Visualization Analysis of Chinese Learning Space Evaluation Research Base on Citespace

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Abstract:
At present, domestic research on learning space is in a period of vigorous development. This research uses the visualization software CiteSpace and the Python programming tool are used to collect the literature data on the topic of learning space through CNKI database. Based on these, the research conducts data analysis on the screened 1351 literature data in the ten years from 2011 to 2021, digging out the information of authors, research institutions, research keywords and highlight words in the field of learning space research. As the result, it is found that current trending keywords of learning space research include smart education, classroom, libraries, learning space, deep learning, machine learning, Artificial intelligence, flipped classroom, etc. Main research topic include future classrooms, libraries, model of instruction, artificial intelligence, deep learning, and educational reform.

Keywords: *learning space; co-word analysis; CiteSpace; visualization.*

1 INTRODUCTION

In the time of the ever-increasing development of the Internet and Artificial intelligence, the boundaries between jobs in the future are becoming increasingly blurred. The frequency of changes in working content is accelerating, and the rapid development of technology makes the requirements for future jobs more flexible and changeable. In 2016, the "STEM 2026: A Vision for Innovation in STEM Education" published by the U.S. Department of Education believes that one of the keys to maintaining competitiveness in the complex world of the 21st century is the students' ability to solve complex problems, which is based on the ability to communicate and cooperate, innovate and make critical thinking, and the ability to gather and evaluate information. The development of these competencies requires "flexible and inclusive learning spaces supported by innovative technologies" [1].

As learning theories and information technology evolve, learning space has become an important trend in educational technology research and school practice in recent years[2]. The Horizon Report released in 2016 believes that the current school learning space is still designed with teachers as the center. With new technologies coming up, the reconstruction of learning space needs to support learning-centered teaching. It works best when students learn independently and collaboratively. The 2018 Horizon Report believes that the remodeling of learning space needs to integrate technology organically, redesign the real learning environment, add more display screens, provide virtual environments and 3D holographic content, etc. [3].

2 DATA SOURCES AND RESEARCH METHODS

2.1 Data Sources

The data used in this research comes from CNKI (China National Knowledge Infrastructure) database. The retrieval scope is Chinese academic journals (online version), and advanced journal retrieval is used. The literature sources are CSSCI (Chinese Social Sciences Citation Index) and core journals, and the dates range is from January 1, 2011 to December 31, 2021. The subject heading is used to search, and is set to "learning space". A total of 1378 papers are retrieved, and 1351 papers were manually screened from other irrelevant content.

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2.2 Research methods

2.2.1 CiteSpace

CiteSpace is a knowledge graph informatization visualization software, which is based on theories such as scientific frontiers, structural holes, and information foraging. Through further analysis, the visibility graph by CiteSpace can give us information about a research field like the hotspots, evolution process, and development frontiers [4]. This research uses CiteSpace V5.8 to conduct information visualization analysis on crucial domestic learning space literature from 2011 to 2021. Through co-word analysis and cluster analysis, it generates a co-word analysis visibility graph, cluster topic distribution map, Burst detection, etc., which come together to reveal the knowledge base, research fields, research hotspots, and research frontiers of domestic learning space research.

In this study, 1351 pieces of literature related to learning space are exported in RefWorks format and saved as downlaod*.txt format. Next, the data format was converted into a CiteSpace-recognizable format using the built-in data conversion tool. A project file is created after the conversion and is stored in a specified location.

The key parameters settings of the keyword co-word analysis are configured as: “Years per Slice” selects 1, “Term Source” selects all options at the same time, “Nodetype” selects keywords, “Time slice” selects 2011-2021, select “TOP N” in the threshold assignment, set the value to 50, and keep the default visualization options. Then, run the CiteSpaceV5.8 program to get the keyword co-word analysis visibility graph. On this basis, the cluster analysis process is carried out, and the cluster diagram is obtained. Afterward, burst detection is performed to get the burst words between 2011 and 2021.

For the data on research teams and institutions, the research adjusts the configuration of CiteSpace, changes the “Nodetype” to Author and Institute, selects “Top N%” per slice for the threshold assignment, set the value to 50, selects 5 for Years per slice, and restarts the analysis to get the results.

2.2.2 Python

Python is a programming language invented by Dutch engineer Guido van Rossum in 1989. Python is an interpreted language, which is across-platform. Because of its rich third-party libraries, it is one of the most popular programming languages so far. Python is widely used in web crawler, data analysis, artificial intelligence, machine learning, web development, and many other fields. Jieba is a python third-party library, mainly used for word segmentation. It supports precise mode, full mode, and search engine mode, and has functions such as custom dictionary and keyword extraction.

3 RESEARCH RESULTS AND ANALYSIS

3.1 Literature Quantity Analysis

The analysis of literature's annual quantity can reveal the evolving trends of literature on this topic. The research finds that the number of papers related to learning space has shown a rapid upward trend since 2011, as shown in Figure 1. In 2011, there were only 67 articles, while there are 191 articles by 2021.

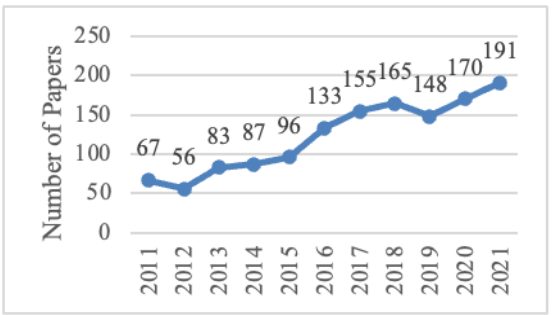

Figure 1: Annual Quantity Statistics of Literature (2011-2021)

3.2 Primary Researchers and Journals Sources

The primary researchers' sources analysis can reveal the subject area and research maturity degree of such research. The co-occurrence map of researchers and research institutions is shown in Table 1. It can be seen from the table that the main researchers and institutions of learning space are: Shen Shusheng of Nanjing Normal University, Zhu Zhiting of East China Normal University, Huang Ronghuai of Beijing Normal University, Wu Di of Central China Normal University, Xu Yafeng of the School of Education, Xizang Minzu University, etc.

Table 1: Core author from 2011-2021

Author	Publishing Quantity	Academic Institution of the Authors
Shen Shusheng	17	College of Educational Science, Nanjing Normal University
Xu Yafeng	12	School of Education, Xizang Minzu University
Zhu Zhiting	10	Department of Education Information Technology, East China Normal University
Wu Di	7	Education Informatization Innovation Center, Central China Normal University
Huang Ronghuai	7	Faculty of Education, Beijing Normal University
Wu Nanzhong	6	Big Data Application Research Institute, Chongqing Radio&TV University
Zhang Jinliang	6	School of Educational Technology, Northwest Normal University
He Xiangchun	6	School of Educational Technology, Northwest Normal University
Guo Shaoqing	6	School of Educational Technology, Northwest Normal University
Zhong Shaochun	6	Engineering & Research Center of E-learning, Ministry of Education of the People's Republic of China

Based on the core author group of learning space and according to the Price Equation:

$$m_p = 0.749\sqrt{n_{p\max}} \quad (1)$$

m_p is the threshold value for the publication quantities of the core authors group; $n_{p\max}$ is the publication quantities of the author who publishes the most research. The author is counted as one of the "core authors group" when researcher publications are bigger than m_p [5]. In this study, Shen Shusheng, from Nanjing Normal University, published the most research, with 17 papers. According to the empirical formula, N≈3 was obtained. After calculation, there were 44 authors who published more than 3 papers, and a total of 200 papers, accounting for 15% of all the related literature. According to Price's theory, if the core author group needs to publish more than 50% of all the literature, the core author group has been formed. Since the learning space is a new research field, although there have been important researchers in this field, but not yet formed a core author group.

3.3 Research Hotspots Analysis

The hotspots in the research field can be seen through keyword co-word analysis. The visual diagram of keyword co-word analysis is shown in Figure 2, in which the name of each node is a keyword. The larger the font size of the keyword, the higher the frequency, forming the research hotspots.

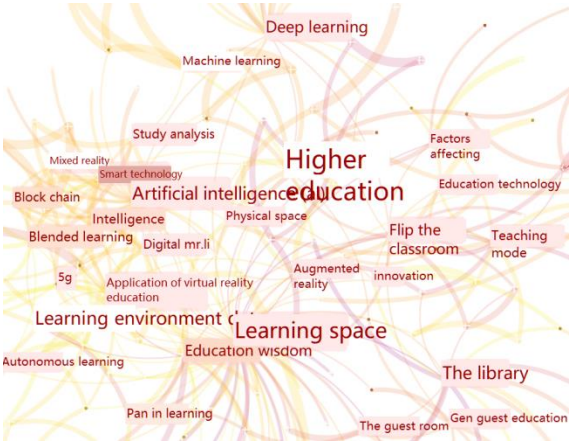

Figure 2. Keyword co-occurrence network analysis (2011-2021)

The betweeness centrality represents the connectivity ability of a keyword node. A higher betweenness centrality means that the node is connected to more fields, which is of great significance [6]. The frequency and betweenness centrality of the keywords in the field of learning space research are shown in the following table.

Table 2: Betweenness Centrality and Frequency of the core Keywords (2011-2021)

Keyword	Betweeness Centrality	Frequency
Learning Space	0.3	116
Learning and Memory	0.01	41
Deep Learning	0.11	33
Library	0.05	30
Artificial Intelligence	0.08	30
Smart Education	0.02	18
Flipped Classroom	0.06	17
Influencing Factors	0.04	16
Learning	0	15
Machine Learning	0.01	14
Learning Environment	0.02	14
Memory	0	13
Higher Education	0.03	12
Information Technology	0	12
Vocational Education	0.01	11

In addition to the keyword co-word analysis, the abstract is also the content summary of the literature, so the abstract collection of literature in this field is also an important reference for research hotspots. In this research, the Python and Jieba libraries are used to perform word segmentation and word frequency summary on the abstract parts of 1351 articles. After removing various modal particles and meaningless prepositions and other words in the literature, the abstracts of 1351 pieces of literature were analyzed to generate important research hotspots and word frequencies as shown in Table 3.

Table 3: core Keywords and Frequencies of Literature's Abstracts (2011-2021)

Keyword	Frequency
Learning	6419
Space	4651
Education	1890
Research	1547
Library	987
Technology	956
Teaching	947
Network	925
Develop	898
Model	852

The research word cloud map of the field of learning space, generated Using Python's wordcloud library, is shown in Figure 3.

Figure 3: WordCloud of Learning Space (2011-2021)

Based on the data above, it can be concluded that learning space is closely related to artificial intelligence, virtual reality, blending learning, etc., indicating that these keywords are the most important content of current learning space research. Besides, the model of instruction that maintains a certain distance from the learning space is connected through flipped classroom, maker education, learning analysis, etc., indicating that under the new learning space and new instructional form, the guidance and reform from the instructional model are needed. An important content of the learning space is the physical learning space. The current physical learning space mainly includes research on future classrooms and

libraries. In addition, machine learning and deep learning are on the edge of the co-word network. Although their central values are low, they represent important trends in the study of learning space.

3.4 Cluster Analysis

Clustering the keywords of the literature can automatically divide the keywords into multiple sets of keywords, and these sets often represent the topic of the research. The keyword data is clustered and processed in CiteSpace, and the generated cluster diagram is shown in Figure 4. In this study, the module value Q=0.706, and the Q value is an indicator to evaluate the clustering effect. The larger the Q value, the better the clustering effect, and the Q>0.3 indicates that the clustering structure is significant. Another indicator to evaluate the clustering effect is the average silhouette value(S). When S>0.7, it means that the clustering is efficient. In this study, S=0.9279. From the cluster map, the main research topics in the filed of learning space in China are future classrooms, libraries, higher education, vocational education, teaching models, artificial intelligence, deep learning, educational reform, etc.

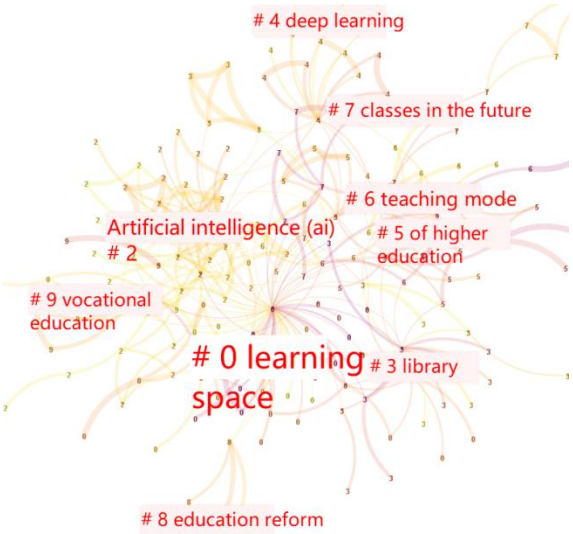

Figure 4: Keyword cluster co-occurrence analysis (2011-2021)

3.5 Research Trend Analysis

In CiteSpace, the Burst value means that a keyword has changed greatly in a period. From a long-term perspective, the research trends in this field can be obtained. In the field of learning space research, the Burst values of the corresponding keywords and the years are shown in Table 4.

Table 4: Keywords Burst Values and Corresponding Years (2011-2021)

Keywords	Strength	Begin	End	2011 - 2021
Learning Memory	6.84	2011	2015	
Renrentong	2.55	2013	2016	
Future Classroom	2.52	2013	2015	
Flipped Classroom	4.86	2014	2017	
Maker Space	3.47	2015	2018	
U-Learning	2.85	2015	2016	
Maker Education	3.98	2016	2017	
Higher Education	3.22	2016	2018	

Knowledge Sharing	2.98	2016	2017	
Artificial Intelligence	5.1	2017	2021	
Education Reform	2.89	2017	2018	
Information Technology	2.84	2018	2019	
Deep Learning	3.86	2019	2021	
5g	3.07	2019	2021	
Space Reconstruction	2.71	2019	2021	

Combining Figure 2 and Table 4, it can be found that the domestic research hotspot in 2011 was learning and memory; in 2013, after the "Three-way Project" proposed by the Department of Science and Technology, Ministry of Education of china, network learning space for everyone project and Future Classroom became the research hotspots of that year. In 2014, MOOC (Massive Open Online Courses) and SPOC (Small Private Online Courses) were popularizing in China, and flipped classrooms had become a major instruction mode that needs to be supported by learning spaces. Since 2015, national innovation and entrepreneurship activities have entered a climax, with maker spaces, maker education, and ubiquitous learning as the research hotspots. In 2017, with the gradual popularization of 5G technology and the application of artificial intelligence entering a mature stage, artificial intelligence and deep learning have become important topics in the field of learning space. Schools and institutions have begun a new round of space reconstruction. Empowered by artificial intelligence and 5G technology, a new round of reform has been launched in the field of education.

4.CONCLUSION

This paper uses CiteSpaceV5.8 to analyze the literature of learning space research in CNKI from 2011 to 2021, and obtains information such as authors, research institutions, research keywords, and knowledge maps of keywords in this field. At present, the research on learning space is in a stage of rapid development in China. In the past ten years, the number of papers has increased steadily. There are several core research teams and leaders in this field, but no core author group has been formed. The trending keywords of current learning space research include smart education, classroom, library, learning space, deep learning, machine learning, artificial intelligence, flipped classroom, etc. The main research themes include future classrooms, libraries, instruction modes, artificial intelligence, deep learning, and education reform. Deep learning, 5G technology, and space reconstruction are trending research fields in China in recent two years. What is the philosophical basis for the construction of learning spaces? What is the practical basis? What is it like to build a framework? How do people learn in a learning space? How does technology empower learning spaces? Only by constantly thinking and trying to solve these problems can the learning space continue to empower teaching and learning.

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