

Post-COVID Era the Trend of Digital Transformation of Education in China

-- Bibliometric Analysis Based on CiteSpace

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Abstract

With the application and development of educational informatization and digital technology, the importance of "educational digital transformation" in educational innovation and reform has become increasingly prominent, and educational digital transformation has become a hot spot of current educational reform and innovation. COVID-19 pandemic has accelerated the process of digital transformation of education in China, which is a rare opportunity for development. However, the digital transformation of education in China is in the initial stage, and the connotation and development trend of the transformation are not clear enough, so it is difficult to grasp the practical logic and direction scale. Therefore, this paper uses CiteSpace software to conduct bibliometric analysis, draws knowledge maps from the perspectives of authors, institutions and keywords, and discusses the development and hot spots of education digitalization in China, followed by the Horizon Report (Teaching and Learning Edition) in the past three years. This paper analyzes the trend of education digitalization transformation: post-COVID era, China's education digitalization transformation pays more attention to the innovation and reform of epidemic situation, digital technology on teaching paradigm, teaching organization structure, teaching mode, teaching process and evaluation methods.

Keywords

Digital transformation of education; Horizon Report; CiteSpace; Epidemic situation; Teaching Trend.

1. Introduction

In the context of the global epidemic, it is difficult for human society to recover to the state before the epidemic. Faced with the epidemic, many schools are facing problems such as the reduction of school-running funds, the reform of teaching organization and the complexity of teaching management, which has prompted some schools to think about and accelerate the digital transformation of education.

Digital transformation has been mentioned in recent years, and the definition of "digital transformation" given by the American Association for Higher Education Informatization is: the process of optimizing and transforming the operation, strategic direction and value proposition of an organization through deep and coordinated transformation of culture, labor force and technology[1]. In the field of education, the broad meaning of "educational digitalization" refers to the complex of educational transformation in which the educational system and digital technology are deeply integrated. In a narrow sense, it refers to the introduction of technology into educational organizations, as well as the innovation and change of products, processes or models based on these technologies[2]. In this paper, this meaning belongs to the narrow level.

The development of education digitalization is based on intelligent technology, which is used to promote the reform of education system. However, according to Moore's Law, the exponential rate of change in digital technology has outpaced the ability of society, politics, and many economic institutions to adapt[3]. In this regard, the "digital transformation of education" began to be mentioned, this study quotes Professor Zhu Zhiting's definition, "digital transformation of education" refers to the integration of digital technology into all levels of the field of education, promoting the transformation of educational organizations into teaching paradigms, organizational structure, teaching process, evaluation methods and other all-round innovation and change, from supply-driven to demand-driven. To realize the quality and fairness of education and support lifelong learning, so as to form a good educational ecology with openness, adaptability, flexibility and sustainability[2].

The digital transformation of education in China is in the early stage, with both opportunities and challenges. In this regard, this paper uses CiteSpace visualization tool to analyze the literature of CNKI database, summarizes the authors, institutions and keywords in the field of education digitalization, and analyzes the development opportunities and challenges of education digitalization transformation trend and transformation, which has important reference value for post-COVID era and China's education digitalization transformation.

2. Data Sources and Research Tools

1.1. Data sources

All data in this paper are from CNKI. Advanced search on the Internet: theme "digitalization of education", full-text "transformation", search academic journals SCI, CSSCI, Peking University Core and other journal literature from 2002 to 2022, a total of 442 articles were retrieved, and 253 articles with high relevance were selected (retrieval on June 27, 2022).

1.2. Research tools


CiteSpace is a bibliometric analysis software, which is mainly used to analyze the trend of a research direction. CiteSpace uses the basic principles of information visualization method, bibliometrics and data mining algorithm integration to draw a visual map and establish the association between nodes to analyze the co-occurrence and co-citation relationships between research objects[4]. This paper uses CiteSpace visual analysis tool to analyze the development trend of education digital transformation driven by data intelligence, which has certain credibility.

3. Analysis of Data Results

1.3. Statistical analysis of basic information

1.3.1. Distribution of the number of published articles and the period

As shown in Figure 1, limited by the metrology visualization analysis of CNKI, 200 documents were analyzed, and the data statistics showed that the total number of references was 1194; The total number of citations is 2671; Total number of downloads 175941; The average reference number is 5.97; The average number of citations is 13.36. From the above statistical results, the sample data of this study has a high credibility in this field.

 Data source: 200 selected documents (exceeded the upper limit of the number of analysis, only the first 200 were analyzed)

Analysis of indicators

Number of literature	Total number of references	Total citations	Total number of downloads	Number of references per article	Number of citations per article	Average number of downloads	Download Citation Ratio
200	1194	2671	175941	5.97	13.36	879.7	0.02

Figure 1. Indicator Analysis

Figure 2 shows the distribution of the number of articles published in CNKI over time in China's education digitization. It can be seen from the figure that the number of articles published from 2002 to 2009 is 5 or less, indicating that the development of education digitalization is in a quiet period during this period. In 2012, 12 articles were published in this field, causing a small peak. From 2014 to 2018, more than 10 articles were published for five consecutive years, indicating that the development of this field has reached a climax. Although there are only 4 articles in 2019, more than 20 articles have been produced from 2020 to this year, which shows that the development of digital education is one of the current hot spots.

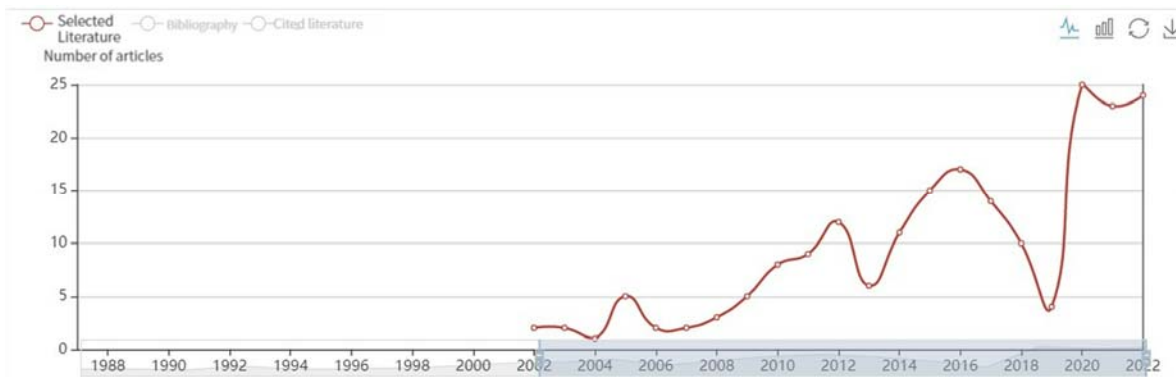


Figure 2. The change of the number of articles sent over time

From the above data, we can see that the development and transformation of education digitalization has attracted wide attention and attention in China. Internationally, the United Nations Educational, Scientific and Cultural Organization (UNESCO) released the "Digital Transformation of Education: School Connectivity, Student Empowerment" last year, which clearly put digital connectivity in an important strategic position for development. In the same year, the European Union issued the Digital Education Action Plan (2021-2027), which regards the two major trends of digital education ecosystem and digital transformation as the strategic direction of future education development[5]. This shows that education digitalization is a hot spot in current education, and the transformation of education digitalization has become an important way of innovation and transformation of education digitalization.

1.3.2. Core Study Author and Institutional Analysis

Mechanism visualization analysis. The time span is set as 2002-2022, the slice is 1, the node is set as institution, and other parameters remain unchanged. The result data statistics: the knowledge map with 215 nodes, 0 connections and 0 density (Figure 3). From the analysis of the map, it is concluded that the nodes of the School of Open Education, the Department of Educational Information Technology of East China Normal University and the School of Education of South China Normal University are larger. The analysis shows that these two universities have a large number of papers and strong academic and scientific research strength in the research of the development of educational digitalization in China. It can also be seen from the figure that there is no number of connections between nodes, and the number of connections represents the connection between nodes, from which it can be seen that the connection between institutions is not close enough and lacks a sense of cooperation.



Figure 3. Knowledge Map of Institution Co-occurrence

Author visualization analysis. The node selects the author, other parameters remain unchanged, and the author co-occurrence knowledge map with 344 nodes, 260 connections and 0.0044 density is obtained (Figure 4). The analysis shows that Professor Zhu Zhiting has the largest number of nodes, followed by Cheng Jingjing, Huang Jingjing, Hu Jiao, Wu Yonghe and Wang Yunwu. In the atlas, we can see that scholars cooperate with each other, among which the network structure headed by Zhu Zhiting, Wu Yonghe and Cheng Jingjing is more prominent. The analysis also shows that Zhu Zhiting, Hu Jiao and Wu Yonghe have more academic exchanges and cooperation, but other scholars such as Cheng Jingjing, Huang Jingjing and Wang Yunwu, who have published more papers, have less cooperation. At the same time, there are many scholars with separate nodes, represented by Song Qihui, Bai Che Ming Dynasty and Zhang Jianping. To sum up, there are few cooperation and exchanges in educational digitalization research in China, and they are mainly cooperation with institutions. It is necessary to strengthen academic exchanges and jointly promote the development of educational digitalization in various regions.

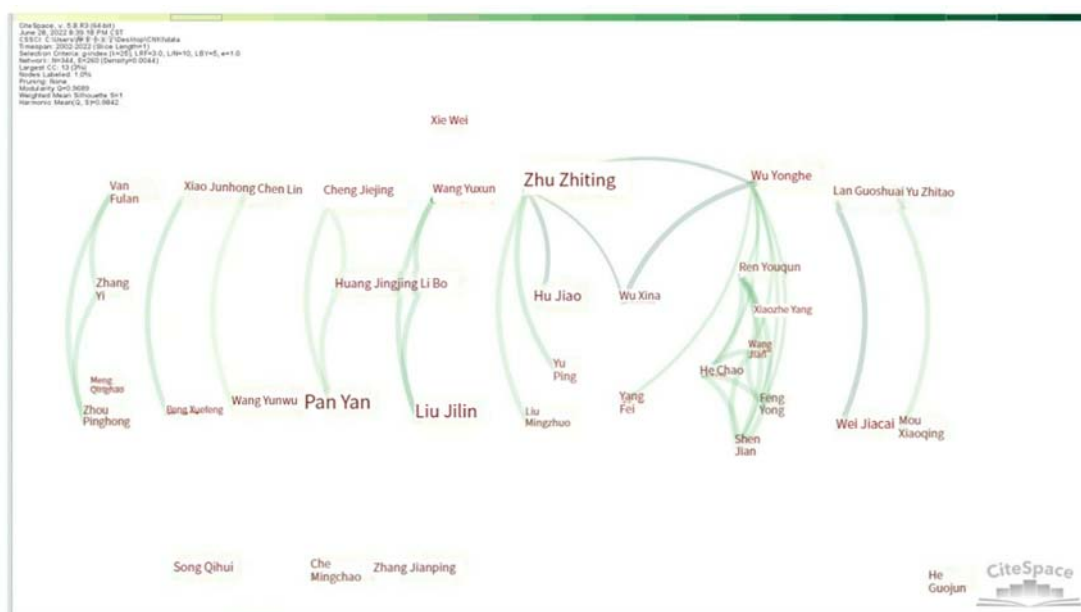


Figure 4. Map of Author Co-occurrence Knowledge Network

1.4. Key words clustering and main points

1.4.1. Keyword clustering

Keywords are the condensation of the central idea of the literature, and the frequency of keywords can accurately reflect the research hotspots in this field[6]. Keyword clustering analysis is based on keyword co-occurrence analysis, which simplifies the keyword co-occurrence network relationship into a relatively small number of clusters by clustering statistics[7].

Run CiteSpace, set the slicing time from 2002 to 2022, and other parameters are the same. Click Keywords and run to get the keyword knowledge network map (Figure 5). The figure presents 10 clusters of "digitalization", "vocational education", "community education", "education occupation", higher education, educational resources, resource sharing, educational reform, informatization and open university, from which the research hotspots of the development of digitalization of education in China are obtained. The key words in each cluster are analyzed, and the research on the development of educational digitalization is summarized into three thematic areas: "educational reform", "educational resources" and "digital transformation".

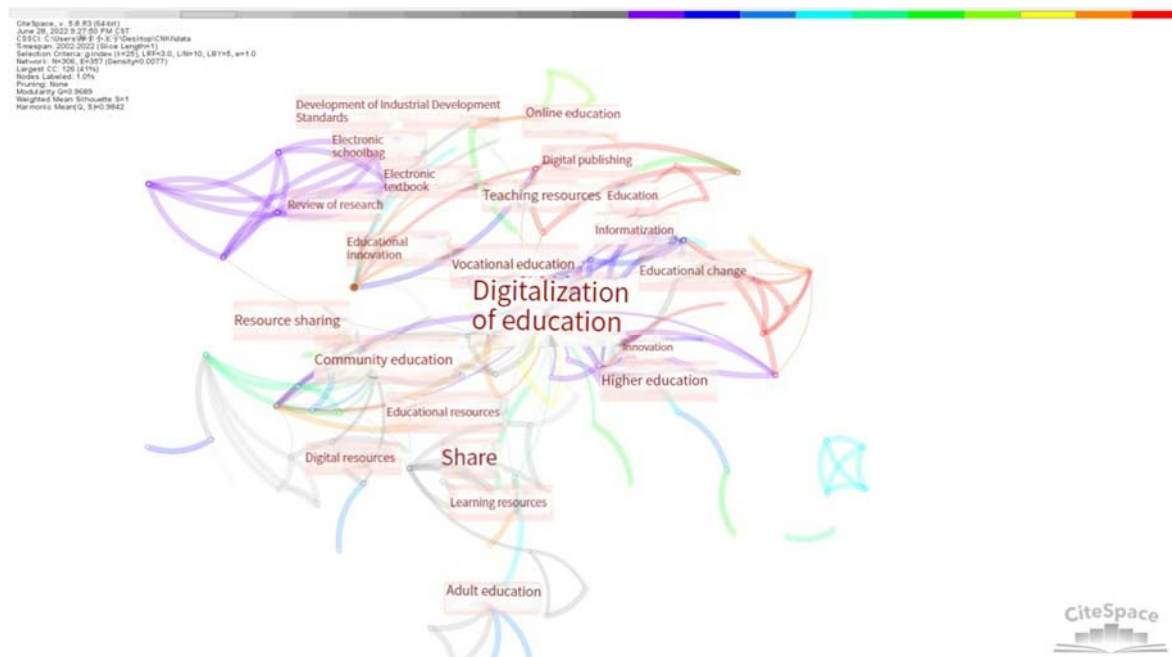


Figure 5. Keyword clustering network map

1.4.2. Analysis of research hotspots and themes

The keywords are further analyzed based on the above analysis results, and 12 core burst words are obtained (fig. 6). The process of digital development of education can be divided into three stages (corresponding to the above three themes).

Perform TimeView function analysis on keywords. Through the visual analysis of the evolution path of education digitalization, the changes of research topics in the field of education digitalization are obtained, and the results are shown in Figure 7.

Top 12 Keywords with the Strongest Citation Bursts



Figure 6. Keyword Emergence Map

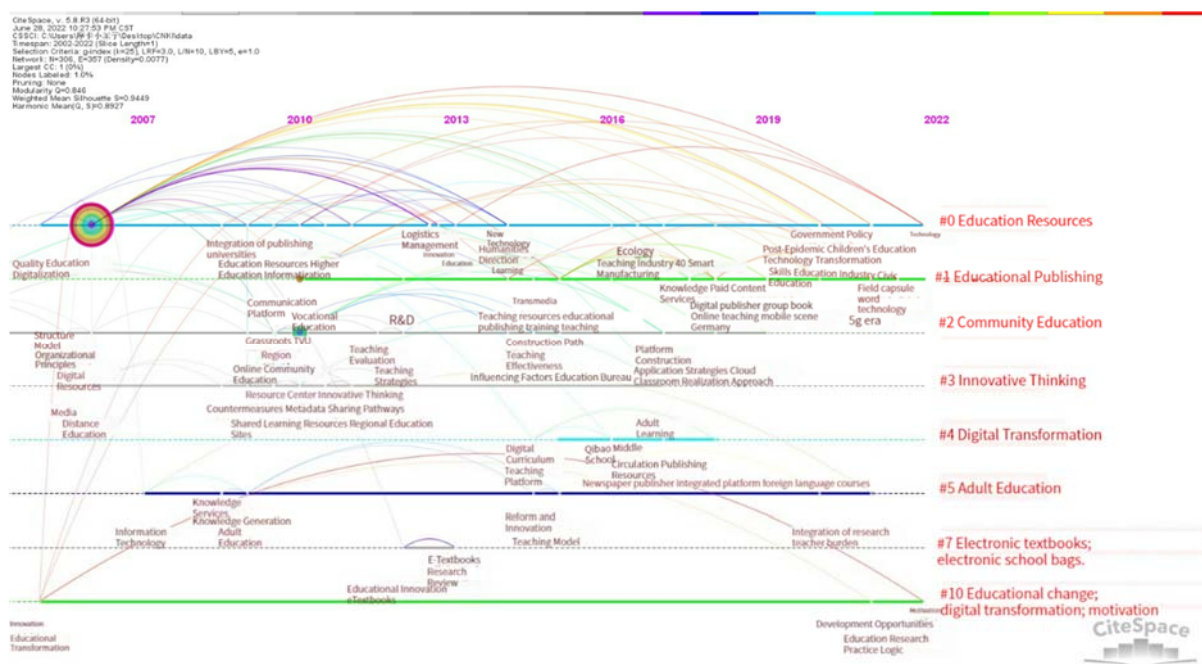


Figure 7. Keyword Timing Diagram

The first stage, from 2002 to 2010, is the period of rapid development of educational informatization, which is also the early stage of educational reform. At this stage, there are six emergent words, namely, resource sharing, learners and digital resources, distance education, Ministry of Education and sharing. Among them, in 2002, the Ministry of Education drafted and issued the program document of "Standards for Educational Management Informatization"; in 2003, the Ministry of Education issued the "Overview of the Development of Educational Informatization in 2002-2003". This series of relevant policy documents have promoted the development of education informatization in China, and the construction of education

informatization has entered a new stage. By 2004, the Ministry of Education issued the 2003-2007 Action Plan for the Revitalization of Education. This period is the early stage of educational reform, resource sharing, digital resources, distance education platform and other rapid development, while the level of educational information network has also been improved, the development of information technology has achieved remarkable results, providing a basic guarantee for future digital integration innovation, transformation and transformation.

The second stage, from 2010 to 2016, is the critical period for the application of educational informatization, which is the critical period for the construction of educational digitalization. The breakout words at this stage are: Open University, Community Education, Publishing Platforms. In 2010, China began to comprehensively promote the construction of education digitalization. The Outline of the National Medium and Long-term Education Reform and Development Plan clearly points out the contents of the application of education informatization and the construction of education digitalization, including distance education construction, campus network construction, digital resources construction and so on. Since then, the application of education informatization and education digitalization in China has been fully developed, and the Open University and community education have become new research hotspots. The construction of education informatization can basically meet the needs of education and teaching, and education digitalization is gradually on the right track.

In the third stage, since 2017, education informatization has officially entered 2.0, and has begun to explore the digital transformation. In 2017, the "National Engineering Laboratory of Educational Big Data Application Technology" was established, and at the conference, China first proposed that education informatization began to enter a new stage of 2.0. The concept of "digital transformation" was first applied to the economic field until July 2021, when the Ministry of Education took Shanghai as a pilot area for the national digital transformation of education, and education informatization formally entered the era of digital transformation.

2. Analysis of the Trend of Digital Transformation of Education

2.1. Development Opportunities and Trends of Digital Transformation of Education

Professor Zhu Zhiting mentioned that the digital transformation of education is not simply the application of technology products, but the integration of digital technology into all levels of education, and the promotion of all-round innovation and transformation of educational organizations in terms of teaching paradigm, organizational structure, teaching process and evaluation methods. Under the external pressure of COVID-19 pandemic, the digital transformation of education has a rare opportunity for development.

Digitalization is a means to improve the effectiveness, openness and transparency of the system, and the factors driving digital transformation are closely related to changes in the external environment[8]. Due to the COVID-19 pandemic, the vigorous development of emerging science and technology, and the two-way empowerment of information technology and education, the digitalization of education has accelerated its transformation and reshaped the education system for the future. Since 2020, the EDUCAUSE Association of the United States has published the Horizon Report (Teaching and Learning Edition)[9][10] for three consecutive years, which analyzed the profound changes in teaching and learning under the influence of the epidemic, technology and other factors in the context of the epidemic. The above report provides a new perspective for understanding the digital transformation and development trend of education from the four dimensions of trends, key technologies, scenarios and countermeasures (this paper mainly from the two dimensions of trends and key technologies).

Table 1. Comparison of the main points of Horizon Report (Teaching and Learning Edition) from 2020 to 2022

Dimension		2020	2021	2022
Five Trends in Reinventing the Future of Teaching and Learning	Social trends	Happiness and mental health; Demographic changes; Fairness and justice	Remote working/learning; The widening of the digital divide; Mental health issues	Blended and online learning; Skill learning; Work remotely
	Technology trends	Artificial intelligence: technical implications; The next generation of digital learning environments; Data analysis and privacy issues	Widespread adoption of blended learning models; Greater use of learning technologies; Online Faculty Development	Learning analytics and big data; Redefine the teaching mode; Network security
	Economic trends	Cost of higher education; Future jobs and skills; Climate change	Reduced funding for higher education; The need for new and different workforce skills; Uncertainty in economic models	The cost and value of a university degree; Digital economy; Financial deficit
	Environmental trends	Changes in the number of students; Other means of education; Online education	Climate change; Reduced travel for work; Sustainable Development	Improve the physical environment of the campus; Sustainable development goals; Planet Health
	Political trends	Reduced funding for higher education; The value of higher education; Political polarization	The growth of network globalization; The rise of nationalism; Public Funding for Higher Education	Political instability leads to the uncertainty of higher education; Political ideology influencing pedagogy;
Six Key Techniques of Teaching and Learning		Adaptive learning technique	Artificial intelligence	Artificial intelligence for learning analytics
		Artificial intelligence/robot learning education application	Blended and blended curriculum models	Artificial intelligence for learning tools
		Student Achievement Analysis	Learning analysis	Blended learning spaces
		Improvement of Instructional Design, Learning Engineering and User Experience Design	Micro authentication	Blended/Distance Learning Model Mainstreaming
		Open Educational Resources	Open Educational Resources	Micro authentication
		Augmented reality (AR, VR, MR, haptic) technology	High quality online learning	Professional Development for Blended/Distance Learning

According to Table 1, a comparative analysis of the contents of the Horizon Report (Teaching and Learning Edition) from 2020 to 2022. It can be seen that compared with the 2020 and 2021 reports, the new changes in the 2022 report are mainly reflected in the following aspects:

Pay more attention to the reform and innovation of teaching paradigm by epidemic and emerging information technology. Reconstruct the form and function of education to better

meet the needs of future industries and the future labor market. In the future, there will no longer be a clear boundary between university degree courses and continuous professional learning, and high-level and cross-disciplinary skills education and training can better meet the needs of the emerging labor force. More and more colleges and universities focus on providing students with practical, customizable and continuous skills education and training to meet the actual needs of work. Traditional subject majors are declining and emerging subject majors are favored by students[11]. The digital transformation and development of education will become a new trend.

Pay more attention to blended and online learning, and redefine the teaching organizational structure and teaching mode. Digital technology is deeply integrated with education and teaching, thus forming new teaching modes, such as blended learning, virtual learning, flip, synchronization, online learning and so on. The future development will redefine the teaching mode, establish a better teaching organizational structure that is conducive to the understanding and adaptation of teachers and students, promote the online and offline mixed teaching mode, and ensure the realization of educational reform and the optimization of the education system with the support of intelligent technology and data.

Pay more attention to the use of artificial intelligence technology in learning analysis and learning tools, and promote the innovation and change of teaching and learning process and evaluation methods. In the process of teaching and learning, with the support of artificial intelligence, big data, decision analysis model and other technologies, multimodal learning analysis is becoming a new research direction(103), which is used to analyze the learning behavior data generated in the learning process and promotes the occurrence of effective learning to a certain extent. In the teaching scene, the multi-modal data acquisition system takes the teaching data and environment of the physiological signs of the students as the basis for real-time monitoring of the multi-modal data. For example, when teachers teach in class, the data acquisition system will collect skin electricity, ECG, heart rate, EEG, temperature, eyes, hand movements, head movements, non-verbal communication, facial expressions, real environmental data and so on. The system cleans, labels and synchronizes the collected multimodal data of different types, and then performs social network analysis, semantic analysis, expression analysis, emotion analysis and attention input analysis on the processed multimodal data by means of clustering and association(104). The multimodal data after learning analysis can be fed back to teachers and teaching administrators, who can monitor the cognitive, emotional and behavioral States of learners in this way, so as to adjust the teaching methods, methods and strategies, improve the efficiency of teaching and learning, and promote teaching reform. Using artificial intelligence, we can also intelligently analyze the massive data in various systems and course plaorms, and enhance the process evaluation and dynamic evaluation of learning.

In the context of sudden large-scale COVID-19 pandemic and the vigorous development of emerging technologies, online learning, mobile learning and blended learning play an important role. "We can no longer and should not return to the state of teaching and learning before the outbreak of the epidemic"[14]. In the complex external environment, the digital transformation of education has accelerated its pace, and the sustainable development and persistence of the education system have put forward new requirements for the digital transformation of education, as well as pointed out new directions. Post-COVID era, the digital transformation to enhance the resilience of the education system tends to be borderless, multi-channel, decentralized, distributed, autonomous and self-cultivation, and eventually develops into a resilient ecosystem[15]. For the sustainability of education, it is necessary to reshape and construct teaching paradigms, organizational structures, teaching processes and evaluation methods that are more suitable for the development of teachers and students through digital transformation.

To sum up, the digital transformation of education will pay more attention to the reform and innovation of teaching paradigm by epidemic and emerging information technology, reconstruct the form and function of education, and better adapt to the needs of future industries and future labor market. It will pay more attention to blended and online learning, redefine the organizational structure and mode of teaching, and make the education system more resilient and durable. More attention will be paid to the use of artificial intelligence technology in learning analysis and learning tools, based on intelligent technology, giving full play to data-driven efficiency, promoting innovative changes in the process of teaching and learning and evaluation methods, and realizing the two-way empowerment of information technology and education.

2.2. Challenges and Solutions to the Digital Transformation of Education

At present, the digital transformation of education has become one of the hot spots of education reform. The development of information technology has brought new impetus to education. Digitalization is becoming the core and resource to promote education reform, and also the basic premise of digital transformation of education. Here, how to promote the digital transformation of education, what challenges will be encountered in the transformation, and how to solve them are also the elements we should focus on at present.

In the process of digital transformation of education, many schools and educational organizations remain in the stage of technology introduction, and superficially believe that the application of technology in the process of education is "digital transformation of education". The digital transformation of education is a process of continuous evolution, which is highly complex and dynamic, and will not happen automatically. It needs continuous active exploration, from the construction and application of information technology to the integration of technology and education, and then to the integration of digital technology into all levels of education. Promote educational organizations to transform teaching paradigm, organizational structure, teaching process, evaluation methods and other all-round innovation and change, from supply-driven to demand-driven, to achieve quality and fairness of education and support lifelong learning, so as to form a good educational ecology with openness, adaptability, flexibility and sustainability. Therefore, there should be a relevant thinking framework or transformation maturity assessment model for educational digital transformation to help schools and educational organizations specify transformation strategies and methods. There are some reference cases abroad, for example, the General Directorate of Education and Culture of the European Commission has formulated the European Digital Education Organization Reference Framework (DigCompOrg)[16]; The University of Zagreb, in cooperation with the Faculty of Informatics and CARNet, has developed the Framework for Digital Maturity of Schools[17] for primary and secondary schools in Croatia, based on the European DigCompOrg framework. At present, China is in the initial stage of education digital transformation, lacking the digital maturity model and framework[2] for education digital transformation, and the good and bad aspects of digital transformation practice are intermingled, which will delay the pace of transformation. Therefore, it is necessary to speed up the research and development of the maturity evaluation model and thinking framework for the digital transformation of education in China.

To a certain extent, the digital transformation of education is limited by the top-level design and the digital quality of grass-roots organizations. In addition to the challenges of complex external environmental factors, the top-level design at the national level is an important guarantee for the digital transformation of education. At present, there are few safeguard policies in this regard in China, so it is one of the breakthroughs to do a good job in the system and theoretical research of the digital transformation of education. At the same time, the personnel of various organizations need to improve the ability of data governance, improve the

digital literacy of teachers and students, and promote the development of high-quality digital education system. Relevant national education departments also need to strengthen supervision and communication with grass-roots organizations, keep abreast of the transformation, promote the optimization and iteration of the transformation, and ensure the quality of the digital transformation of education!

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