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Mapping the pedagogical–affective coupling in computational thinking research: a bibliometric analysis

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Abstract :

Computational thinking (CT) skills have developed rapidly across various fields. CT skills have even become a fundamental competency akin to basic literacy. The development of CT skills is not determined solely by the mastery of cognitive concepts, but also by the role of pedagogy in relation to affective aspects. However, existing literature has not yet reached a consensus on integrating pedagogical (learning) and affective aspects to enhance CT skills, and research in this area remains limited. This study aims to map the global research landscape regarding the relationship between pedagogical (learning) and affective aspects in the development of CT skills. Data were analysed using bibliometric analysis of 103 documents sourced from the Scopus database, the period from 2016 to 2025. Data were processed using RStudio, VOSviewer, OpenRefine, and Excel to focus the analysis on growth trends, the most influential contributors, and to analyse bibliographic coupling, co-citation, and co-occurrence. Findings indicate a significant increase, peaking in 2024. The main contributors were Hsu, T.C., and the most influential countries were Taiwan and the United States. Network analysis revealed five major themes in pedagogical implementation, such as game-based learning, robotics, and collaborative learning, which consistently enhance CT skills and improve affective aspects such as motivation, self-efficacy, and students' learning attitudes. Data visualisation underscores a shift in research focus away from mere cognitive mastery towards the involvement of attitudes. These findings make a significant contribution to understanding the development and trends in research regarding the relationship between CT skills and pedagogical and affective aspects.

Keywords: *Computational Thinking, Learning Models, Affective Factors, Bibliometric*

INTRODUCTION

Digital transformation dominates the modern world. Computational thinking (CT) is not merely a technical skill, but a fundamental competency in the world of education. As Computational Thinking (CT) skills become increasingly popular as a thematic content area in education, more researchers are beginning to explore the range of skills contained within CT to equip students. The development of CT skills has become as important as reading, writing, and arithmetic in terms of logical thinking, adapting to technology, and solving everyday problems. CT is viewed as a fundamental cross-disciplinary ability that is not limited to computer science, but also extends to science, mathematics, and even the arts (Chen, H. E., Sun, D., Hsu, T. C., Yang, Y., & Sun, J. 2023). The development of these skills does not rely solely on cognitive aspects, but is also significantly influenced by pedagogical approaches related to students' affective aspects, such as self-efficacy, motivation, and other affective factors. This integration fosters the creation of an effective learning environment within the classroom. Consequently, research into these dynamics is of strategic and comprehensive importance as a direction for future research.

The existing literature has not yet reached a consensus regarding the integration of pedagogical and affective aspects in the development of CT skills. Previous research has employed various perspectives, such as bibliometric approaches and analysis of publication trends, as tools to explore CT-related research. This literature identifies the impact of implementing learning methods on the improvement of CT skills, whilst also reviewing affective aspects. Database analyses of sources such as Scopus and Web

of Science (WoS) indicate a significant increase since 2014, with a focus on learning. This aligns with research conducted by Chen, H. E., Sun, D., Hsu, T. C., Yang, Y., & Sun, J. (2023), which utilised game-based learning, block-based programming, and integration within science. Other studies have highlighted the use of computer games to improve learning attitudes, as well as the use of the 6E model for student learning performance. Furthermore, various literature has begun to highlight the relationship between CT skills and affective aspects such as motivation and self-efficacy in learning. The research conducted analysed keyword mapping and author collaboration using the VOSviewer tool. These findings demonstrate the development of CT from a conceptual focus towards pedagogical aspects and the involvement of affective aspects. Existing research makes an important contribution to identifying the structure and direction of research development related to CT skills.

Recently, several studies have begun to direct research towards the involvement of affective aspects in the development of CT skills. Although still limited and fragmentary, some studies have begun to indicate the potential for relationships between pedagogical factors and affective aspects such as motivation and self-efficacy in relation to CT skills (Yan, Y.-M., Chen, C.-Q., Hu, Y.-B., & Ye, X.-D. 2025; Moon, H., & Cheon, J. 2023;Li, Q., Jiang, Q., Liang, J. C., Xiong, W., & Zhao, W. 2025; Chen, C. H., et al. 2026; Safitri, F., et al., 2025; Apriadi, H., & Majid, A. A. 2025).

The aim of this study is to review the existing literature to investigate the relationship between pedagogical (learning) and affective aspects in the development of computational thinking skills using a bibliometric approach.

This study aims to answer the following question:

1. How has the volume of data and published literature relating to pedagogical (learning) and affective aspects contributed to the development of CT skills?
2. What is the citation landscape, as viewed through the most productive and influential contributors to the literature?
3. How does the literature conduct content analysis through bibliographic coupling, co-citation, and co-occurrence?

RESEARCH METHODS

This study employs bibliometric analysis to generate quantitative results regarding learning models and affective factors in the development of computational thinking. Bibliometric analysis is combined with content analysis to ensure the reliability and validity of the descriptive review. Furthermore, this type of analysis is conducted to understand the evolution, trends, status of scientific publications, and current research within a field (Avecilla et al., 2024; Ayaviri-Nina et al., 2023; Orbe et al., 2024; Rodriguez-Ulcuango et al., 2023).

Data Collection

Data collection took place on 24 November 2025 using the main keywords *"computational thinking" AND "learning model" OR "instructional model" OR "teaching model" OR "learning approach" OR "pedagogy" AND "affective factor" OR "affective domain" OR "self-efficacy" OR "motivation" OR "anxiety" OR "attitude" OR "resilience"*. The researcher then applied restrictions to articles written in English only, document type limited to articles and conference papers, source type limited to journals and conference proceedings, and publication stage limited to final. The results yielded 103 documents, and all identified publications were included.

Analysis Tools

The data analysis employed in this study utilised bibliometric analysis, utilising the following analytical tools: RStudio, VOSviewer, and Excel. Bibliometric analysis is a rigorous method of exploring and

analysing large datasets (Bozkurt et al., 2021; Donthu et al., 2021). This bibliometric approach provides insights into the development of related literature, relevant journals, the most cited articles, and highly productive authors. Meanwhile, the OpenRefine software is used to clean the data and identify duplicates, particularly in author and keyword fields. Subsequently, the VOSviewer software is utilised to support network and content analysis. VOSviewer enables users to create and visualise bibliometric networks (Van Eck and Waltman, 2013). The use of VOSviewer software will generate bibliographic maps related to the distribution of publications by year, document type, field type, source type, author, author's country, and the most cited publications (Ge et al., 2023). Furthermore, in this study, we used Microsoft Excel as a complement to RStudio for the creation of graphs and tables.

Data Analysis

Data analysis was conducted by considering three main aspects: (1) analysing data and literature growth, such as the most relevant authors, countries of origin, and affiliations; (2) conducting citation analysis, which examines the most cited documents, references, and influential researchers; (3) conducting content analysis through bibliographic coupling, co-citation, and co-occurrence.

RESULTS AND DISCUSSION

Result

1. **Documents Based on the most influential authors, affiliations, and countries**
   a. **Annual growth in documents**

A search of publications in the Scopus database from 2016 to 24 November 2025 identified 103 documents, including articles, conference proceedings, and others. The growth rate of publications concerning the relationship between pedagogical aspects, affective aspects, and CT skills indicates an increase over the past decade. Consequently, this suggests that this topic has garnered attention and is developing across various fields of science. This study confirms a shift in research focus from mere cognitive mastery towards an integrative understanding. This can be seen in Table 1.

Table 1
Summary of the Review

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2016:2025
Sources (Journals, Books, etc)	49
Documents	103
Annual Growth Rate %	21.26
Document Average Age	3.21
Average citations per doc	10.82
References	836
DOCUMENT CONTENTS	
Keywords Plus (ID)	501
Author's Keywords (DE)	297
AUTHORS	
Authors	365
Authors of single-authored docs	4
AUTHORS COLLABORATION	
Single-authored docs	4
Co-Authors per Doc	4.14
International co-authorships %	17.48
DOCUMENT TYPES	
article	58
conference paper	45

The growth in documents, based on an analysis of the most productive annual publication trends in this topic, occurred in 2024 with 19 articles published. Based on the graph in Figure 1, there is a clear increase in publications throughout the period in the early phase. Although this increase was not entirely linear, the fluctuations indicate that research on this topic is gaining significant attention and has the potential to continue developing.

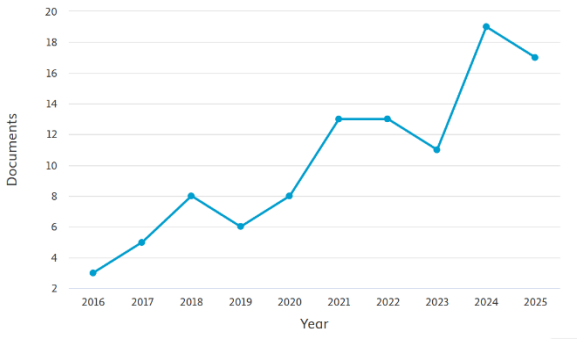

Figure 1
Document Growth by Year

b. Distribution of the Most Productive Authors in Publications

We identified the 10 most productive authors. Figure 4 shows the top contributing authors. Hsu, T.C. is the most influential researcher with the highest contribution, having published six articles. This position indicates that Hsu, T.C. has a strong research focus on CT, particularly in education and learning. They are followed by several other authors such as Blazquez M, Castro M, Plaza P, and Sancristobal E, each of whom has five published articles. Next are Carro G and Chang C with 4 articles, Gracia-loro F and Ragusa G with 3 articles, and finally Bart A.C. with 2 published articles. The diversity in the level of contribution from these authors indicates that the field of CT research is still developing and open-ended. Based on the graph, it is evident that the authors' productivity reflects a dynamic research landscape spread across several groups of researchers rather than being centralised.

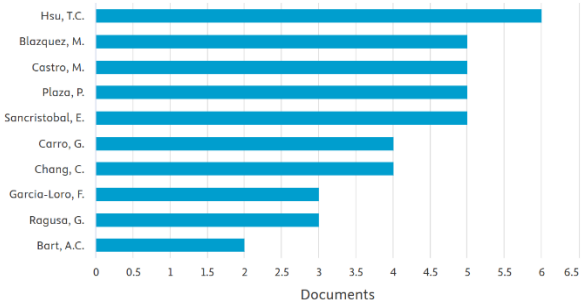

Figure 2
Most Productive Authors

c. Documents by Affiliation

There are 10 author affiliations with the highest number of publications, showing a relatively stable trend. Figure 3 displays the 10 most frequently appearing affiliations: National Taiwan Normal University with 9 documents, followed by the National University of Education and the National University of Distance Education (Universidad Nacional de Educación a Distancia) with 5 documents each, as well as other universities with 2–4 documents.

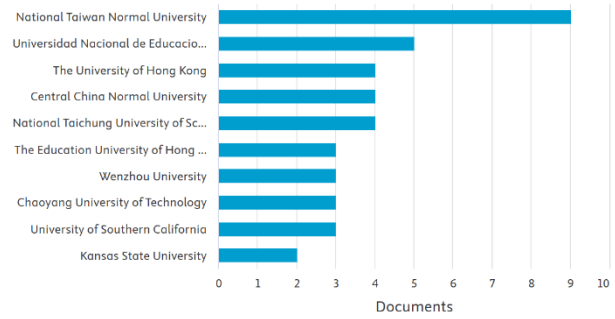

Figure 3
Number of documents published by affiliation

d. Documents by Country

The ten countries with the highest number of publications relating to the development of CT skills through the application of learning models and affective factors present an interesting area for research. Figure 4 shows the distribution of countries, revealing the dominance of Taiwan and the United States (26 documents), followed by China (13 documents), Spain (10 documents), Hong Kong (6 documents), Indonesia and Malaysia (4 documents), and Finland, Portugal and Singapore with a smaller contribution of just 3 documents.

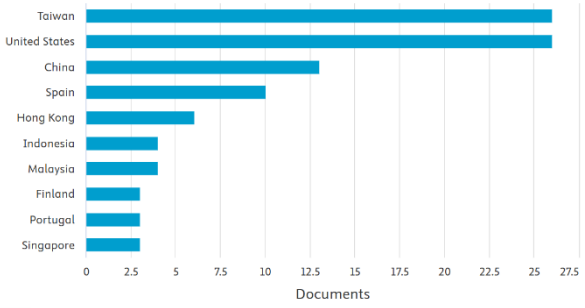

Figure 4
Number of documents published by Country

2. Citation Analysis

This section discusses the analysis of document citations, references, and sources, along with the impact of sources and authors. Based on the table of most-cited documents, the most prominent documents discuss the use of adaptive educational computer games in enhancing students' knowledge and attitudes within the context of CT. However, in

general, Table 2 shows there are three main directions: conceptual aspects through review studies, technology-based pedagogical approaches, and the integration of affective aspects into learning. Furthermore, regarding local citations, local citations provide an indication of the extent to which a document serves as a key reference within the analysed dataset, whilst both local and global citations document influential literature related to pedagogical practices, learning technologies, and the enhancement of CT competencies. Local citations provide an indication of the extent to which a document serves as a key reference within the analysed dataset, whilst global citations indicate the document's level of widespread recognition. Furthermore, the authors' impact analysis perspective reveals that the contribution of a research topic is not solely determined by the number of publications, but is also influenced by the consistency of the work produced. Table 4 shows there are two contributors within the CT research topic. The first contributor is an author who has long focused on CT research and has a stable citation record, whilst the second contributor is a new author in the CT research topic but has had a rapid impact. Authors Blazque-Merino, Castro, Plaza, and Sancristobal are long-standing authors in the CT topic with a fairly stable citation record, whilst Hsu T.C. is a new author with a publication output that has had a strong impact. Table 2 discusses the articles that most frequently cite literature on computational thinking, learning models, and affective factors. Table 3 discusses the most frequently cited references locally; Table 4 discusses the impact of authors.

Table 2
Top Ten Cited Global Documents

Author	Title	Year	Journal	Citations
Hooshyar D	An Adaptive Educational Computer Game: Effects on Students' Knowledge and Learning Attitude in Computational Thinking	2021	Comput Hum Behav	112
Tang K-Y	A Content Analysis of Computational Thinking Research: International Publication Trends and Research Typology	2020	Asia-Pacific Educational Research	74
Jenson J	Exploring Media Literacy and Computational Thinking: A Study of the ' ' Game Maker Curriculum	2016	Electron Journal of E-Learning	59
Hsiao H-S	Using Robot-Based Practices to Develop an Activity Incorporating the 6e Model to Improve Primary School Students' Learning Outcomes	2022	Interact Learn Environ	52
Threekunprapa A	Unplugged Coding Using Flowblocks to Promote Computational Thinking and Programming among Secondary School Students	2020	Int J Instr	48
Weese Jl	STEM Outreach: Assessing Computational Thinking and Problem Solving	2017	Proceedings of the Annual Conference and Exhibition Sigcse -	40
Feldhausen R	Increasing Student Self-Efficacy in Computational Thinking via STEM Outreach Programmes	2018	Proceedings of the ACM Technical Symposium on Computer Science Education	37
Echeverría L	Improving Students' Computational Thinking Skills with Collaborative Learning Techniques	2019	Rev. Iberoam. Technol. Aprendizaje	30
Peixoto A	Robotics Tips and Tricks for the Inclusion and Integration of Students	2018	IEEE Global Engineering Education Conference, Educon	28
Varela C	Computational Thinking Skills of First-Year Engineering Students	2019	Heliyon	25

Table 3.
Top Ten Most Locally and Globally Cited References

No	Document	Year	Local Citations	Global Citations
1	Threekunprapa A, 2020, Int J Instr	2020	2	48
2	Ragusa G, 2016, ASEE Annual Conference and Exposition Proceedings	2016	2	6
3	Chen B-H, 2021, Proceedings of the IEEE Eurasia Conference on IoT, Communication Engineering, and ECICE	2021	1	2
4	Echeverría L, 2019, IEEE Global Engineering Education Conference, Educon	2019	1	11
5	Weese Jl, 2017, ASEE Annual Conference and Exposition, Conference Proceedings	2017	1	40
6	Bart Ac, 2017, Proceedings of the Conference on the Integration of Technology, Computer Science and Education (ITICSE)	2017	1	24
7	Muthmainnah M, 2025, Discovering Sustainability	2025	0	5
8	Aksakal H, 2025, Journal of Systems Software	2025	0	1
9	Ye X, 2025, Humanities and Social Sciences Communication	2025	0	1
10	Hsu T-C, 2025, Educational Technology and Society	2025	0	1

Table 4
Author's Impact

Author	h-index	g_index	m_index	TC	NP	PY_start
Blazquez-Merino M	5	5	0.625	83	5	2018
Castro M	5	5	0.625	83	5	2018
Plaza P	5	5	0.625	83	5	2018
Sancristóbal E	5	5	0.625	83	5	2018
Carro-Fernandez G	4	4	0.5	71	4	2018
Hsu T-C	4	6	1	47	7	2022
Chang C	3	4	0.75	38	4	2022
Garcia-Loro F	3	3	0.375	33	3	2018
Bart Ac	2	2	0.222	43	2	2017
Chen J-H	2	2	0.5	58	2	2022

H-index = an author has an h-index of 'h' when they have h papers that have been cited at least h times, G-Index = is where the top G articles have together received G citations, M-index = is the H-index divided by the number of years that an author has been active, Tc = Total Citations, Np = Number of papers, Py_Start = starting publication year.

3. Network Analysis

a. Bibliographic Coupling

Bibliographic coupling was performed using the VOSviewer tool to map 103 articles. There are three types of analysis in bibliographic coupling when using VOSviewer: journals, publications and authors. We used the full-text document calculation method. The minimum number of citations for a single article was set at 5, resulting in a threshold of 58 out of 103 documents. Figure 5 shows the results of bibliographic coupling from VOSviewer. Based on Figure 7, we identified four interconnected clusters. Cluster 1 is coloured red, cluster 2 is coloured green, cluster 3 is coloured blue, and cluster 4 is coloured yellow. These clusters indicate that the development of CT research does not rely on a single pathway, but spreads across several complementary main streams. The most prominent red cluster is found in the Hoosyar 2021 document, meaning this study serves as a primary reference. Furthermore, the blue cluster remains connected to the main cluster. The Tang 2020 document serves as a conceptual reference that maps the broader development of CT research.

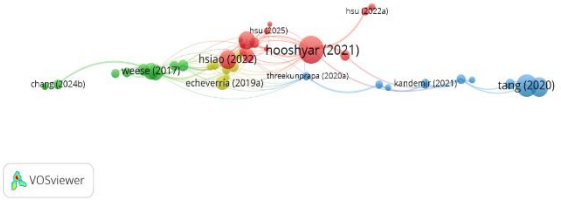

Figure 5
Bibliography of 103 Articles

b. Co-citation analysis

Co-citation analysis was conducted using document sources to visualise the network between related journals. Co-citation analysis reveals the interconnections and relationships between articles and research topics (Kim and McMillan, 2008). As shown in Figure 6, publications on the topic are distributed across several sources and are interconnected. This interconnectedness reinforces the fact that the development of CT skills is inseparable from pedagogical aspects, the use of technology, and affective aspects. In the figure, the co-citation mapping places the journals Communications of the ACM and ACM Inroads as the main reference channels. Figure 8 shows the interconnections between the published journals.

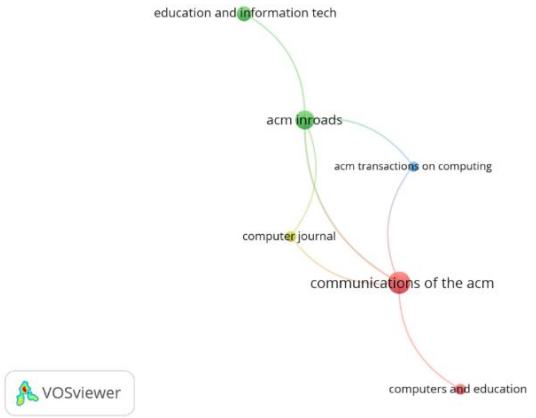

Figure 6
Co-citation of journals

c. Co-authorship analysis

The co-authorship analysis was conducted using two approaches: one using

authors and the other using countries as units of analysis. The method employed in this analysis utilized a fractional calculation to mitigate the influence of documents with multiple authors. We set the minimum number of documents per author at "2" and the minimum number of citations at "1" to ensure a comprehensive analysis of the documents' origins. In general, collaboration among authors indicates that this topic is evolving through the exchange of ideas and research cooperation. However, the figure still shows a reliance on a single author, meaning that opportunities for the development of this topic remain wide open. Furthermore, the country analysis reveals significant international research collaboration. The United States and Taiwan are the dominant countries playing a key role in CT research production. Subsequently, Hong Kong, China, Spain, and Indonesia have begun to engage in CT research development.

Figure 9 shows the results of the co-authorship analysis using authors as the unit of analysis. Figure 10 shows the results of the co-authorship analysis using countries as the unit of analysis.

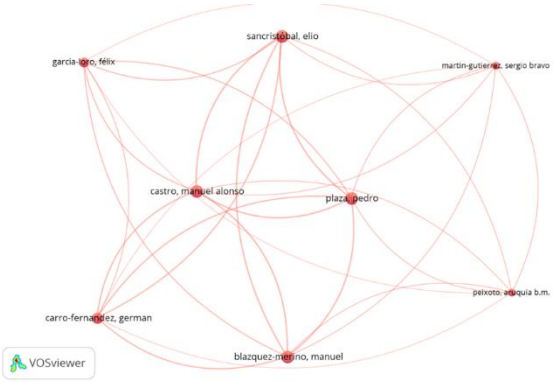

Figure 7
Co-authorship by author

Figure 8
Co-authorship by author

d. Cartographic analysis

Cartographic analysis was conducted to characterize the fundamental research themes based on the articles' keywords. We selected co-occurrence as the analysis method and chose all keywords as the units of analysis. The minimum number of occurrences for a keyword was set to "3." The colors in the VOSviewer visualization overlay indicate the temporal evolution of keyword appearances, while node size indicates the level of dominance of the research themes. The VOSviewer search results identified five clusters comprising 70 papers. Cluster 1 is red with 31 items, Cluster 2 is green with 13 items, Cluster 3 is blue with 11 items, Cluster 4 is yellow with 8 items, and Cluster 5 is purple with 7 items. Figures 10 and 11 show a shift in CT research themes from a focus on technical aspects toward more pedagogical and affective aspects. Initially, research on CT focused primarily on programming, STEM, educational robots, computation theory, computing education, and the learning process. In the next phase, CT research began to examine how CT is taught, student engagement in the learning process, and effective pedagogical strategies to support CT. The keyword 'student' at the center of the network indicates that the development of CT research topics is centered on students as the primary subjects. This is followed by the keywords computational thinking, teaching, computing education, learning approaches, game-based learning, and collaborative learning. Furthermore, more recently, affective aspects have emerged with keywords such as self-efficacy, learning motivation, learning engagement, and attitude. Additionally, technological contexts and problem-based learning support CT research. Figure 10 shows the analysis results from VOSviewer, while Figure 11 displays a visual overlay of keyword occurrences with their recency.

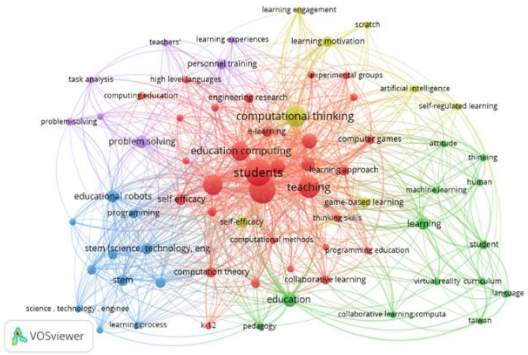

Figure 9
Keyword co-occurrence

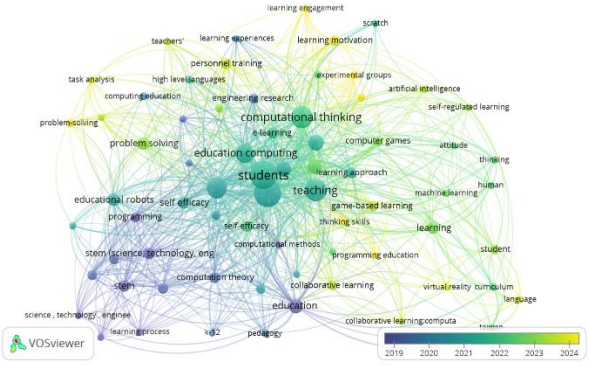

Figure 10
Keyword co-occurrence visualisation overlay

Discussion

Based on the data generated from the bibliometric analysis, there has been a significant increase in research on learning models and affective factors in the development of computational thinking during the period 2016–2025. The number of identified publications rose from just 3 in 2016 to over 10 in 2021, peaking at nearly 20 in 2024. This phenomenon reflects the growing interest and popularity of the topic of computational thinking among academics and practitioners (Su, J., & Yang, W., 2023; Irawan, E., et al., 2024; Bocconi, S., et al., 2016).

From the perspective of the most productive countries in terms of article publication, the field is dominated by Taiwan and the United States, followed by China, Spain and Hong Kong, with National Taiwan Normal University emerging as the most productive affiliation alongside several universities in Hong Kong, China and Spain. The results of the country and institution network analysis reveal a strong orientation between East Asia and the Global West. At the level of the most productive authors, Hsu T.C. is the most prolific contributor, whilst a very close collaboration cluster is evident among the group of Spanish authors (Castro, Plaza, Blazquez, Sancristobal, Carro, and colleagues). Furthermore, co-citation mapping identifies journals such as Communications of the ACM and ACM Inroads as the primary reference channels.

Diverse learning approaches such as game-based learning, programming education, robotics, STEM projects, and collaborative learning—integrated with affective aspects such as learning motivation, self-efficacy, engagement, attitudes towards CT, and self-regulation—constitute emerging research themes for the period 2016–2025. Furthermore, in classroom learning, improvements in CT skills are evident in the keyword co-occurrence map, which shows that "students", "teaching", and "computational thinking" are closely related to the terms "game-based learning", "educational robots", "programming education", "self-efficacy", "learning motivation", and "learning engagement".

The highest-cited studies on the enhancement of CT skills were found in the research by Hooshyar, D., et al., 2021 ; Jenson, J., 2016; Hsiao, H.-S., 2022 ; Threekunprapa, A., 2020; Weese, J. L., 2017; Feldhausen, R., 2018; Echeverría, L., 2019) which confirm that the implementation of educational games, robotics, maker curriculum, and collaborative learning successfully enhances students' CT skills, provides sound cognitive understanding, and boosts students' motivation and self-confidence. Thus, this clarifies that the interconnection between pedagogical (learning) and affective aspects is significant in enhancing CT skills.

Furthermore, analyses of bibliographic coupling, co-citation, and co-occurrence were conducted using the VOSviewer tool to identify themes through nodes (publications) and relationships (links) based on citations or

co-citations. Regarding bibliographic coupling, co-citation, and co-occurrence, the VOSviewer tool was used to identify themes through nodes (publications) and relationships (links) based on citations or co-citations; the resulting visualisation demonstrates the strength of connections between publications, with larger nodes indicating a stronger influence of the publication's contribution, whilst the distance between nodes reflects the proximity of the topics discussed. The visualisation in Figure 5 regarding bibliographic coupling shows four clusters. Cluster 1 is coloured red, cluster 2 green, cluster 3 blue, and cluster 4 yellow. However, the main findings indicate three clusters as the strongest. The interconnections between these nodes indicate a relatively fragmented development, dominated by differing perspectives, yet remaining open to new perspectives. This means that current research on CT skills is not only focused on how students master these skills, but also considers student engagement, motivation, and self-confidence. (Li, Q. et al., 2025; Possaghi, I., & Papavlasopoulou, S., 2025; Yin, S. X., et al., 2025; de Jesus, Â. M., & Silveira, I. F., 2022). Furthermore, regarding co-citation, the visualisation produced indicates a strong integration of research within the contexts of education and computational thinking. The number of citations serves as a key indicator of a study's influence and significance, reflecting the extent of its contribution to existing knowledge and its impact on other research (Gusteti, M. U., et al., 2024). Finally, the keyword co-occurrence analysis presented in Figures 9 and 10 provides a visual representation of the relationships between keywords and themes in research on computational thinking (CT) skills. These visuals demonstrate that CT skills are not only related to programming, computer games, and technology, but also to learning, motivation, and self-efficacy.

Based on this analysis, several recommendations can be made for future research, particularly focusing on the integration of pedagogical and affective aspects in enhancing students' CT skills. Furthermore, the use of methods should be varied to gain a deeper understanding of these themes.

CONCLUSION

With a peak in publications in 2024 and a preponderance of contributions from Taiwan, the US, and China, bibliometric results show that research on computational thinking (CT) in the context of learning models and emotional aspects is expanding quickly. While coupling, co-citation, and co-occurrence analyses identify five stable major themes: technology-based learning models, affective factors, STEM integration, curriculum design, and CT assessment, global citation patterns confirm that game-based, robotics-based, and collaborative learning approaches are the main references. These results demonstrate that a crucial component of CT development's efficacy is the interaction between learning models and affective elements.

These findings' practical consequences highlight the necessity for educational institutions to implement learning models that specifically promote motivation, self-efficacy, and positive attitudes towards.

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