

Explorations and Analysis on Innovative Education's Hot Spots and Frontier Issues

--Bibliometric Analysis Based on the Literature in Chinese Social Science Citation Index Database from 2000 to 2020

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Abstract. After exploring innovative education research's current situation and frontier issues, the work utilized bibliometrics and scientific knowledge mapping methods to reveal research hotspots and development trends and study the literature published in the China Social Science Citation Index database from 2000 to 2020. The authors, research institutions, and keywords were analyzed by bibliometrics to draw the mapping knowledge domains. Results showed that there were only a few core authors in the innovative education field, with less papers published. Furthermore, a research institution group formed, including Nanjing Normal University, Zhejiang University, Huazhong University of science and technology, South China Normal University, and Beijing Normal University as the centers and other normal schools as the main bodies. In the past twenty years, innovation education research's hot spots in China mainly focused on innovation education ideas, innovation education mechanisms, innovation personnel training, teaching reforms, educates and other aspects. However, the frontier issue in the innovation education research in China refers to college and university students nowadays.

Keywords: Innovative education; Bibliometrics; Mapping knowledge domains.

1. Introduction

Serving as the source of human civilization, innovation is not only the driving force for human society's continuous development and progress, but also the impetus for the self-improvement of individuals.

From the etymology, "innovation" originates from the Latin "innovare", referring to human beings' activity providing unprecedented things. In 1912, Schumpeter, an Austrian economist, put forward the concept of "innovation" from the economics perspective. The innovation here refers to establishing a new function, which introduces new ideas and methods into economic life to realize a new combination of production factors. Today, with the rapid development of science and technology, innovation plays an essential role in promoting economic and social development.

Innovation is needed both in the economy and the education field. At the turn of the century, the Chinese Government's quality education is an education innovation focusing on cultivating students' innovative spirit and practical ability. Innovative education is a new education form to adapt to the future society.

The traditional and incompatible educational concepts, curriculum, system, and methods must be reformed to transform the innovative form for China's education [1]. Learning to Survive points out that "education has the dual power of cultivating creative spirit and suppressing creative spirit," [2] that is to say, education is a double-edged sword. A good education can cultivate the educatee with an innovative spirit. On the contrary, improper education reduces educatee's innovative spirit and suppresses the germination of their creativity.

Therefore, the education field's innovation is particularly significant and critical because it is related to individual development and ultimately affects society's progress. The current situation and future development trend's analysis and detection of innovative education will help us sort out the research ideas and improve the pertinence of the research.

2. Research objects and tools

Combined with Mapping Knowledge Domains analysis, the work mainly used bibliometric methods for bibliometric analysis and visual analysis on literature. CiteSpace software v5.6.R5 developed by Dr. Chen Chaomei was used for the literature's quantitative analysis and visual presentation. Simultaneously, the statistical analysis function of the CNKI database was used for statistical analysis on authors, institutions, and the number of papers.

Selecting the CSSCI database literature as the research sample, the work expected to explore the core authors, core institutions, research hotspots, and trends of innovation education research through analyzing published literatures. The retrieval period was set from 2000 to 2020, and 552 papers were on the list. After eliminating repetitive papers, solicitation notices, meeting notices, and other non-academic papers, 541 valid literatures met the standard (See Fig. 1).

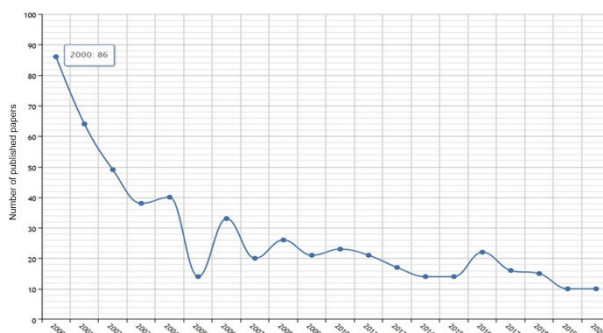


Fig. 1 Papers published in China Social Science Citation Index Database (2000-2020)

The number of papers had been declining year by year in the past twenty years. Eighty-six papers were published in 2000, the year with most papers in this work. This phenomenon was closely related to quality education policy proposed at the turn of the century with innovative spirit as the core. Since then, the number of papers had decreased year by year. By 2020, the number of papers was basically stable at about ten per year.

3. Data collection and processing

3.1 Research subjects

Research subjects generally include the authors and institutions. The core research subject refers to the research group with more published literature and high prestige, whose views can generally represent the frontier and development trend in the research field. The work explored the core authors and research institutions in the innovation education research field in China through quantitative analysis on the authors and institutions.

3.1.1 Analysis on authors

As the scientific research main body and the key factor affecting academic journals quality, an author's scientific research ability directly determines the quality and quantity of scientific research. The published papers' quantity reflects the author's scientific research achievements and ability to a certain extent. Through the authors' quantitative analysis, we can determine the core authors in the innovation education research field and the cooperation and communication among different authors. For the definition of core authors, many scholars have put forward different models, among which the formula proposed by Price is widely accepted. According to the calculation formula in Price's law

[3], there should be at least m papers published by the core author, and the calculation formula is $m = 0.749 * n_{\max}$ ($n_{\max}$ is the number of papers published by the most productive author in the statistical years).

Statistics on the number of papers published by the selected authors showed that among the 498 authors, Xiaoyong Hu and Xianjun Liu published the most, with three papers for each. Meanwhile, 24 authors have published two papers, and 472 have published one paper for each. From the above formula, $m \approx 1.30$, indicating that the journal's core authors are those who have published two or more papers. Table 1 shows 26 authors meeting the requirements and publishing 54 papers, accounting for 10% of the total literature. The maximum number of published papers is three, indicating that the core authors in innovative education research in China has not formed, with few influential experts and scholars.

Table 1. Number of papers published by core authors

Authors	Published papers' number	Authors	Published papers' number
Xiaoyong Hu	3	Jianhua Zhao	2
Xianjun Liu	3	Zaiming Yang	2
Mingrong Feng	2	Yuechen Dang	2
Zihua Li	2	Guanghua Peng	2
Bin Lin	2	Peigen Li	2
Huahua Cui	2	Huian Yin	2
Qinggen Hong	2	Shujun Liu	2
Xia Yang	2	Yanhong Fang	2
Guangming Zeng	2	Xueyong Gu	2
Ping Liu	2	Yunguo Liu	2
Xiaohui Pan	2	Biqing Liu	2
Yusheng Li	2	Jingbo Sun	2
Xingqi Liu	2	Yunxiang Zhang	2

The CiteSpace run in the work took the authors as the analysis objects, with the following settings: Time slicing was from 2000 to 2020, with years per slice of one year, the threshold of Top50, and the node label of By Citation. Finally, the obtained authors' co-citation network profiles in Fig. 2 had 499 nodes and 256 connections, with the density of 0.0021. The nodes represented the cited authors. The larger the nodes, the higher the authors' influence.



Fig. 2 Authors' co-citation network profiles (2000-2020)

3.1.2 Research institutions

Research institutions refer to the university's department or research center, but some secondary institutions of the authors' units are missing. Therefore, the work pre-processed the research

institution by removing the department or research center, and retaining the unit's first name. For example, Nanjing Normal University is merged with School of Educational Science and School of Educational Science of Nanjing Normal University into Nanjing Normal University.

Table 2 shows the statistical analysis' result of research institutions. The research focuses on normal colleges and universities. Six of the top ten are normal universities, which constitute the research subjects centered on Nanjing Normal University, Zhejiang University, Huazhong University of Science and Technology, South China Normal University and Beijing Normal University. Besides, Nanjing Normal University has published the largest amount of papers, with 17 papers. However, there is a large gap in the number of papers published by institutions. The published papers' number of top 20 accounts for only 22.92% of the total, with a poor core aggregation effect.

Table 2. Numbers of papers published by China Social Science Citation Index Database (2000-2020)

Serial number	Document-issuing institutions	Published papers' number	Proportion n
01	Nanjing Normal University	17	3.14%
02	Zhejiang University	13	2.40%
03	Huazhong University of Science and Technology	9	1.66%
04	South China Normal University	8	1.48%
05	Beijing Normal University	7	1.29%
06	Shaanxi Normal University	6	1.11%
07	Central China Normal University	6	1.11%
08	Tsinghua University	6	1.11%
09	Xi'an Jiaotong University	5	0.92%
10	East China Normal University	5	0.92%
11	Northwest University	5	0.92%
12	Peking University	5	0.92%
13	Southwest China Normal University	4	0.74%
14	Chongqing University	4	0.74%
15	Zhejiang University of Technology	4	0.74%
16	Yancheng Institute of Technology	4	0.74%
17	Harbin Institute of Technology	4	0.74%
18	China University of Mining and Technology	4	0.74%
19	Xidian university	4	0.74%
20	Shanxi University	4	0.74%
Total		124	22.92%

3.1.3 Fund situation

Fig. 3 shows the funding status of the literature fund, indicating the low proportion of the related research funding. There are six national educational science planning projects, three national social science foundations, two national natural science foundations, two Guangdong graduate education innovation funds, and two scientific research projects of Zhejiang Education Department.

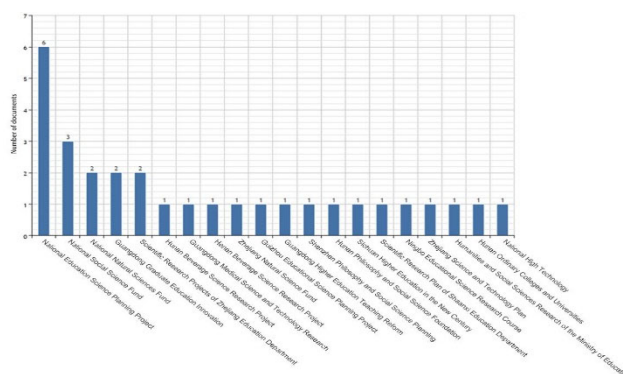


Fig. 3 Literatures' funding of China Social Science Citation Index Database (2000-2020)

3.2 Research hotspots

Research hotspots are scientific issues in many papers having internal connections within a certain period. Research hotspots in a certain field can be determined by Citespace's keyword frequency statistics [4]. Although there are only 3 to 5 keywords in a paper, they embody the paper's core, and summarize the theme[5]. The keyword frequency is directly proportional to its occurrence number in the literature and the subject attention. Meanwhile, as the keyword node's medium function in the entire graph, the strength of the keyword centrality is positively correlated with the node positions' number and the strength of the information flow between the controlled keywords. The better the centrality, the greater the influence of the topic. Quantitative analysis of high-frequency keywords can reveal the research status, hot issues, and development trend of a research field.

For running CiteSpace V 5.6.R5, the settings are as follows: Time slicing is from 2000 to 2020, with years per slice of one, the node type of keyword, the threshold of 9, and other default parameters. Finally, the generated keyword co-occurrence knowledge graph has 561 nodes and 944 connections, with the network density of 0.006.

The results show that the highest co-occurrence frequencies of keywords are innovative education, innovation, innovative talents, innovative ability, the new era of the knowledge economy, and innovative-talent cultivation. There are 351 times of innovative education, with the largest node (See Fig. 4), reflecting the focus of research concern. Meanwhile, the highest centralities include innovative education, innovation, the new era of the knowledge economy, innovative-talent cultivation, innovative education concept and talent cultivation. Keyword centrality is proportional to its importance in the network. The keywords with a centrality greater than 0.1 have an important influence in the field, indicating that innovative education and innovation have the greatest influence. Table 3 shows the specific results.

Table 3. Frequency and centrality of keywords

Serial number	Keywords	Word Frequency	Centrality	Year
1	Innovative education	351	0.73	2000
2	Innovation	34	0.12	2000
3	Innovative talents	20	0.04	2000
4	Innovation ability	19	0.03	2000
5	Knowledge economy era	16	0.06	2000
6	Cultivation of innovative talents	16	0.06	2000
7	Talent training	13	0.05	2000
8	Quality education	13	0.01	2000
9	Innovative consciousness	12	0.01	2000
10	Innovative talent	11	0.02	2001
11	Knowledge economy	10	0.01	2000
12	Innovative education concept	9	0.05	2003
13	Educatee	9	0.04	2000
14	Innovative education system	9	0.02	2001
15	Innovative training model	8	0.03	2000
16	Creative talent	8	0.02	2000
17	Educational reform	8	0.02	2005
18	Undergraduate	8	0.02	2006
19	Innovative thinking	8	0.02	2000
20	Enterprise education	7	0.03	2001

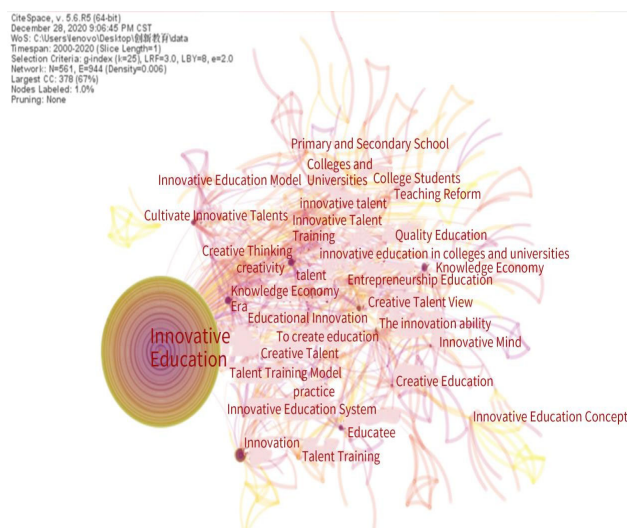


Fig. 4 Mapping knowledge domain of keyword co-occurrence

From bibliometrics, the clustering structure of the literature co-citation network can analyze the research hotspots and main directions of a specific research field [6]. The work used CiteSpace V5.6.R5 to perform cluster analysis on keywords, and formed 11 obvious clusters: #0 Innovative Education, #1 Knowledge Economy Era, #2 Innovative personality, #3 Innovation, #4 Primary and Secondary Schools, #5 Construction, #6 Innovative Education Concept, #7 Educatee, #8 Innovative Talent, #9 Talent Training, and #10 Teaching Reform, separately corresponding to related research hotspots.

CiteSpace provides the Modularity (Q value) and the Silhouette (S value) according to the clarity of the network structure and clustering contours to judge the clustering effect. $Q > 0.3$ indicates that the obtained network community structure is significant; $S > 0.7$ indicates that the clustering result is credible; $S > 0.5$ indicates that the clustering result is reasonable [7]. The effect indicators of this clustering are as follows: module value (Q)=0.742, and Silhouette value (S)=0.5792, indicating that the clustering result is reasonable (See Fig. 5).

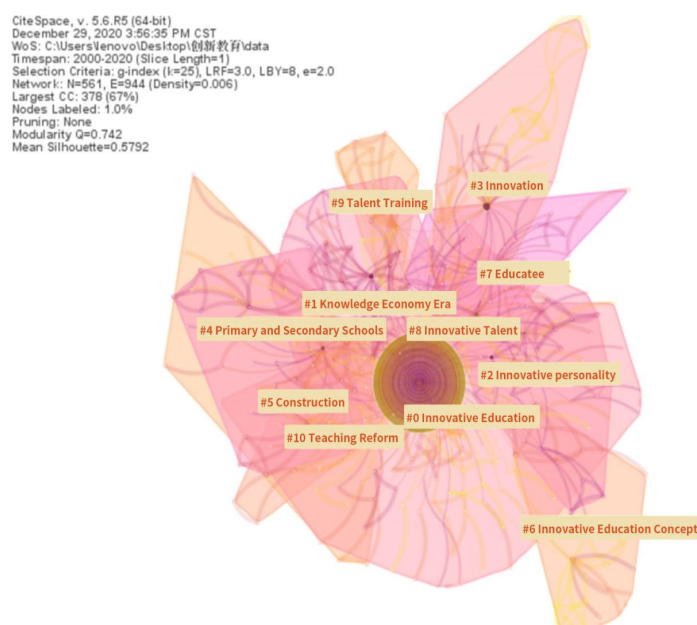


Fig. 5 Mapping knowledge domain of keyword clustering

#0 is innovative education. The cluster contains 84 keywords, the cores of which are "system," "optimization scheme" and "influencing factors". It puts forward an optimization scheme on the construction of the innovative education system and its influencing factors.

#1 is the era of knowledge economy. This cluster contains 47 keywords, the cores of which are "eight-step teaching method," "thoughts on teaching," "global warming" and "innovative concept". It focuses on the innovative education's development in the era of the knowledge economy.

#2 is innovative personality. The cluster contains 39 keywords, the cores of which are "innovative potential," "academic activities," "innovative ability" and "innovative education for young children". It focuses on the cultivation of innovative potential and ability, which promotes the personality development of educatee.

#3 is innovation. The cluster contains 37 keywords, the core of which are "quality," "practice," "learning" and "informal learning". It focuses on the content, approaches, and methods of innovative education.

#4 is elementary and middle school. This cluster contains 33 keywords, the core of which are "physical education reform," "cooperated system," "instructors and researchers" and "school-based". It focuses on the development of innovative education and school-based teaching and research at the primary and secondary levels.

#5 is construction. This cluster contains 26 keywords, the cores of which are "employability," "university education" and "function". It focuses on the function of university education and the cultivation of graduate employability.

#6 is an innovative education concept. The cluster contains 21 key words, the cores of which are "double first-rate," "physical teaching innovation," "contemporary universities" and "theory and practice research". It discusses the theory and practice of innovative education around the construction of double first-rate in colleges and universities.

#7 is the educatee. The cluster contains 17 key words, the cores of which are "belongingness," "creative talents," "creative activities" and "teacher view". It recommends teachers to establish scientific-educational concepts through creative activities, which can develop students' potential and education quality.

#8 is innovative talent. The cluster contains 17 keywords, the cores of which are "engineering university," "receptive teaching," "personality" and "learner-centered". It advocates abandoning traditional indoctrination teaching to carry out personalized teaching with learners as the center, and focuses on the teaching innovation of engineering universities.

#9 is talent training. The cluster contains 16 keywords, the cores of which are "new media environment," "promoting demonstration" and "feature specialty." It attaches importance to the innovative talent training model under the new media environment and promotes characteristic professions.

#10 is teaching reform. This cluster contains 15 keywords, the cores of which are "principles," "ideological and political theory," and "educational concepts." It focuses on the principles and concepts of innovative education reform.

In the keyword timeline map (See Fig. 6), keywords are spread out in chronological order, showing each hot topic research's venation. The density of keywords distribution represents the difference in the attention of different hot issues at different time. For example, the research on "innovative education" and "educatee" starts early, but the former lasts the longest with the highest hot spots; while the latter's attention declines rapidly, with little attention in 2008.

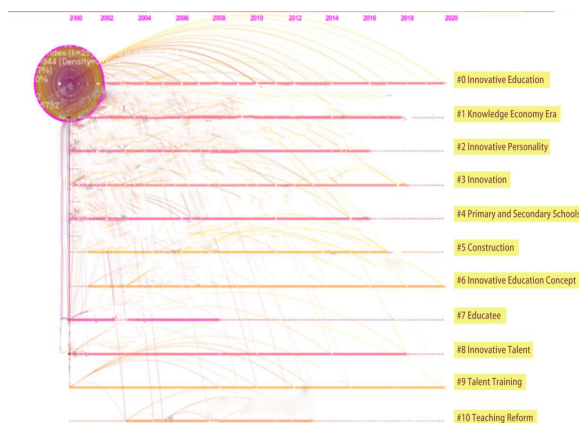


Fig. 6 Keyword co-occurrence timeline map

3.3 Research fronts

Research fronts are a set of emerging dynamic concepts and potential research questions. Emergent terms are more suitable for detecting emerging trends and sudden changes in subjects' development than high-frequency keywords[8]. Emergent terms are keywords that have been quoted more frequently in a certain period, which reflects the research trend of that period.

CiteSpace's keyword emergence function set the parameter to "Burstness" to get a keyword emergence map (See Fig. 7). Visualization analysis shows that keywords in the past 20 years are educatee, cultivating innovative talents, knowledge economy, quality education, knowledge economy era, university innovative education, university libraries, teaching reform, innovative talents, innovative ability and college students.

The research can be divided into three stages: The first stage is from 2001 to 2004. The keywords that emerged are educatee, cultivating innovative talents, knowledge economy, quality education, knowledge economy era, innovative university education, and university libraries. At this stage, higher education reform and the cultivation of innovative talents are studied around the knowledge economy and quality education. The emergence intensity of training innovative talents reaches 4.5744, ranking first among all emergent keywords, followed by the knowledge economy era, which proves the vigorous development of innovative educational research. Besides, the research literature also illustrates this phenomenon.

The second stage is from 2005 to 2012, and the keywords that emerged are teaching reform, innovative talents, and innovative ability. This stage is a smooth transition, and the teaching reform is studied around the cultivation of innovative ability and talents. The third stage is from 2012 to present, and the keyword that emerges is college students. The research topics at this stage are concentrated and in-depth, with a long duration, which is a period of in-depth exploration.

Top 11 Keywords with the Strongest Citation Bursts



Fig. 7 Keyword emergent knowledge map

4. Research conclusions and enlightenment

The work took the literature published in the Chinese Social Science Citation Index database from 2000 to 2020 as the research object for the bibliometric analysis of authors, research institutions, and keywords of the papers. Then, the mapping knowledge domain was drawn with the following conclusions and enlightenment.

4.1 From the perspective of research subjects

The authors and the issuing institutions' bibliometric analysis shows that the current core institutions of innovative education research are mainly normal universities and colleges. There are seven normal universities in the top 10, which constitute the research's main force. Nanjing Normal University has published the largest amount of papers (17). However, the centrality of these institutions is lower than 0.1 with little influence. Besides, the network density between institutions is only 0.001, indicating that the cooperation between institutions and different departments of the same institution is small, with the poor awareness of resource sharing and cooperation.

The core authors in innovative education research in China have not formed, with few influential experts and scholars. The most prolific two authors have published only three articles for each, showing a weak research power. Moreover, there is little cooperation between authors with single research scope.

Research institutions and researchers should strengthen cooperation and exchanges, resource sharing, and complementary advantages to improve innovative research quality.

4.2 From the perspective of research content

Since 2000, with the development of quality education, innovative education research has become a hot issue, but it has gradually cooled down. Researches mainly focus on the renewal of innovative education concepts, the construction of an innovative education program system, the innovation of a talent training model, and the cultivation of the educatee's innovative ability.

Xiaoli Gou, in response to the problems of entrepreneurship for the sake of entrepreneurship, low-end entrepreneurship, and low success rate in the innovation and entrepreneurship education for college students, suggested that colleges and universities should take advantage of technology and talents to cultivate future entrepreneurs with the innovative spirit [9]. Chenwei Zhu believed that the practice of innovative education concepts has built a balanced development of teachers and students, a continuous drive by internal and external mechanisms. Besides, a "two-wheel-drive" undergraduate tutorial system is established to highlight teacher-student interaction and improve innovative talent training [10]. Jinping Jia and others believed that carrying out innovative education for college students and strengthening the integration of science and education is conducive to the quality of higher education and the construction of China's higher education power [11].

4.3 From the perspective of research trends

The research of innovative education can be divided into three stages: vigorous development period, smooth transition period and in-depth exploration period. In the first period, the reform of colleges and universities and the cultivation of innovative talents are studied around the knowledge economy and quality education. The research on the latter is prominent with the rich research literature. In the second period, the innovation ability and the cultivation of innovative talents are studied around the teaching reform, focusing on innovative talents. The in-depth exploration period lasts from 2012 to now. The research in this stage focuses on college students, which lasts for a long time, and may continue into the future. It belongs to the forefront of innovative educational research.

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