2023 13th International Conference on Information Technology in Medicine and Education (ITME) | 979-8-3503-1915-6/23/$31.00 ©2023 IEEE | DOI: 10.1109/ITME60234.2023.00042

Hot Spots and Trends of Computational Thinking Research in China

CiteSpace visualization and analysis based on CNKI data

Yiwei Wang *(Author 1)*
School of Information Science and Engineering
Shandong Normal University
Jinan, China
e-mail: 1479715986@qq.com

Liancheng Xu* *(Corresponding Author)*
School of Information Science and Engineering
Shandong Normal University
Jinan, China
*Corresponding author: e-mail: lcxu@sdnu.edu.cn

***Abstract*—With the rapid development of computer technology, computational thinking, as one of the core literacy elements of information technology majors, has been widely noticed, and at the same time, it has gradually become one of the core competencies cultivated by education and teaching. This paper uses CiteSpace to visualize and analyze the Chinese core papers related to computational thinking included in CNKI. By studying the current situation of domestic research on computational thinking and related hot keywords, it aims to explore the prospects for the application of computational thinking in secondary education, try to incorporate the educational model of C elements in STEM education, and provide research ideas for the cultivation of computational thinking ability of secondary students.**

Keywords-computational thinking; information technology; STEM education; vocational secondary education; CiteSpace

I. INTRODUCTION

In recent years, there have been many studies on computational thinking both at home and abroad, and the currently accepted definition of computational thinking was put forward by Yizhen Zhou, a professor at Carnegie Mellon University in the United States, in 2006: "A series of thinking activities involving a wide range of areas of computer science such as applying the relevant basic concepts in computer science to solve problems, design systems and understand human behavior. " [1] Computational thinking should be a necessary skill for everyone, not just computer experts. When developing students' parsing skills, it is important that they not only learn to read, write, and do arithmetic (3R), but also to think computationally.

STEM+C is an educational model in which the five organic wholes we know as Science (S), Technology (T), Engineering (E) and Math (M) are deeply integrated with Computational Thinking (C). [2] Derived from a National Science Foundation program in the United States, the model takes a problem-solving and project-based learning approach to the curriculum with the goal of developing computational thinking in students.

With the development of the information age, the importance of computational thinking is becoming more and more prominent. In order to have a clearer understanding of the current relevant situation in China, this paper visualizes and analyzes the Chinese core journal articles about computational thinking research from 2009 to August 2023 in CNKI by adopting the bibliometric method using the CiteSpace software, with the aim of understanding the current situation and the future trend of computational thinking in China, so as to provide research ideas for the cultivation of computational thinking ability of middle-level students.

II. DATA SOURCES AND RESEARCH METHODOLOGY

CiteSpace is an open source tool for scientific literature analysis and visualization. The software is designed to help scholars, researchers, and scientists better understand the relationships between the literature, [3] such as collaborations, keyword relationships, and citation relationships. This paper uses CiteSpace, a visualization and analysis software that is widely used in the study of academic papers in many disciplines.

A. Data Sources

In this paper, we take the data in CNKI as an example to analyze, take "computational thinking" as the keyword search, choose the time of publication from 2009 to August 2023 as the time range of search, check "Chinese core journals" in the "all journals" as the source of the literature, and through manual review and screening of the results of the search, after removing the news conference notification, no journal information, abstract keywords and other articles that do not meet the conditions, and finally get 496 papers that meet the conditions. On this basis, through the literature export function of CNKI, the data information of eligible Chinese core journals was exported in Refworks format and named as Download_1, and the data in CNKI format was converted by using CiteSpace software for visualization and analysis.

B. Research Methodology

In this paper, we use the 6.2.R4(64-bit) Basic version of CiteSpace software to construct a knowledge map of 496 valid journal documents screened by CNKI search, and we use the combination of bibliometrics and knowledge mapping to analyze and demonstrate the current domestic research development on Computational Thinking research development, and analyze the resulting result map, which

2474-3828/23/$31.00 ©2023 IEEE
DOI 10.1109/ITME60234.2023.00042

can help us understand the frontier and hot issues in this field more clearly.

III. Findings and Analysis

A. Analysis of Annual Trends in Literature Publication

In order to better understand the research trends in the field of computational thinking, this paper searched and screened the Chinese core journals in CNKI from 2009 to August 2023, and utilized the visual analysis of CNKI on the 496 documents obtained to obtain an analysis of the overall trend of computational thinking as shown in Figure 1.

Figure 1. Overall Trend Analysis of Computational Thinking Postings.

Overall, the number of literature on computational thinking in Chinese core journals has been increasing year by year since 2013, and reached a peak in 2019, and then tended to a stable state, but overall, the number of related journal studies is in a period of booming development.

B. Analysis of the Distribution of Disciplines

Through the visualization and analysis function of CNKI, the disciplinary distribution of the field of computational thinking was obtained as shown in Figure 2. As in the figure, we can clearly find that the number of articles in the field of higher education, computer hardware and software field, secondary education and teaching theory and education management is the most, and the number of articles are more than 100, and there are more researches in the field of primary education and vocational education, and at the same time, by searching for the keywords of secondary education and computational thinking, we can find that there are more and more researches on cultivating the ability of computational thinking of the students of secondary school and vocational school in recent years, which has certain research value.

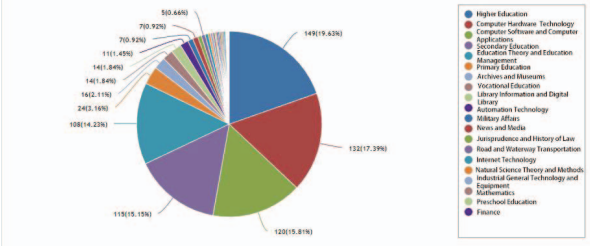

Figure 2. Distribution of Computational Thinking Disciplines.

C. Co-occurrence Mapping Analysis of Issuing Organizations

After importing the converted data using CiteSpace software, the Time Slicing is set to January 2009 to August 2023, the Years Per Slice is set to 5 years, the Node Types is selected as Institution, and other options are defaulted, then clicking GO! and adjusting the relevant parameters on Control Panel, we get the co-occurrence mapping of issuing institutions in the field of computational thinking as shown in Fig. 3. From the figure, we are able to find that the 496 papers screened involve 294 issuing organizations, and there are 174 connecting lines between them, indicating that there is more cooperation between them.Major issuing organizations include the Faculty of Education of Beijing Normal University, the Department of Educational Information Technology of East China Normal University, and the Faculty of Artificial Intelligence in Education of Central China Normal University, which are well-known teacher training colleges and universities in China.The Teaching Steering Committee for University Computer Programs in Higher Educational Institutions of Ministry of Education and Teaching Steering Committee of Computer Basic Courses in institutions of higher learning of the Ministry of Education are the organization with a large number of publications in the field of computational thinking research. All these are showing that computational thinking is getting more and more attention in education and teaching, as well as the importance of cultivating students' computational thinking ability, which is currently a hot spot in the field of education and teaching research.

Figure 3. Computational Thinking Domain Publishing Institutions Co-occurrence Mapping.

D. Keyword Mapping Analysis

Table 1 is a selection of high-frequency keywords screened from January 2009 to August 2023 in the field of computational thinking in Chinese core journals on CNKI. The most frequent keyword in the field of computational thinking is "computational thinking" itself 178 times, followed by "artificial intelligence" 30 times and "programming education" 18 times.

TABLE I. HIGH FREQUENCY KEYWORDS IN COMPUTATIONAL THINKING, JANUARY 2009-AUGUST 2023

Serial Number	Citation frequency	Keyword
1	178	computational thinking
2	30	artificial intelligence
3	18	programming education
4	14	information technology
5	11	experimental teaching
6	11	teaching reform
7	5	science education
8	5	digital literacy
9	5	practical teaching
10	3	stem education

Keyword co-occurrence mapping refers to high-frequency keywords represented by a co-occurrence matrix. Using CiteSpace software, the Time Slicing is set to January 2009 to August 2023, the Years Per Slice is set to 5 years, the Node Types are selected as keywords, and other options are defaulted, and then clicked GO!, adjusting the After adjusting the relevant parameters on the Control Panel, we get the computational thinking keyword co-occurrence map with the number of keyword nodes (N) of 169, the number of connections (E) of 292, and the network Density of 0.0206 as shown in Figure 4. From Figure 4, we are able to find that "artificial intelligence", "programming education" and "evaluation system" are high-frequency keywords, and the connection between these keywords is relatively strong.

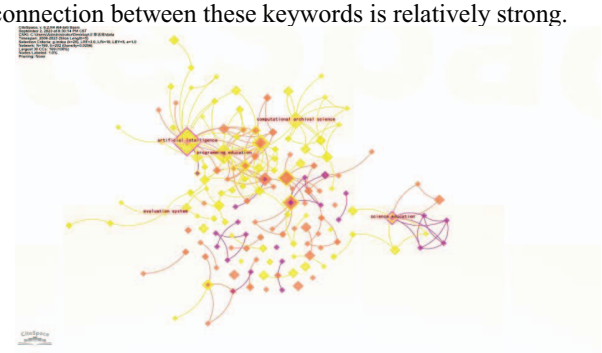

Figure 4. Computational Thinking Keyword Co-occurrence Mapping.

Using the clustering function of CiteSpace software to perform clustering operations on the keywords, we get the computational thinking keyword co-occurrence clustering map shown in Fig. 5, with the figure can be seen, the Modularity Q is 0.5752, generally speaking, Q>0.3 implies that the clustering structure is significant, here Q value is greater than 0.3, which means that the structure of this clustering is significant, and the Weighted Mean Silhouette S is 0.9057, in general, S>0.5 means that the clustering is reasonable, S>0.7 means that the clustering is convincing, here the value of S is greater than 0.7 means that the result of this clustering is convincing. Taken together, the clustering is reasonable. The keyword co-occurrence clustering mapping can reflect the hot issues and current status of the research in the field of computational thinking, and with the figure, it can be seen that 9 clusters are formed as shown in the figure.

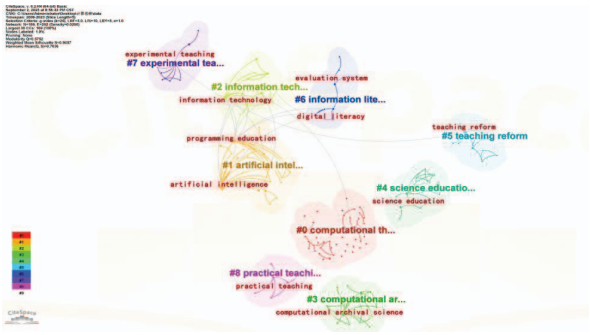

Figure 5. Computational Thinking Keyword Co-occurrence Clustering Mapping.

Based on the co-occurrence of keywords, a computational thinking keyword emergence mapping as shown in Figure 6 and a computational thinking keyword timeline mapping as shown in Figure 7 were plotted. In Figure 6, the research focuses of different time periods are represented by the darker parts of the lines, from which we can see the starting time of the research of these keywords, which is convenient for us to understand the hot topics in the related fields. Keyword timeline mapping is mainly used to outline the relationship between clusters and the time span of a certain cluster, thus facilitating us to sort out the changing trend of computational thinking research hotspots and clarify its development direction. We can clearly see the evolution of the hotspots of each clustering of computational thinking from Figure 7. From these keywords, we can find that computational thinking is an important element in the core literacy of information technology majors, and most of the current ways to develop students' computational thinking are in the form of programming, experiments, or STEM courses.

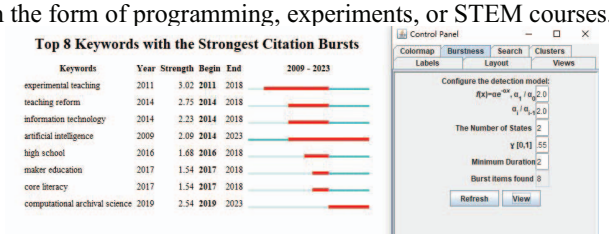

Figure 6. Computational Thinking Keyword Emergence Mapping.

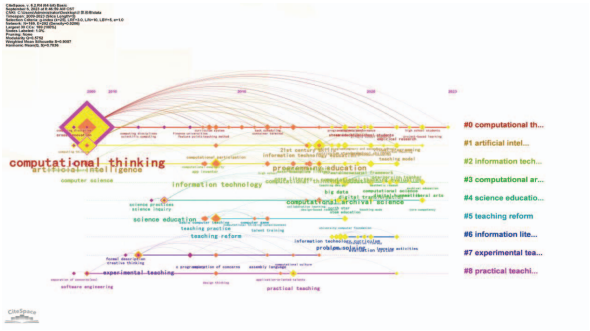

Figure 7. Computational Thinking Keyword Timeline Mapping.

IV. Problems and Future Trends in the Development of Computational Thinking Skills

A. Problems

- The computational thinking curriculum is not well developed.In the era of the information society, the level of high and new technologies, such as artificial intelligence technology, big data and data mining, has become an important indicator of a country's core competitiveness. In order to cultivate talents capable of adapting to the development of the new era, many developed countries have incorporated computational thinking into the curriculum standards of basic education and invested a lot of money and manpower to promote its implementation, which shows the importance of computational thinking. In China, computational thinking has also gradually become a hotspot of research for the majority of scholars. At present, in primary and secondary schools, a lot of relevant courses have been set up to cultivate students' computational thinking, and the system has been gradually improved, but there are still problems such as focusing too much on the learning of theoretical knowledge and lack of practice and lack of depth in cultivation. [4] At the same time, we can find that compared with primary and secondary schools, vocational secondary schools do not pay much attention to the cultivation of computational thinking ability, and the cultivation of computational thinking is not closely connected between the various stages of education.
- There is a lack of specialized teaching staff with the necessary skills to develop computational thinking. Teachers play a leading role in the process of developing computational thinking, and therefore there are certain requirements for teachers' professionalism in information technology, such as theoretical knowledge and practical skills. [5] From the previous analysis of the keyword knowledge map, we are able to find that with the development of computational thinking research, the National Curriculum and Teaching Guidance Committee and other related departments have been carrying out pedagogical reforms on the educational model and teaching content, etc. The quality of education and teaching can only be effectively improved if teachers have the relevant literacy and know how to develop students' computational thinking skills.
- Insufficiently developed indicators for evaluating computational thinking skills. At present, the evaluation of computational thinking ability is relatively single, [6] mostly based on test paper examination results, there is no way to accurately understand the level of students' computational thinking, and therefore there is no way to formulate relevant teaching programs for its characteristics.

B. Future Trends

- Computational thinking skills will be emphasized more and become an important part of the overall quality of future students. As researchers study computational thinking, the definition and understanding of computational thinking will become clearer and better, and educators will have a clearer idea of how to develop students' computational thinking skills in greater depth. In the future, there will also be more practical sessions for students to experience the beauty of computers with their own hands, so as to stimulate their interest in computer science, which will be more conducive to the development of students' computational thinking skills. [7]
- There is a growing pool of professionally qualified teachers, diversification of teaching styles, and greater interest in cross-fertilization between disciplines. Online learning platforms and some self-directed learning tools will become important tools for teachers and students to teach and learn. [8] Through open educational resources, teachers can better enrich their professional knowledge and practical skills, and students can recognize their own learning situation more clearly and make some adjustments to their learning strategies independently.
- Diversified forms of teaching and learning help to develop computational thinking skills, and more diversified and persuasive evaluation methods. [9] STEM education is widely used in the development of computational thinking skills, resulting in the STEM+C education model shown in Figure 8. More diversified educational evaluation methods, [10] such as the use of a combination of computational thinking scales, interviews and flowchart text evaluation. The computational thinking complex ability is examined from multiple perspectives, such as the computational thinking evaluation index shown in Figure 7, which is evaluated in five dimensions: Creativity, Critical Thinking, Problem Solving Ability, Algorithmic Thinking, and Cooperation, so that the evaluation results can relatively accurately reflect the students' computational thinking ability.

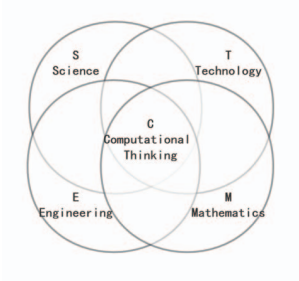

Figure 8. STEM+C Education Model.

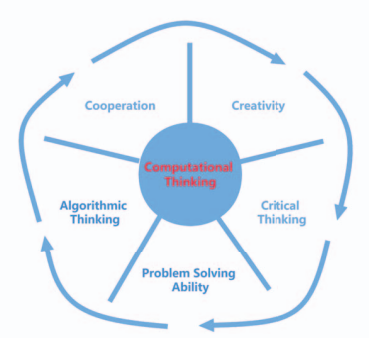

Figure 9. Indicators For Evaluating Computational Thinking.

V. CONCLUSION

A series of maps constructed by screening 496 eligible journal documents from Chinese core journals in CNKI, using CiteSpace software. We can find that research on computational thinking began more than a decade ago and has continued to this day, remaining a hot topic in education in the subject today. At present, many teacher-training colleges and universities, the Council on Education and Teaching and other organizations are actively studying the cultivation of computational thinking skills, and it is believed that the cultivation of computational thinking will be carried out throughout all stages of primary and secondary schools, senior high schools, secondary vocational schools and universities in the near future.

In the information age, computational thinking has gradually become a basic quality necessary for everyone, and the enhancement of computational thinking skills will help students better integrate into the information society in the future. In recent years, computer science has interpenetrated with other disciplines to form many new interdisciplines. The emergence of these cross-disciplines urgently requires secondary students to continuously improve and refine their computational thinking skills to promote the comprehensive development of individuals.

REFERENCES

[1] Yi Zhang, Yu Mo, Yan Zhang, Hanrui Gao, Niu Li and Yufei Lin, "Development and application of computational thinking scale for primary school students in China", China Electrochemical Education, vol. 10, 2020, pp. 49-57.

[2] Xing Li, "Research on design-based STEM+C teaching to cultivate elementary school students' computational thinking", Central China Normal University, 2022, DOI:10.27159/d.cnki.ghzsu.2020.003598.

[3] WenTao Ke, "The demystification of tools: The application and reflection of CiteSpace in educational research", Chongqing Higher Education Research, vol. 7(05), 2019, pp. 117-128, DOI:10.15998/j.cnki.issn1673-8012.2019.05.011.

[4] Jinbao Zhang, "Computational thinking education: conceptual evolution and challenges faced", Modern Distance Education Research, vol. 31(06), 2019, pp. 89-101.

[5] Angeli C, "Computational thinking education: Issues and challenges", Computers in Human Behavior, 2020, 105(C).

[6] Xiaohua Yu, Meiling Wang, Jiamin Cheng and Zhenhua Qiu, "A new way to evaluate computational thinking: micro-certification", Open Education Research, vol. 28(01), 2022, pp. 107-120, DOI:10.13966/j.cnki.kfjyyj.2022.01.011.

[7] Lei Deng, Dechen Zhan and Xuefeng Jiang, "Exploration and Practice of the Value of Cultivating Computational Thinking Ability in New Engineering Education", Research on Higher Engineering Education, vol. 2, 2020, pp. 49-53.

[8] Zhengqing Wang, Lingtong Li and Xiao Tian, "Pointing to the cultivation of computational thinking: the construction of K-12 computer science education system in New York State, USA", Modern Distance Education Research, vol. 34(06), 2022, pp. 43-53.

[9] Xiaohua Yu and Meiling Wang, "How far is the road of computational thinking cultivation? --Based on Computational Thinking Measurement Perspective", Open Education Research, vol. 26(01), 2020, pp. 60-71, DOI:10.13966/j.cnki.kfjyyj.2020.01.007.

[10] Gongjian Hui, Xiaofang Lan and Yizhou Qian, "How should computational thinking be evaluated? --A comparative analysis based on 14 assessment tools at home and abroad", Journal of Distance Education, vol. 38(04), 2020, pp. 84-94, DOI:10.15881/j.cnki.cn33-1304/g4.2020.04.009.