The Research Hotspot and Frontier Evolution of Computational Thinking of Information Technology Discipline in Chinese Primary and Secondary Schools

Visualization Analysis Based on CNKI and CiteSpace Software

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Abstract. In order to explore the research hotspot and frontier evolution of computational thinking of information technology discipline in Chinese primary and secondary schools, this paper uses bibliometric analysis method and CiteSpace software to analyze the related papers in this field collected by CNKI, and sorts out the year distribution of papers, the distribution of authors and institutions, and the evolution of hot research topics. The results show that there is less cooperation among authors. The current research hotspots in this field are from app inventer, ict curriculum, teaching practice, etc., turned to teaching strategy, computational thinking training, project-based learning, etc. It can be concluded that the communication and cooperation between the authors should be strengthened. In the future, emphasis should be placed on the cultivation of core literacy, the selection of teaching strategies and the design of teaching mode. More attention should be paid to students, and they should be trained in computational thinking through project-based teaching.

Keywords: Information technology · Computational thinking · Bibliometric · CiteSpace

1 Introduction

In March 2006, Yizhen Zhou [1] defined the connotation of computational thinking, which considers computational thinking to be a series of thinking activities that use the basic concepts of computer science to solve problems, design systems and understand human behaviors. With the rapid development and widely used of artificial intelligence technology, big data and cloud computing, computational thinking has become the focus of international computer field and computer education research [2]. In September 2016, China released "Core Literacy of Chinese Students" [3], which takes cultivating "well-rounded people" as the core and constructs a core literacy system framework of Chinese students in three fields and six indicators. In 2018, the Ministry of Education released "Information Technology Curriculum Standards for Senior High Schools (2017 Edition)"

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[4], which listed computational thinking as the core literacy of information technology discipline. In 2022, the Ministry of Education released "the Curriculum Standards of Information Technology for Compulsory Education (2022 Edition)" [5], and information technology has officially become an independent discipline. The curriculum standards also list computational thinking as one of the core literacy of the discipline.

In this paper, 643 papers collected in CNKI are taken as the research objects by the bibliographic analysis method, and the knowledge map of computational thinking of information technology discipline in primary and secondary schools is drawn by the literature analysis tool from various aspects, so as to clarify the evolution of research hotspots and frontiers, and strive to provide reference for the further improvement of research in this field.

2 Data Sources and Research Methods

2.1 Data Sources

In order to ensure the reliability and authoritativeness of experimental data, this paper selected CSSCI journal database, core journal database and master and doctoral paper database in CNKI as data sources. On the advanced search page, set the search condition as journal search, select the title of "Information Technology" and "Computational Thinking", and set the time span from 2012 to 2023. A total of 685 literatures were retrieved on February 2, 2023. All the retrieved papers were manually screened and irrelevant papers were excluded. Finally, a total of 643 effective papers were obtained.

2.2 Research Methods and Tools

CiteSpace software is developed by Dr. Chaomei Chen, a Chinese-American scholar, and applied in the field of science and technology to identify and display hot keywords, research progress and frontier directions in this field through intuitive knowledge map [6]. In this paper, with the help of CiteSpace 6.1.R6 software and its powerful visualization function, the 643 papers retrieved were analyzed by time-sharing and dynamic visualization map, so as to scientifically display their macro structure and development context.

3 The Spatio-Temporal Knowledge Map of Computational Thinking of Information Technology Discipline in Chinese Primary and Secondary Schools

3.1 Time Distribution Map

To some extent, the total number of journal literatures in a certain field can show the degree of activity and theoretical level of the academic research field [7]. Before 2012, there was almost no paper on computational thinking of information technology discipline. As shown in Fig. 1, since 2012, the number of published papers has increased year by year, but the total number of published papers is less. The number of papers published

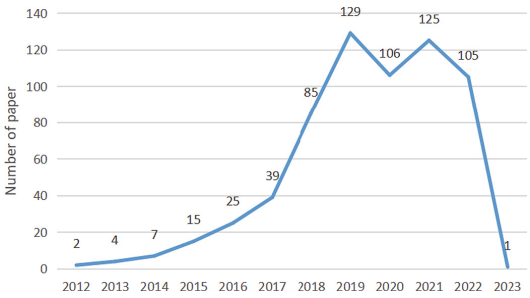

Fig. 1. Chronological distribution of research documents

in 2018 was 85, can be seen that Chinese teaching researchers have paid more and more attention to and studied computational thinking of information technology discipline. 2019 was a breaking point and a turning point, with 129 papers. After 2019, the number of published papers fluctuated somewhat, but the number of published papers every year reached more than 100, indicating that people now attach great importance to the research of computational thinking of information technology discipline. The number of papers published in 2023 is still expected to reach more than 100.

3.2 Spatial Distribution Map

Distribution of Authors. Set the option of Node types as "Author", and then run CiteSpace to get the co-occurrence map of authors of computational thinking of information technology discipline, as shown in Fig. 2. The number of nodes is 223, the number of lines is 41, and the density is 0.0017. It can be found that a total of 219 authors are involved, and there are only a few lines between each author node, and many authors even have no lines among them. Among them, Liu Xiangyong's number of papers is 3, ranking the first, while a small number of other authors' number of papers is 2, and most authors' number of papers is 1, indicating that researchers in this field are dispersed and less cooperative. Most of the authors' research was independent and not in-depth.

Distribution of Institutions. The option of Node types was set as "Institution", the time span was 2012–2023, and the time slice was 1 year. After running, the co-occurrence map of the research institutions was obtained, as shown in Fig. 3.

Fig. 2. Authors co-occurrence map

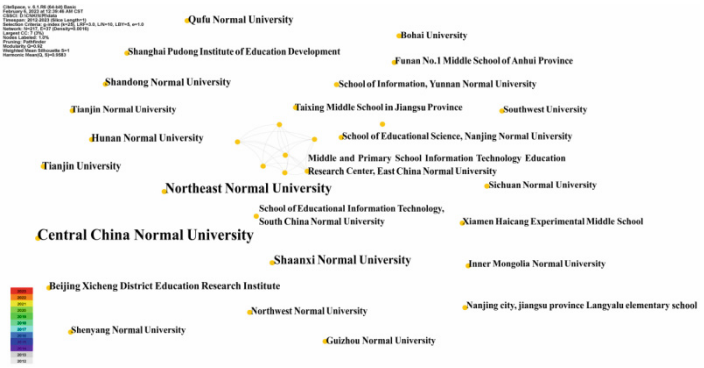

Fig. 3. Institutions co-occurrence map

Through the analysis of the map, it was found that a total of 643 papers involved 217 institutions, and important research forces in this field came from universities and primary and secondary schools, such as Central China Normal University, Northeast Normal University and primary and secondary schools distributed in various regions. The top 10 institutions in terms of publication volume are shown in Table 1. Central China Normal University has conducted in-depth research in this field, with a total of 6 papers published, followed by Northeast Normal University. Most of the institutions with one paper were primary and secondary schools, and most of the primary and secondary school teachers conducted scattered research based on their personal research interests. The number of lines between research institutions is small, which shows that there is only a few cooperation between research institutions. This reflects that most of the research in this field is independent, the lack of cooperation among major research institutions, and the lack of sharing and mobility of knowledge, experience and research results.

Table 1. Top 10 institutions with the number of publications

Serial number	Institution	Number of paper
1	Central China Normal University	6
2	Northeast Normal University	5
3	Shaanxi Normal University	4
4	Beijing Xicheng District Education Research Institute	3
5	Shandong Normal University	3
6	Tianjin University	3
7	Hunan Normal University	3
8	Qufu Normal University	3
9	Guizhou Normal University	2
10	Funan No. 1 Middle School of Anhui Province	2

Table 2. High frequency keywords of computing thinking of information technology discipline

Keywords	Frequency	First Appearance Year
computational thinking	505	2012
information technology	165	2013
core literacy	53	2017
instructional strategy	34	2018
cultivation strategy	33	2017
senior high school	28	2014
culture	23	2015
teaching mode	23	2014
instructional design	23	2017
thinking training	22	2014

4 The Research Hotspot of Computational Thinking of Information Technology Disciplines in Chinese Primary and Secondary Schools

4.1 High-Frequency Keywords

Keywords reflect the research value and direction of a paper. Keywords with high frequency are often used to determine hot issues in a research field. In CiteSpace, set the node type as "Keywords", and get the keyword co-occurrence map after running. The details of the top ten keywords in frequency are shown in Table 2. The keywords "computational thinking" and "information technology" are the first and second most frequently used by the computational thinking and the first appeared very early.

4.2 Keyword Cluster Analysis

CiteSpace can automatically extract literature keywords to generate cluster words, which can be used to summarize research gathering points, and each cluster can be regarded as a closely related independent research field [8]. The keyword network was clustered by LLR (logarithmic likelihood rate algorithm), and the clustering results were shown in Fig. 4. A total of 8 clusters were obtained. They are "#0 information technology", "#1 information literacy", "#2 high school information" and "#3 information technology" course ", "#4 learning mode", "#5 artificial intelligence", "#6 design model", "#7 teaching strategy", "#8 cognitive" deviation ". The module value (Q) and the average contour value (S) are the evaluation basis for the rendering effect of the map [7]. The larger the value of Q, the better the clustering, and the closer the value of S is to 1, reflecting the higher homogeneity of the network. In this study, the network module index $Q = 0.6056$ and the network homogeneity $S = 0.9325$ of the keywords clustering indicated that the

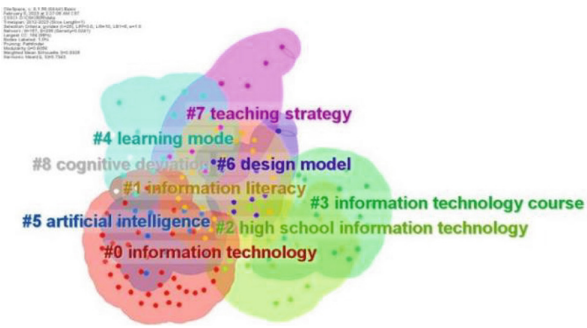

Fig. 4. Keyword clustering map

network structure of the map was reasonable and could represent the research hotspot in the field of computational thinking in information technology discpline.

4.3 Keyword Time Line Distribution and Emergent Analysis

With "keywords" as nodes, the time line map of keywords in this field is obtained after CiteSpace software processing, as shown in Fig. 5. The horizontal dimension represents the time, and the vertical dimension represents the keyword distribution within the corresponding time. Keyword emergence can predict the development trend and research frontier of the research field. As can be seen from Fig. 6, keywords such as "app inventor", "ict curriculum", "teaching practice", "key competence" and "classroom teaching" appeared from 2014 to 2019. But it's all over by 2020. After 2020, the keywords change to "teaching strategy", "computational thinking training", "project-based teaching", "project-based learning", these are the hot spots of current research and will likely continue to be the main research directions of researchers in the future.

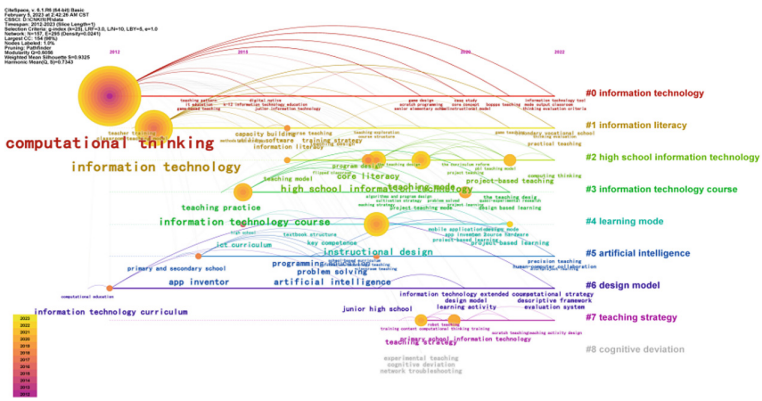

Fig. 5. Key words time line distribution

Top 10 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2012 - 2023
app inventor	2014	1.7	2014	2018	
ict curriculum	2015	1.72	2015	2017	
teaching practice	2015	1.1	2015	2019	
key competence	2017	1.02	2017	2018	
classroom teaching	2018	1.03	2018	2018	
teaching strategy	2019	1.2	2020	2021	
computational thinking training	2020	1.05	2020	2020	
project learning	2020	1.05	2020	2020	
project-based teaching	2021	1.37	2021	2023	
project-based learning	2021	1.02	2021	2023	

Fig. 6. Key words outburst map

5 Conclusion and Prospect

5.1 Conclusion

In order to better review the research context of computational thinking of information technology discipline in Chinese primary and secondary schools, this paper carries out bibliometric analysis through relevant papers, and uses CiteSpace to carry out statistical and knowledge map visualization analysis on relevant research progress, hot topics and hot topics evolution, and draws the following conclusions.

First, the number of papers on computational thinking of information technology discipline in primary and secondary schools shows an overall trend of "slow increase in the early period, sudden increase in the late period, and stable in recent years", while the cooperation between authors and institutions shows the characteristics of "small amount of concentration and overall dispersion". Especially in 2019, the research on computational thinking of information technology discipline in China has been greatly improved. The most likely reason is that the Ministry of Education issued the "Curriculum Standards for Information Technology in Senior High Schools (2017 Edition)" in 2018, which listed computational thinking as the core literacy of information technology discipline. After that, teachers in primary and secondary schools and researchers in universities began to conduct in-depth research on computational thinking of information technology discipline.

Second, primary and secondary schools are the institutions that publish the most articles in this field, but they lack communication and cooperation among them. There are more researches on computational thinking of information technology discipline in normal universities in China. The keywords "information technology", "computational thinking", "core literacy", "teaching strategy", "cultivation strategy" and "teaching mode" are highly popular in the research, which indicates that while studying the computational thinking of information technology discipline, more attention should be paid to the cultivation of core literacy, the selection of teaching strategy and the design of teaching mode, etc., mainly from the perspective of student-centered teaching design.

Third, since 2020, "project learning", "project-based teaching" and "project-based learning" have become hot keywords in research. Therefore, the training of students'

computational thinking can be based on project-based teaching. Teachers carry out project-based teaching, which can more appropriately deliver teaching content, and students can have in-depth understanding in the learning process, which is more conducive to the cultivation of computational thinking.

5.2 Prospect

With the widely used of computer technology, training students' computational thinking is an effective means to train high-tech talents. In the educational practice of computational thinking training, we should constantly summarize and evaluate the training effect, so as to improve the training way. With the support of computational thinking, the scientific research work in all fields will surely get new breakthroughs. The research focus in this field will continue to revolve around the cultivation practice of computational thinking. We can further explore the cultivation rules of computational thinking from the teaching of various subjects, such as mathematics, physics and other courses.

References

1. Wing J M. (2006) Computational Thinking.J,49(3):33–35.
2. Yin S., Li X.Y., Wang J.Y.(2020)Research Hotspots and evolvement of computational thinking—Visualization Analysis based on CNKI and CiteSpace Software.J,36(06):68–77.
3. Core Literacy research group. (2016) Chinese students develop core qualities. J, 2016(10): 1–3.
4. Ministry of Education of the People's Republic of China. (2018) Curriculum Standards for Information Technology for Senior High Schools (2017 Edition). People's Education Press, Beijing.
5. Ministry of Education of the People's Republic of China. (2022) Curriculum Standards for Information Technology in Compulsory Education (2022 edition). Beijing Normal University Press, Beijing.
6. Hu J.P., Lin L.J. (2019)Hot topics and Frontier Evolution of disability studies in China: A Visual analysis based on CSSCI journals.J,No.291(11):118–125.
7. Zhu X.M. (2016) The transformation of classroom evaluation in the era of "Internet +".J, 2016(22):39–41.
8. Chen C.M. (2006) CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. J, 57(3): 359–377.