.
[82] A. Juškevičienė, G. Stupurienė, and T. Jevsikova, "Computational thinking development through physical computing activities in STEAM education," *Computer Applications in Engineering Education*, vol. 29, no. 1, pp. 175–190, Jan. 2021, doi: 10.1002/cae.22365.
[83] W. Liu and L. Hu, "Unplugged programming practice in Chinese rural primary schools: a method to foster students' computational thinking and resilience," *Interactive Learning Environments*, vol. 33, no. 1, pp. 387–407, Jan. 2025, doi: 10.1080/10494820.2024.2349883.
[84] L. Sun, L. Hu, and D. Zhou, "Improving 7th-graders' computational thinking skills through unplugged programming activities: A study on the influence of multiple factors," *Think Skills Creat*, vol. 42, p. 100926, Dec. 2021, doi: 10.1016/j.tsc.2021.100926.
[85] X. Tsortanidou, T. Daradoumis, and E. Barberá-Gregori, "Unplugged computational thinking at K-6 education: evidence from a multiple-case study in Spain," *Educ 3 13*, vol. 51, no. 6, pp. 948–965, Aug. 2023, doi: 10.1080/03004279.2022.2029924.
[86] W. Wahyudin, A. M. Rishanty, M. Nursalman, S. Nazir, and L. S. Riza, "Learning through computer science unplugged on team-assisted individualization on the computational thinking ability," *Linguistics and Culture Review*, vol. 5, no. S3, pp. 1442–1452, Dec. 2021, doi: 10.21744/lingcure.v5nS3.1841.
[87] V. Dagiene and V. Dolgopolovas, "Short Tasks for Scaffolding Computational Thinking by the Global Bebras Challenge," *Mathematics*, vol. 10, no. 17, p. 3194, Sep. 2022, doi: 10.3390/math10173194.
[88] K. S. Ting, O. Talib, A. F. Mohd Ayub, M. Zolkepli, C. C. Yee, and T. C. Hoong, "Word Problems as a Vehicle for Teaching Computational Thinking," *International Journal of Academic Research in Progressive Education and Development*, vol. 12, no. 1, Mar. 2023, doi: 10.6007/IJARPED/v12-i1/16543.
[89] M. Zapata-Cáceres, P. Marcelino, L. El-Hamamsy, and E. Martín-Barroso, "A Bebras Computational Thinking (ABC-Thinking) program for primary school: Evaluation using the competent computational thinking test," *Educ Inf Technol (Dordr)*, Jan. 2024, doi: 10.1007/s10639-023-12441-w.

Authors



Aditya Saputra Dewa is a graduate student in the Master's Program in Primary Education program at Semarang State University and a teacher at SD Negeri 110 Tanjung Jabung Barat, Jambi, Indonesia. His academic interests focus on learning in primary schools. (email: adityasaputradewa1706@students.unnes.ac.id).



Edi Kurniawan is a lecturer in the Department of Geography at Universitas Negeri Semarang (UNNES). His research interests include geography learning strategies, disaster mitigation in educational settings, and the use of digital and environment-based pedagogy to enhance teacher and student competencies. Through his academic and community service activities, he contributes to the advancement of geography education and disaster-resilient learning in Indonesia. (email: edikurniawan@mail.unnes.ac.id),



Bambang Subali is a lecturer in the Physics Education Study Program (undergraduate), Natural Science Education and Elementary Education (master's programs), and Natural Science Education (doctoral program) at Universitas Negeri Semarang (UNNES). The following subjects are being taught: A fundamental examination of physics, an evaluation of physics education, and a critical study of natural science learning. (email:bambangfisika@mail.unnes.ac.id).



Ellianawati is a lecturer in the Department of Physics Education at the undergraduate level, as well as in the Department of Physics Education, the Department of Natural Science Education, the Department of Elementary Education, and the Department of Evaluation Education at the master's level at Universitas Negeri Semarang (UNNES). The following subjects are being taught: Fundamentals of Physics, Evaluation and Assessment of Physics, Primary Education, Wave, and Science Learning Innovation. (email: ellianawati@mail.unnes.ac.id).