



# A Visual Analysis of the Application of Internet of Things Technology in Education Based on Citespace and Vosviewer

Gaoyuan Xie<sup>(✉)</sup>, Die Pu, Mingxin Wang, and Yirong Liu

School of Information, Yunnan Normal University, Kunming, Yunnan, China  
609874094@qq.com

**Abstract.** In order to analyze the application trend of Internet of Things technology in information education, this paper adopts bibliometric analysis method and Citespace visualization analysis method to analyze the application status and application trend of Internet of Things technology in the field of education at home and abroad in recent years. After analysis, the following conclusions are drawn: In recent years, the application of Internet of Things technology in information-based education has attracted extensive attention from the academic community, and Internet of Things technology has occupied an increasingly important position in information-based education. How to better integrate the Internet of Things into education and how to give full play to the advantages of the Internet of Things in education has become a hot topic of research for many years.

**Keywords:** Internet of Things · Education · Information Education · Citespace · Visual analysis

## 1 Introduction

The Internet of Things refers to a network system that connects various physical devices, sensors, software, and networks through internet connectivity and various communication technologies to achieve intelligent interaction and data transmission between each other [1, 2]. It has a wide range of application fields and potential, and the application fields of the Internet of Things are very wide, including smart homes, smart cities, information education, and digital education. How to combine the Internet of Things with information technology education has received high attention from many scholars at home and abroad [3]. Timely understanding of the current application status and latest progress of the Internet of Things in the field of education can provide new research perspectives for IoT technology and education informatization [4].

This article uses CiteSpace and Vosviewer as visual analysis tools. This software is used to visually analyze the literature data related to the application of Internet of Things technology in education at home and abroad during 2017–2022. The analysis results are helpful to systematically understand the development trend of Internet of Things in the field of education, grasp the current research hot spots [5], and identify the future research trend and direction, which is of great significance for the research of Internet of Things technology in the field of education [6].

© The Author(s) 2024

F. Huang et al. (Eds.): ICAIE 2023, AHCS 15, pp. 582–590, 2024.

[https://doi.org/10.2991/978-94-6463-242-2\\_71](https://doi.org/10.2991/978-94-6463-242-2_71)

## 2 Data Sources and Research Methods

### 2.1 Data Source

In order to better grasp the quality of literature related to the application of Internet of Things technology in the field of education at home and abroad, this paper uses CNKI and Web of Science core collection database as the data sources of domestic and foreign references. China National Knowledge Network (CNKI) was used as the data source to search relevant Chinese literature, and the search topic was set as “the application of the Internet of Things in education”. The retrieval time was 2017-01-01 to 2022-12-31. A total of 2,020 articles were obtained excluding English and non-academic literatures such as newspapers and news, and 1955 articles were obtained after removing duplicate literatures. Foreign language data used Web of Science core collection analysis as a data source, subject as “Application of Internet of Things in Education” time span for the 2017-01-01 to 2022-12-31, a total of 1932 articles, The system automatically deletes some duplicate literatures and irrelevant literatures, and further screens the literature data by precisely setting the search conditions.

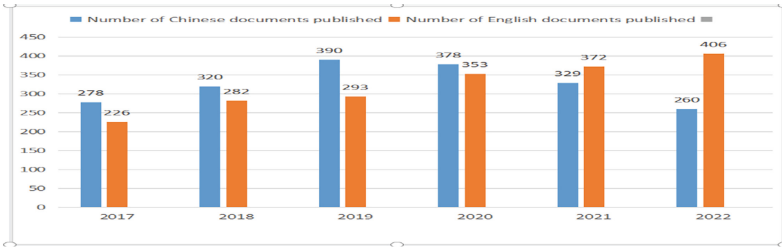
### 2.2 Research Methodology

Through bibliometric analysis method and word frequency analysis method, and with the help of scientific literature data mining and literature information visualization analysis software CiteSpace developed by Professor Chen Meichao, this paper makes a visual analysis of the application literature of Internet of Things technology in the field of education at home and abroad during 2017–2022. By drawing the bar chart of the number of published literatures at home and abroad, we can clearly compare the number of published literatures at home and abroad from 2017 to 2022, so as to help analyze the research trend of Internet of Things in the field of education at home and abroad in recent years. Through the keyword co-occurrence map drawn by the software, the development hotspot and trend of a certain research field can be understood, and the depth and popularity of research in a certain field can be analyzed through the characteristics of node size, connection strength, centrality and so on. The key word clustering map can clearly show the important links between different clusters. The higher the ranking in the clustering knowledge map, the more researchers of the cluster, and the higher the research heat of this topic. By predicting the number of literature publication, keyword co-occurrence, keyword timeline, citation frequency and cluster analysis, this paper explores the application development context and current research hotspots of the Internet of Things in the field of education, and predicts the further combination of the Internet of Things and education [7].

## 3 Research Results and Analysis

### 3.1 Analysis of the Number of Published Related Literature

The number of publications in related papers is often an important indicator of the accumulation of knowledge and the number of research achievements in the research field. By analyzing the number of published literatures in this field, it is helpful to



**Fig. 1.** Histogram of the number of published Chinese and English related documents in 2017–2022

understand the current research status and research popularity of this research field, and to summarize the existing relevant knowledge in this field, so as to facilitate the reference of future scholars. The bar chart of published literature data on the application of Internet of Things in education at home and abroad from 2017 to 2022 is shown in Fig. 1.

As can be seen from Fig. 1, the number of published literature on the application of the Internet of Things in education in China was at a low level in 2017–2018, the number of relevant literature continued to increase in 2019–2020, reaching a high level, and then decreased in 2021–2022. From 2017 to 2022, the number of relevant literatures published abroad continued to increase significantly, and the research popularity showed an increasing trend year by year. In terms of the overall trend, in recent years, the growth of enthusiasm for the application of Internet of things technology in education in foreign countries is significantly higher than that in China.

### 3.2 Keyword Co-occurrence Knowledge Map Analysis

Keywords are a high-level summary of the core content of a paper, and by analyzing the graph of keywords, one can clearly understand the current research hotspots and development trends in this field. In this paper, Vosviewer software is used to sort out the obtained literature data and visually analyze the Knowledge graph. The main analysis focuses on the application prospects of the Internet of Things in the field of education, and the analysis results are shown in Figs. 2 and 3. Each node in the graph corresponds to a keyword, and the size of the node is proportional to the frequency of keyword occurrences. The higher the frequency, the larger the node area and the darker the color. At the same time, the frequency of keyword occurrence also affects the value of keyword centrality, and the frequency is directly proportional to the size of the value. The larger the value, the higher the research enthusiasm in the field. In summary, this article selects the top 5 keywords with the highest frequency of occurrence in domestic and foreign literature data for analysis, as shown in Tables 1 and 2.

As can be seen from Fig. 2 and Table 1, the high-frequency keywords of Internet of Things application in the field of education in China are Internet of Things, education reform, IoT technology, Internet of Things engineer, smart campus and cloud computing. Meanwhile, nodes with centrality greater than 0.1 are generally considered as critical nodes [5]. To sum up, the research on the combination of the Internet of Things and education has become a new research trend in China. As can be seen from Fig. 3,

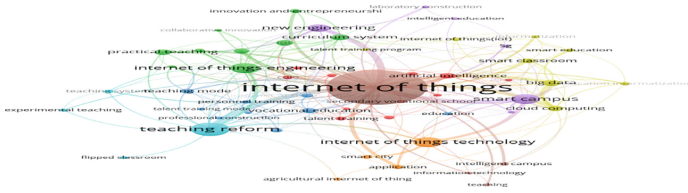


Fig. 2. Domestic keyword co-occurrence knowledge map

Table 1. Analysis of high-frequency keywords and centrality in domestic literature

Number	Frequency	Centrality	Keywords
1	218	0.71	Internet of Thing
2	53	0.73	Teaching reform
3	36	0.65	IoT technology
4	35	0.36	Internet of things engineer
5	54	0.27	Smart campus

the Internet of Things has penetrated into all aspects of education, and the application scenarios of the Internet of Things in education are also increasing. The Internet of Things technology has promoted the reform of education.

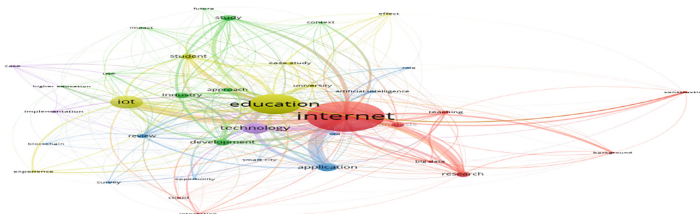


Fig. 3. Foreign keyword co-occurrence knowledge map

Table 2. Analysis of high-frequency keywords and centrality in foreign literature

Number	Frequency	Centrality	Keywords
1	478	0.82	Internet
2	272	0.73	Education
3	202	0.65	Internet of things
4	129	0.36	Technology
5	54	0.27	Application

It can be seen from Fig. 3 and Table 2 that keywords with high frequency and high centrality include Internet, education, Internet of Things, technology, applications, artificial intelligence, big data. Thus, from 2017–2022, foreign applications and researches based on the Internet of Things in education tend to combine education with various applications by using the Internet and Internet of Things technology, and pay more attention to the research on the Internet of Things software. The area and number of key byte points of the knowledge map of foreign literature are larger, which shows that the research content of the combination of Internet of Things and education in foreign countries is deeper and more extensive. The combination of Internet of Things technology and education is more widespread and in-depth in foreign countries, and the number of scholars concerned is larger.

### 3.3 Keyword Clustering Knowledge Map Analysis

In order to better analyze the keywords of the research content, this article conducts clustering knowledge graph analysis on the keywords. Firstly, divide the keywords into different subgroups, and then perform visual analysis. Visual analysis can better identify the potential connections between clusters and grasp the current research status in this field [5].

The important links between different clusters can be clearly seen through the clustering analysis map. The higher the ranking in the clustering knowledge map, the more researchers there are for the cluster, and the more research literature about the cluster.

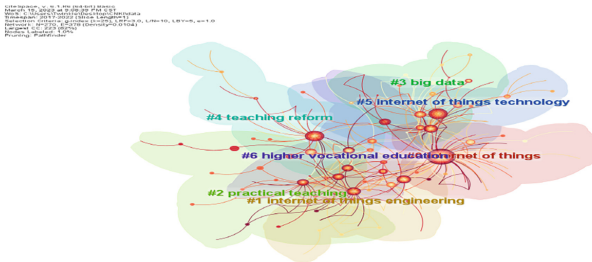


Fig. 4. Domestic keyword clustering knowledge map

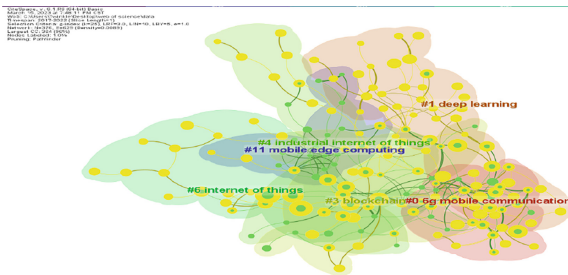


Fig. 5. Foreign keyword clustering knowledge map

Figures 4 and 5 respectively show the clustering knowledge map of the application keywords of IoT in the field of education at home and abroad. The color of each cluster label is different, and there will be some overlap before different labels, which indicates potential connections between clusters. It is generally believed that Modularity greater than 0.3 means significant clustering structure, and Silhouette greater than 0.7 means high clustering accuracy and will be convincing. The clustering knowledge map can divide the main database into different clusters.

As can be seen from Fig. 4, before the cluster label of research on the application of Internet of Things in education in China, the smallest is #0 Internet of Things, followed by #1 Internet of Things engineer, #2 practical teaching, #3 big data, #4 teaching reform, #5 Internet of Things technology, #6 higher vocational education. This indicates that the current domestic research on the application of the Internet of Things in education mainly focuses on the use of the Internet of things to reform the traditional way of education.

As can be seen from Fig. 5, in the application of Iot in education abroad, the smallest cluster label is #0 6g mobile communication. This was followed by #1 deep learning, #3 block chain, #4 industrial internet of things, and #6 internet of things #11 mobile edge computing etc. This shows that foreign research on the application of the Internet of Things in education is more inclined to the research on emerging technologies such as 6g, deep learning and blockchain, which is quite different from the research direction of domestic scholars.

### 3.4 Keywords Time Line Knowledge Map Analysis

To identify and excavate research frontiers, it is necessary to track the evolution of previous hot spots in the research field. CiteSpace software can introduce the concept of time line into clustering network to describe the evolution process of keywords under different clustering [7].

The time graph mainly focuses on the mapping of the relationship between clusters and the historical span of literature in a cluster. If the Timeline graph is selected, CiteSpace will first cluster the default network and assign appropriate labels to each cluster to complete the process of automatic clustering and labeling. Then each node is set in the corresponding position [5] according to the clustering (vertical axis) and publication time (horizontal axis) of the node [8]. Time graphs are often used to study the development of clustering, from the emergence of clustering to the increase of clustering, and when clustering has a landmark literature. The time graph pays more attention to the relationship between clusters and is more conducive to analyzing the development process of clustering [9, 10]. The cutting-edge analysis of the application of the Internet of Things in education is mainly carried out through the change of keyword clustering over time. CiteSpace software is used to make the visualization analysis of the keyword time graph of literature clustering data obtained to generate the cutting-edge research content of the Internet of things in education at home and abroad. See Figs. 6 and 7.

As can be seen from Fig. 6, from 2017 to 2022, a large number of high-frequency keywords appeared in China, and these high-frequency keywords can be identified and mined at the forefront of research. First of all, it is necessary to track the evolution of previous hot spots in this research field. CiteSpace can introduce the concept of timeline into the clustering network to depict the evolution process of keywords under different

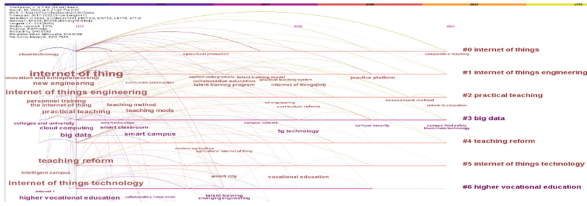


Fig. 6. Domestic keyword time line knowledge map

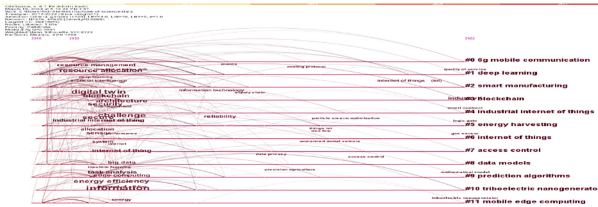


Fig. 7. Foreign keyword time zone knowledge map

clustering [11, 12]. See Fig. 6 for the timeline of research keywords in the education field of the Internet of things in China. Figure 6 contains both the clustering label and the keyword cluster under the label, and the keyword cluster under each cluster is arranged according to the time when the initial literature appears, and each clustering label has a straight line matching the evolution of the keywords under the clustering [13]. The hotspot clustering labels given in the figure have all appeared since 2017, but it can be seen from the figure that the research of Internet of Things engineers has gradually become indifferent in recent years, and there are not many high-frequency keywords, while the rest of the clustering has high-frequency keywords in recent years. It indicates that these research topics are getting more and more attention, and the results are increasing. In the future, they are likely to continue to be the hot research direction in this field [14].

As can be seen from the foreign time chart, foreign studies on the application of the Internet of Things in education have been relatively mature in 2017. From 2017 to 2022, many high-frequency keywords have been continuously developed, and these keywords reflect the research trend of the Internet of Things in education to some extent. In recent years, foreign research on the Internet of Things in education mainly focuses on 6g technology, deep learning, block chain, Internet of Things technology, mobile edge computing and other new technologies. In recent years, Mobile edge computing research is relatively rare. The rest are hot research clustering. From the general trend, the research hotspot has developed from the initial research on the Internet of Things technology itself to the extensive application of 6G and mobile communication at present, which has greatly promoted the development of the Internet of Things in the field of education and education reform.

## 4 Conclusion and Outlook

Through the above research and analysis, it can be seen that the status of Internet of Things technology in the field of education is becoming increasingly important, and it is an important component of information education. In recent years, the Internet of Things technology has gradually matured, and the combination of the Internet of Things and education can improve the learning experience and provide a more personalized and interactive learning environment. Through IoT devices and sensors, teachers can obtain real-time data and feedback from students, understand their learning progress and difficulties, and provide customized teaching content and support based on individual differences, promoting students' learning effectiveness and motivation. In terms of the number of literature publications, the number of foreign literature publications was slightly lower than that of domestic literature in the early stage, and has increased significantly in the past three years. By 2022, the number of relevant literature published abroad has significantly led that of domestic literature. At the same time, there are different research focuses on the application of the Internet of Things in education both domestically and internationally. In the past five years, research on the application of the Internet of Things in the field of education in China has mainly focused on how to use Internet of Things technology to reform traditional education models, with a focus on the practical application of existing technologies. Foreign research on the application of the Internet of Things in education tends to focus more on the application of new technologies in the Internet of Things, and more on the combination of emerging Internet of Things technologies and education. Overall, foreign research on the application of the Internet of Things in education is more in-depth, systematic, and has a certain degree of scalability. The research results of foreign countries have certain reference value for the application of the Internet of Things in education in China.

With the continuous development and maturity of Internet of Things technology, its application prospects in information education have become very broad. The application significance of the Internet of Things in information education cannot be ignored. It promotes interdisciplinary integration, improves learning experience, and provides interactive classrooms for students and teachers. These application meanings help to promote the modernization of education, cultivate students' comprehensive qualities, and adapt to future society. This research uses visual software to visually analyze the literature data and Knowledge graph of the Internet of Things in the field of education at home and abroad. By analyzing the development and change of its keywords and the relationship between keywords, it predicts the future development trend and provides theoretical reference for future researchers.

## References

1. Q. Liu, L. Cui, H. and Chen, Key technologies and applications of the Internet of Things [J], Computer Science, vol. 37(06), 2010.
2. Deevi Sri Aditya, Manoj B. S. Data Summarization in Internet of Things [J]. SN Computer Science, 2022, 3(4).
3. Z. Y.Liu, X. W. Wang C.M. Chen The method of mapping scientific knowledge and its application in science and technology Application in Information [J]. Digital Library Forum. 2009, (10): 14–34.



4. Shalini Sharma, Bhupendra Kumar Pathak, Rajiv Kumar. Understanding of Network Resiliency in Communication Networks with its Integration in Internet of Things - A Survey [J]. *ELECTRICA*, 2023, 23(2).
5. Y.Chen, Z.Liu, chen, et al. Methodological functions of Knowledge Map [J]. *Studies in Science of Science* vol., 33(02), pp:242–253, 2017. Yue Junping.
6. A deep learning method for intelligent decision-making in enterprise management based on the Internet of Things [J]. *Journal of Computational Methods in Sciences and Engineering*, 2023, 23(2).
7. Huang Linchao, Zhou Jincheng, Wang. Visualization Analysis of Global Self-Regulated Learning Status, Hotspots, and Future Trends Based on Knowledge Graph [J]. *Sustainability*, 2023, 15(3).
8. Introduction to the special issue on machine learning and artificial intelligence for the internet of things, 5G, and beyond[J]. *Computer Networks*, 2023, 227.
9. Raghavendar K., Batra Isha, Malik Arun. A robust resource allocation model for IoT environments [J]. *Decision Analytics Journal*, 2023, 7.
10. Dai Zhicheng, Zhang Qianqian. A Comparative Study of Chinese and Foreign Research on the Internet of Things in Education: Bibliometric Analysis and Visualization[J]. *IEEE ACCESS*, 2021, 9.
11. Muaz A.Niazi. Review of “CiteSpace: A Practical Guide for Mapping Scientific Literature” by Chaomei Chen [J]. *Complex Adaptive Systems Modeling*, 2016, 4(1).
12. Chang Liang, Watanabe Teiji, Xu Hanlin, et al. Knowledge Mapping on Nepal’s Protected Areas Using CiteSpace and VOSviewer [J]. *Land*, 2022, 11(7).
13. Wang Feiran, Tan Bo, Chen Yue, et al. A visual knowledge map analysis of mine fire research based on CiteSpace.[J]. *Environmental science and pollution research international science*, 2022, 29(51–122).
14. Zhuoqun Qing. Knowledge Map of Urban Climate Map: A Bibliometric Analysis Based on CiteSpace [J]. *Journal of Humanities and Social Sciences Studies*, 2022, 4(1).

**Open Access** This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

