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Literature Review on the Role of Generative Artificial Intelligence Technologies in Education

-- Knowledge Graph-based Visual Analytics

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Abstract

With the continuous development of information technology, artificial intelligence technology represented by generative artificial intelligence will have a far-reaching impact on the field of education. Generative artificial intelligence in classroom teaching has a greater application value for intelligent load reduction and efficiency, and intelligent learning assistance, intelligent return to the humanities, as an innovative technical means, on the one hand, it can provide more efficient and accurate support for education, on the other hand, its emergence has brought more possibilities for education, and provided new paths and solutions for the enhancement of the quality of education, educational efficiency, and educational equity. In this paper, we take "the role of generative artificial intelligence in education" as the theme, search the literature through "Web of Science", and use CiteSpace software to draw the relevant knowledge map: author, institution co-occurrence map, keyword co-occurrence, clustering, etc., so as to explore the development, hotspot, and trend of this research field. Finally, we give our suggestions based on the problems in the research, to provide a basis for the development of this field in the future.

Keywords

Generative artificial intelligence, ChatGPT, Higher education, CiteSpace.

1. Introduction

In the past two years, the application of generative artificial intelligence in education and teaching has become more and more widespread and has received the attention of a large number of scholars. The rapid development of generative AI not only leads to the explosive growth of AI technology, but also has a significant impact and influence on various fields of society, and education is no exception. [1]In November 2022, the US Open AI Research Center released the third generation of Chat Generative Pre-training Transformation Model opening a new historical period in which generative AI has shifted from research and development to commercial and civilian use. In the nearly one year since the release of ChatGPT, it has had a great impact on the education field. [2]2023 The Guide to the Application of Generative Artificial Intelligence in Education and Research, released in September 2023, summarises the basic controversies about generative AI, to reveal the impacts of the controversies on the educational applications of generative AI, to clarify the roles of generative AI technology in education, and to propose the governance countermeasures and practical application suggestions. [3] Therefore, to understand the research on the role of generative AI technology in education, this paper uses CiteSpace software to visualize and analyze the relevant literature in the "Web of Science" platform, to explore the current research status and hotspot issues in this research area, and to give corresponding suggestions, to grasp the possible future research.

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2. Research Tools and Data Sources

2.1. Research tools

The literature analysis tool used in this study is CiteSpace software which is based on the Java programming language environment to visualize and analyse the data. CiteSpace software presents the main data in the form of a knowledge graph, integrates information visualization methods, bibliometrics, and data mining algorithms, and by drawing visual graphs, and, establishes associations between nodes to analyze the co-occurrence relationship and co-citation relationship between related research objects, etc., to present the distribution, law and structural characteristics of a discipline or field. [4]

2.2. Data sources

The main purpose of this paper is to visually analyze the status and trend of the role of generative AI technology in education using knowledge mapping, therefore, on Web of Science, the topic "the role of generative AI technology in education" was searched, but the result was that there were no records related to it; so with the help of the With the help of advanced search, we input the topic "generative artificial intelligence" or "ChatGPT" and "education", and a total of 321 papers were retrieved; then we filtered the retrieved documents and removed 9 documents. Then, we filtered the retrieved documents removed 9 irrelevant documents, and finally obtained 312 documents. In the search results, it was found that the literature under this research field started to be published from 2023 onwards, because OpenAI, an AI research laboratory in the United States, released the generative interaction tool ChatGPT at the end of 2022, which triggered the attention of the majority of users, and therefore the graphs in this paper will mainly analyze the data after 2023. Finally, the 312 documents obtained from the search were exported in the format required by the CiteSpace software and then transcoded to prepare the data for the next step of processing and analysis.

3. Data Analysis

3.1. Research basics

To understand how institutions and authors collaborate in the retrieved literature related to the topic of this study, this paper maps the related knowledge map by using CiteSpace software. Firstly, the period is set to 2023-2024, the time slice is set to 1, and the node type is set to Institution. as shown in Figure 1. The nodes generated by the Education University of Hong Kong (EdUHK), the University of Queensland, and the University of Hong Kong generate larger nodes, indicating that for the topic of the role of generative AI technology in education, these three institutions have the highest number of publications. As can be seen from the figure, N=97, which indicates that a total of 97 institutions are involved in the analyzed literature; E=94, which indicates that 94 institutions are connected; and a density of 0.0202, which indicates that the collaboration between these institutions is relatively dispersed. It can therefore be shown that the linkages between the institutions are not strong enough and there is a lack of a certain sense of co-operation, which needs to be strengthened between the institutions.

Similarly, without changing the basic settings, the node type is set to Author to get the co-occurring knowledge graph about author cooperation, as shown in Figure 2. Where N=84, indicating that a total of 84 authors are involved in the analyzed literature, and E=73, indicating that 73 authors are connected; it can be seen from the figure that the density of this knowledge graph is 0.0209, which is still at a low level, even though some of the authors are connected in some way. Therefore, it indicates that there is a lack of cooperation and communication between researchers related to this research area, which may lead to many problems in academic research, and then cause the road of scientific research to come to a halt.

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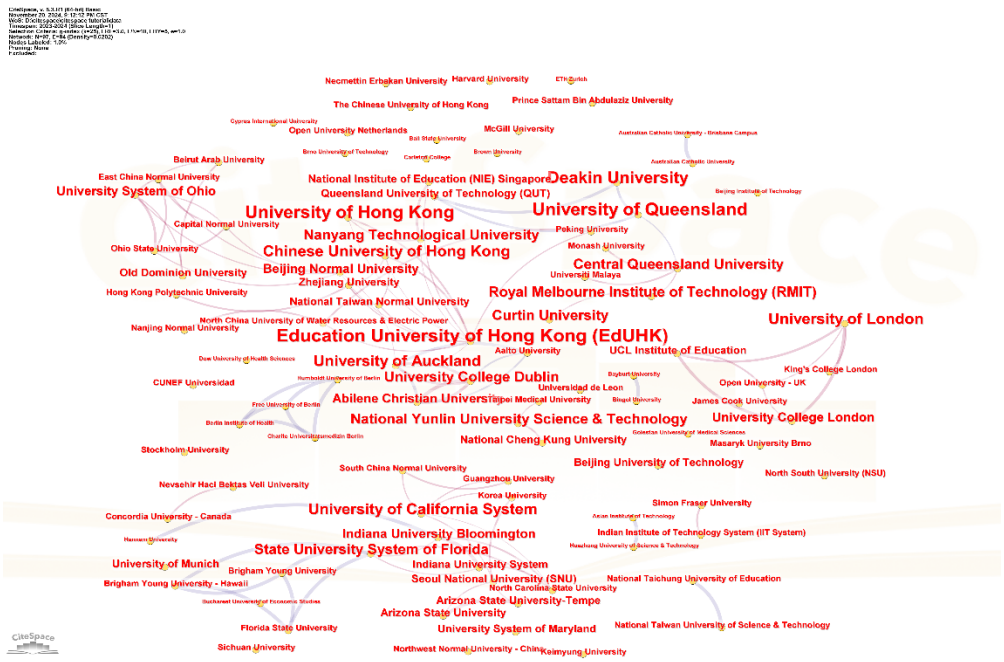

Figure 1. Institutional co-occurrence knowledge map

Figure 2. Author co-occurrence knowledge map

Table 1 combines institutions and authors and ranks them in descending order of the number of publications (only the first few entries in the table are intercepted). From the table, it can be seen that since the introduction of ChatGPT, the role of generative AI in education has recently received more and more attention from researchers. From the several institutions in the table, most of them belong to comprehensive colleges and education-related institutes, so it can be seen that the combination of education and generative AI is a hot research direction for most colleges and scholars at present.

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Table 1. Institutional & author publications

count	centrality	year	Author/institutions
9	0.10	2023	Education University of Hong Kong(EdUHK)
8	0.01	2023	University of Hong Kong
8	0.01	2023	University of Queensland
7	0.01	2023	Deakin University
6	0.00	2023	Chinese University of Hong Kong
6	0.07	2023	University of Auckland
6	0.00	2024	University of California System
6	0.00	2024	University of London
5	0.00	2023	Becker, Brett A
5	0.01	2023	Central Queensland University

3.2. Research hot topics

The research purpose of this paper is to analyze the hot issue of the role of generative artificial intelligence in education, so CiteSpace software is used to visualize and analyze the keywords. Keywords are highly condensed and summarised for the article's research object, research content, research methodology, and research conclusion, [5] and the analysis of keywords can explore the research direction and focus of this research topic, so the analysis of this part is very important. CiteSpace software is used to generate the keyword co-occurrence map, as shown in Figure 3. N=155, indicating that a total of 155 keywords are involved in the analysed literature; E=552, indicating that there is a connecting relationship between 552 keywords; the network density in the map is 0.0463, which is obviously a great improvement compared with the institutional co-occurrence and author co-occurrence map, but there is still a lot of room for improvement. This requires the researchers concerned to grasp the cutting-edge hotspots in the process of research, precisely select the topic, and then carry out in-depth research, while not stopping at the point and grasping the depth of the research.

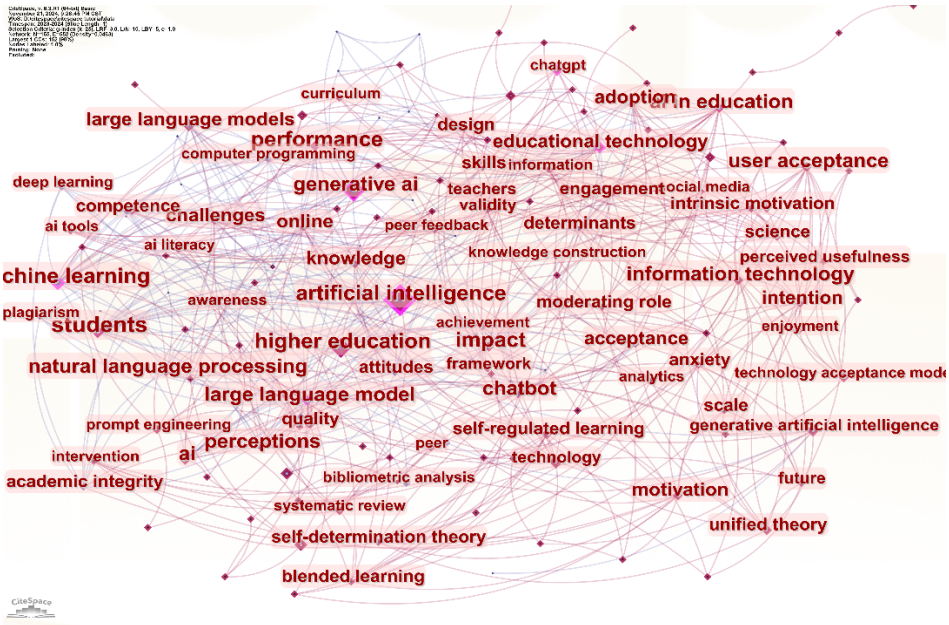

Figure 3. Keyword co-occurrence mapping

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Combined with the relevant data of keyword co-occurrence mapping, the top six keywords with the highest frequency of occurrence are collated and plotted, as shown in Table 2. Combined with Figure 3, it can be seen that the keyword "artificial intelligence" has the highest frequency and the largest node, and the centrality of the node around "artificial intelligence" is 0.23, indicating that compared with other keywords, "artificial intelligence" has the highest frequency and the largest node. The next most frequent keywords are "generative ai" and "higher education".

Table 2. Keyword co-occurrence

count	centrality	year	keywords
109	0.23	2023	artificial intelligence
58	0.17	2023	generative ai
53	0.13	2023	higher education
29	0.07	2023	large language models
22	0.06	2023	generative artificial intelligence
20	0.16	2023	students
15	0.00	2023	education
11	0.02	2024	medical education
11	0.13	2023	performance
11	0.04	2024	technology

From the above chart, it can be seen that the several keywords with the highest frequency are in line with the theme and direction of this study, but the connection between the keywords is not close enough to facilitate the depth of the study. Keywords are selected from the titles, abstracts, and texts of the literature, and they are words of substantial significance for expressing the central content of the articles. Keyword cluster analysis takes the frequency of their appearance in different articles as the object of analysis, using the statistical method of clustering, the keywords that are closely linked together to form a class group. Cluster analysis reflects the affinity relationship between these high-frequency keywords, and the results can roughly reveal the research hotspots of the flipped classroom, [6] so the cluster mapping analysis is carried out by using CiteSpace software. Set the nodes as keywords, the algorithm type selects LLR, and finally, the keyword clustering map is generated, as shown in Figure 4. Among them, the module value Q=0.5242>0.3, which indicates that the clustering graph delineates a significant graph structure; the average contour value S=0.8076>0.5, which indicates that the clustering in this graph is reasonable. From the graph, it can be seen that the keywords are mainly divided into eight modules according to regional colors: moderating role, generative artificial intelligence, intervention, writing practicum, generative ai-assisted academic writing, project performance, and ai-driven curriculum adaptation pattern.

Based on of the keyword clustering map, click "Cluster Explorer" to obtain the log-likelihood ratio, to generate the keyword clustering table shown in Table 3, which is a kind of clustering tag word extraction algorithm. [7] In the table, only the first eight clustering modules are selected, and only the first five tag words in each module are listed.

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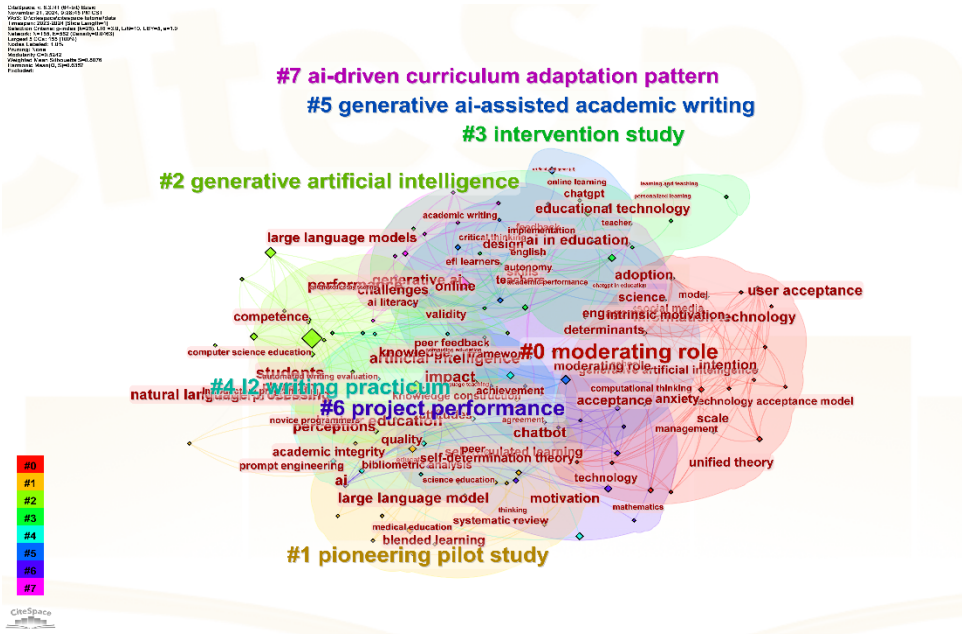

Figure 4. Keyword clustering mapping

Table 3. Keyword clustering

cluster	size	top terms
0	24	moderating role; design professional; job replacement; ChatGpt adoption; education student
1	21	self-regulated learning; generative artificial intelligence; science education; pioneering pilot study; empowering student
2	20	artificial intelligence; large language model; cross-disciplinary framework; research agenda; using natural language processing
3	19	critical thinking; intervention study; efl learner; English literature classes; era agency
4	18	exploratory investigation; l2 writing practicum; feedback source; essay writing; teacher feedback
5	18	algorithmic subjugation; poietic symbiosis; marketing communications education; generative artificial intelligence; research supervision
6	16	generative artificial intelligence; language education; human-chatbot comparison research; systematic review; college student
7	16	artificial intelligence; reshaping curriculum adaptation; mapping teacher; ai-driven curriculum adaptation pattern; solving authentic assessment

Analyzed in conjunction with Figure 4 and Table 3, several hot issues on the current role of generative AI in education can be summarised.

Firstly, generative AI contributes to the change in higher education and the cultivation of innovative talents. Generative AI technology has a certain role in promoting innovative development and change in higher education, and it will also have a positive impact on the cultivation of higher education talents. This shows that on the one hand, schools should pay attention to the individual needs of students, the premise is to focus on the efficient management of educational resources, the advantages of generative artificial intelligence technology lie in the generation of content and dialogue aspects, which will bring a certain impact and influence on higher education, and colleges and universities can efficiently access

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and manage educational resources through the intelligent support of generative artificial intelligence technology, and make a more reasonable and fair distribution of educational resources. Better support the educational teaching work of the school; at the same time, generative AI technology can recommend the educational resources that students need to learn according to their needs and preferences, and customize personalized learning programs; on the other hand, the introduction of generative AI technology into the daily teaching of colleges and universities can trigger a change in the innovative talent cultivation system, change the teaching mode and method, subvert the traditional teacher-centered classroom, and bring convenience to teachers" teaching and students" learning.

Secondly, generative AI changes students' view of knowledge. Generative AI can accelerate the process of knowledge transfer, allow students to understand and apply knowledge through exploration and practice, and change the existing evaluation system, not only for the evaluation of knowledge itself but more importantly, the comprehensive evaluation of "knowledge + literacy". ChatGPT can quickly generate learning materials to help students review and learn the course content, and better acquire knowledge.

Third, generative AI empowers teachers' professional development. The integration of artificial intelligence and other new technologies with teacher team building can boost the pilot work of teacher team building, and the emergence of generative AI brings new opportunities for teachers, on the one hand, promotes the innovation of teachers'" professional concepts, change teachers" view of education and teaching, and make teachers pay attention to the cultivation of innovative talents, and at the same time, generative AI can assist teachers with lesson planning and teaching, so that teachers can pay more attention to students and give corresponding support, while generative AI can assist teachers with lesson planning and teaching so that teachers can pay more attention to students and give corresponding support. Teachers can pay more attention to their students and give them appropriate support, instead of just staying on the surface of the teaching materials. Teachers can also complete self-learning and reflection through generative AI, and better practice the educational concept of human-machine collaboration in educating people; on the other hand, it promotes the growth of teachers' professional knowledge and the enhancement of their professional ability. A large amount of information and knowledge stored in the generative AI corpus can provide teachers with a wealth of professional knowledge and resources, which also includes excellent dialogue context comprehension and the vast amount of theoretical knowledge and teachers'" teaching experience stored in the corpus create more possibilities for teachers" professional competence and professional knowledge enhancement.

Fourth, generative AI poses risks and challenges to the educational ecology. Some scholars have pointed out that there are some risk issues for the use of generative AI in education. Alshater believes that ChatGPT has some limitations, including dependence on the quality of data, limited knowledge domain, ethical issues, and over-reliance on technology with the possibility of misuse. [8] Overall, although generative AI has many roles in education, there are also some risks and challenges, the first is academic integrity, students cheat and plagiarise through generative AI software, which makes education lose its fairness, and teachers are unable to accurately judge and know the real learning situation of the students; the second is that the students are overly addicted to and dependent on generative AI products, which reduces students' creativity and Secondly, students are overly addicted to and dependent on generative AI products, which reduces their creativity and discernment, in which the status of teachers will be weakened to a certain extent; thirdly, the accuracy of information cannot be guaranteed, as the related products have limited knowledge of the world, and the accuracy and safety of the answers cannot be guaranteed; and lastly, there is the problem of ethical awareness, as the generative AI products do not have the ability to think, and the resources and answers provided

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by them may be biased, and it is not known if the data that the students have stored in them will be leaked or not is also unknown.

4. Research Trends

Burstness refers to a sudden surge in the value of a keyword to become a hotspot in a short period. [9] To understand the research trend of this research topic, CiteSpace software is used, and the parameter "Burstness" is set to obtain the keyword emergence map, as shown in Figure 5.

Top 15 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2023 - 2024
large language model	2023	1.23	**2023**	2024	
machine learning	2023	1.23	**2023**	2024	
attitudes	2023	1.05	**2023**	2024	
computer programming	2023	1.04	**2023**	2024	
digital technologies	2023	1.04	**2023**	2024	
competence	2023	1.04	**2023**	2024	
deep learning	2023	1.04	**2023**	2024	
human-computer interaction	2023	1.04	**2023**	2024	
research supervision	2023	1.04	**2023**	2024	
academic integrity	2023	0.7	**2023**	2024	
design	2023	0.7	**2023**	2024	
determinants	2023	0.7	**2023**	2024	
computer science education	2023	0.7	**2023**	2024	
plagiarism	2023	0.7	**2023**	2024	
knowledge	2023	0.53	**2023**	2024	

Figure 5. Keyword surfacing chart

The figure plots the top 15 keywords with high emergence intensity. Among them, the keyword with the highest emergence intensity is "large language model", and the emergence time is from 2023 to 2024; it means that "large language model" is a core research question of this research topic during that period. This indicates that the "large language model" was one of the core research questions in this research topic during that period. In addition, "machine learning", "attitudes", "computer programming", and "digital technologies" are all highlighted, "digital technologies", although not as strong, have been widely used since the introduction of ChatGpt and continue to be used today, suggesting that issues centered on these keywords may become a future research trend.

5. Conclusions and Recommendations

The official release of the generative artificial intelligence system ChatGPT, has triggered widespread attention in industry and academia, and its excellent performance in text-based content generation, contextual understanding, etc., has also had a great impact on the education field and a profound revelation, which promotes and catalyzes the deep-rooted changes from the conception of education to the practice of education. By visualizing and analyzing the retrieved literature in CiteSpace software, it is found that since the release of ChatGPT, the amount of literature published has gradually shown an upward trend. Meanwhile, according to the keyword clustering mapping and clustering table, five hot issues in this research field are summarised: firstly, generative AI contributes to the change of higher education and the

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cultivation of innovative talents; secondly, generative AI changes the students' view of knowledge; thirdly, generative AI empowers the professional development of teachers; and fourthly, generative AI poses risks and challenges to the education ecology. However, there are some problems in the research, the lack of communication and cooperation between authors and institutions involved in the literature is not conducive to the depth of the research, and most of them are predominantly educational institutions, which lack certain technical guidance. Therefore, the following suggestions are made about the problems that have arisen.

First, strengthen the communication and cooperation between authors and institutions to promote the in-depth development of research. In the study, scholars and research institutions should strengthen the cooperation and exchange between them, determine the research theme in the continuous discussion and exchange, and accurately locate the research direction, based on which the research background is deeply analyzed and the depth of the study is broadened, at the same time, cooperation can be reached between the members of the group of each institution, regular sharing and discussion, and sharing of high-quality resources.

Second, expanding the diversity of research institution types to promote the development of technology-guided education. For the teacher training category, research institutions provide more ideas on the integration of education and technology, and how to use the advantages of generative AI technology in education and teaching to promote the innovative development of schools. At the same time, it is also necessary to expand other categories of research institutions to provide certain technical support, so that in the process of promoting the development of generative artificial intelligence, it can better help educational change, and at the same time for the emergence of problems promptly using advanced technology to improve.

Third, the rational use of generative artificial intelligence products strengthens the awareness of risk. While generative AI brings us educational innovation, it also induces risk problems in education to a certain extent, which we must consider carefully, and in the process of technological development, many developers ignore the ethical and moral issues in generative AI. We should plan and use these products reasonably, promote the synergistic development of AI and human beings, take the initiative to move towards the era of human-machine co-education and create a new form of human civilization. In conclusion, generative AI brings many opportunities and challenges to education. As future researchers, we should correctly view its role in education and promote new developments in teaching reform.

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