Policy Innovations in Language Education: Leveraging Digital Technologies for Personalized Learning Experiences

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Abstract: In the context of digital transformation, the increasingly mature digital technology has accelerated the change of education and learning mode. As an important means of cultivating talents, personalized learning, empowered by digital technology, is highly compatible with the requirements of the strategy of "developing the country through science and education" and the goal of digital transformation of education. The study takes 1,651 documents included in the CNKI database from 1999 to 2024 as the research samples, and with the help of the visual analysis software CiteSpace, analyzes them in terms of keyword co-occurrence, core authors, and research institutes, and draws out the related knowledge maps. The study outlines the overall evolution of personalized learning under the collaboration of digital technology, and reveals the specific mechanism of digital technology to promote personalized learning experience. The study finds that personalized learning research in China has experienced three stages of slow development (1999-2009), rapid development (2010-2018), and stable development (2018-present). The process of digital technology for personalized learning experience mainly involves six aspects: educational concept, learning resource recommendation, openness and flexibility, personalization and customization, intelligent assessment and feedback, and outcome visualization. The latest frontiers of future research include the application of digital technologies such as artificial intelligence and smart education in personalized learning in language education.
Keywords: personalized learning; visual analytics; CiteSpace; knowledge graphs

I. 1. Introduction

With the development of the times, the application of digital technology in the field of education is becoming more and more extensive. In the field of language education, digital technology provides learners with many innovative methods and tools, especially in the application of personalized education, empowering learners to achieve better results in the process of language acquisition [1-2].

The realization of personalized learning depends on teachers' in-depth understanding of students' individual differences and flexible adjustment of teaching strategies, which not only puts forward higher requirements on teachers' professional ability, but also drives the rapid development of educational technology [3-6]. Digital technology can provide customized learning content and learning methods according to learners' individual learning needs and levels, and provide language learners with more accurate and effective learning resources through intelligent recommendation system and personalized assessment system. On the one hand, digital technology is used to establish an intelligent recommendation system, which can recommend articles, videos or courses on related topics according to learners' previous choices and preferences [7-8]. Such personalized recommendations can stimulate learners' interest in learning and provide learning materials that better meet their needs [9]. On the other hand, digital technologies can assess learners' learning outcomes through personalized assessment systems and provide appropriate feedback and recommendations based on the assessment results [10-11]. This personalized assessment can help learners better understand their learning strengths and weaknesses and adjust their learning strategies to enhance their learning outcomes [12]. In response to the wave of personalized learning within the field of educational research in the new century, digital technology will promote personalized learning will enter a whole new stage and provide better quality learning resources for the less developed areas of education, which has great social value [13-15].

Literature [16] states that learning is essentially a personalized experience that allows a person to expand his or her knowledge,

perspectives, skills, and understanding, and that the use of technology integration to build a personalized learning model helps learners to achieve their own needs and goals in order to facilitate a personalized learning experience. Literature [17] investigated the language learning of students at a private university and the results showed that most of the students transformed themselves from traditional to personalized language learning through the use of digital educational technology to assist them, and that digital educational technology helps to improve self-management skills, take care of non-academic matters, and allow for flexibility in learning according to one's own abilities and interests. Literature [18] proposes a game-based approach to language learning, pointing out that the pedagogical game platforms built are capable of integrating and creating interesting and personalized learning paths, and proposing adaptive learning solutions for learners' specific learning needs. Literature [19] explored the role of adaptive language assessment systems in facilitating the language learning experience by integrating personalized learning paths using data-driven and artificial intelligence technologies to provide learners with customized learning content and real-time feedback and guidance. Literature [20] describes a personalized text retrieval algorithm that identifies the complexity of vocabulary through an active learning model and selects reading materials for language learners with the required proportion of new, challenging and familiar vocabulary in conjunction with their abilities. Literature [21] investigates the process of AI-assisted language learning and shows that learning tutoring systems based on AI technology can facilitate personalized diagnosis, learning paths and material recommendations for language learning, and effectively improve learners' language learning outcomes. Literature [22] explored the integration of generative AI and English language education and designed a personalized speaking assessment method based on it, which creates a dynamic and adaptive learning environment for language learners with the help of data collection from IoT devices and the language generation capability of generative AI. Literature [23] analyzes the role played by OpenAI conversational AI ChatGPT in language learning, and utilizes the features of accessibility, personalization, immersive learning and instant feedback that ChatGPT has to help

language learners and educators learn and work better. Literature [24] has also shown that ChatGPT has had a profound impact on language learners' learning patterns, as it provides language learners with a personalized learning experience that improves learner engagement in the language learning process by simplifying complex concepts.

Using CiteSpace software and information visualization method, literature research method, and statistical method as research methods, this study conducted keyword co-occurrence and clustering analyses to map out the relevant knowledge maps of the 1,651 research literatures on personalized learning under the synergy of digital technology, which were included in the CNKI database from 1999 to 2024. The knowledge base, hot topics, historical evolution and development trend of personalized teaching research in the past twenty-five years are explored to reveal the specific mechanism of digital technology to promote personalized learning experience. Through a comprehensive and in-depth analysis of these scientific research results, it helps to grasp the main structure and development trend of language personalized teaching research, and provides new ideas for subsequent research.

II. 2. Methodology and data sources

A. 2.1 Data selection

The data of this study comes from China Knowledge Network Data (CNKI), a concept of National Knowledge Infrastructure (NKI), which was proposed by the World Bank in 1998 and co-sponsored and created by Tsinghua University and Tsinghua Tongfang in 1999.CNKI contains the most comprehensive full-text literature of Chinese journals, and it is the world's largest continuously and dynamically updated full-text database of Chinese academic journals.

Personalized learning is an extremely comprehensive cross-discipline, and the analysis requires the use of a wider range of data, i.e., try not to artificially set too narrow data conditions for the study when mining it. Therefore, in order to ensure the comprehensiveness of the research sample, the research subject, object, goal and other studies related to personalized learning should be included as the

research sample in this study. The method of data collection according to the subject is mainly with the help of subject search in information retrieval, where the data vocabulary of the subject to be collected is locked in the title, abstract and keyword parts of the text.

The specific search steps selected for this study are:

(1) Select the CNKI database “center website” link to enter.

(2) Select the advanced search, the search strategy is, the topic “personalized learning”, the time until June 30, 2024, the start time is not set. The search time is August 27, 2024, and the resource type is “Periodicals”.

After completing the above steps, after screening and eliminating the non-compact literature, we finally obtained a valid sample of 1,651 documents to visualize and analyze the research on personalized learning under the collaboration of digital technology.

B. 2.2 Software selection

In this study, we choose the information visualization software CiteSpace, which is written in Java programming language, based on the theory of citation analysis, and developed by Dr. Chaomei Chen of the School of Information Science and Technology of Drexel University and Dalian University of Technology in 2004.CiteSpace software is a knowledge visualization and mapping analysis tool based on citation analysis, which can build up a knowledge map of the development process and structural relationship of disciplines. CiteSpace software is a knowledge visualization mapping analysis tool based on citation analysis, which can construct the development process of disciplines and the structural relationship of the knowledge map, and its advantage lies in the deep mining of massive data.

CiteSpace is a multivariate, time-sharing, dynamic and complex network on the knowledge map, which is widely used in knowledge mapping, and is quite distinctive and influential.CiteSpace software can find the most critical and important information of the researched knowledge field from the huge amount of literature data, and display a knowledge map intuitively and clearly by using the methods such as the word frequency analysis method and the detection method of the emergent words. Knowledge map. It allows people to quickly detect the research hotspots in the relevant

knowledge fields, recognize the research frontiers in the relevant knowledge research fields, and predict the development trends in the relevant knowledge research fields.

C. 2.3 Data processing

This study conducts knowledge mapping and visualization and analysis of research data processing steps are as follows:

(1) Data Collection

In accordance with the above search strategy, 1651 research papers related to personalized learning in collaboration with digital technology were downloaded completely and saved in a fixed form.

(2) Data Conversion

Since the data analyzed by CiteSpace software is based on WoS data and the data collected from other databases need to be converted before visualization and analysis, the literature obtained from the download is entered into the data format converter that comes with CiteSpace for data conversion, and the conversion results are then imported into CiteSpace for visualization and analysis.

(3) Parameter setting

a) Time zone segmentation, the analyzed data need to be segmented into time zones before mapping in CiteSpace software, and the time interval chosen in this study is one year.

b) Threshold selection, CiteSpace software has three levels of threshold selection, which are the number of citations, co-citation frequency and co-citation coefficient (C,CC,CCV), and the selection of the threshold is directly related to the number of connections and clarity of the visualization network. In this study, the range of thresholds chosen according to the characteristics of the research data is the system default value.

c) Streamlining algorithm, the Pathfinder option in CiteSpace is an option for streamlining the visualization network, which can be freely selected according to the need, and it is generally not recommended to use network cropping.

d) Generate mapping, through the above settings can be used after the CiteSpace information visualization software to generate a visual map of personalized learning research under the collaboration of digital technology, and then according to the map to display the

effect of the map, the size of the map, fonts, and other further adjustments to beautify the map.

III.3. Data analysis

After obtaining the relevant sample data, CiteSpace software was used to conduct quantitative and qualitative multimodal analysis studies on the available data.

A. 3.1 Analysis of the current state of research

1. 3.1.1 Time Distribution of Personalized Learning Research

The published literature on personalized learning in China is shown in Figure 1. It can be seen that the amount of personalized learning literature published shows a general upward trend, in which the first article was published in 1998, and the author came from basic education, indicating that personalized learning was firstly paid attention to in basic education. The analysis concludes that personalized learning in China can be divided into three stages, 1999 to 2009 is the slow development stage. 2010 to 2018 is the rapid development stage, the National Medium and Long-Term Educational Reform and Development Plan Outline (2010-2020) of the proposal to provide learners with convenient, flexible and personalized learning conditions, which set off a boom in personalized learning research driven by the policy [25]. 2018 is followed by a steady development stage (2024 statistics are half-yearly publications as of June 30th).

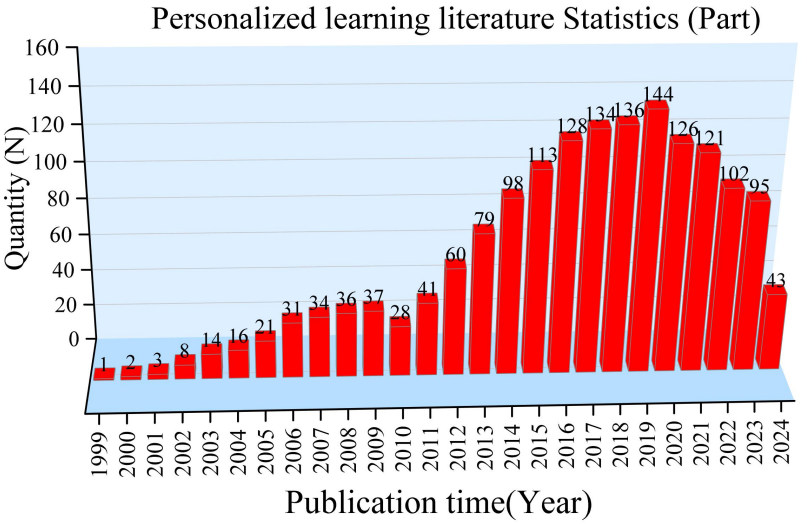

Figure 1 Statistics on the number of published documents on personalized learning in China

2. 3.1.2 Spatial Distribution of Personalized Learning Research

(1) Author co-occurrence mapping

According to Price's law, the standard formula for the number of publications of core authors is $m = 0.749\sqrt{n_{\max}}$, where $n_{\max}$ is the highest number of publications among the authors counted is 37. Therefore, m is calculated to be 4.6, indicating that the minimum number of publications of core authors of personalized learning research in China is 5. CiteSpace was used to map the co-occurrence of authors with more than 5 publications as shown in Figure 2. It can be seen that there are 6 collaborative teams of 3 core authors or more, 4 collaborative teams of 2 core authors, and 15 independent research authors in Chinese personalized learning research. Overall Chinese personalized learning researchers, show a predominance of collaborative research, supplemented by independent research.

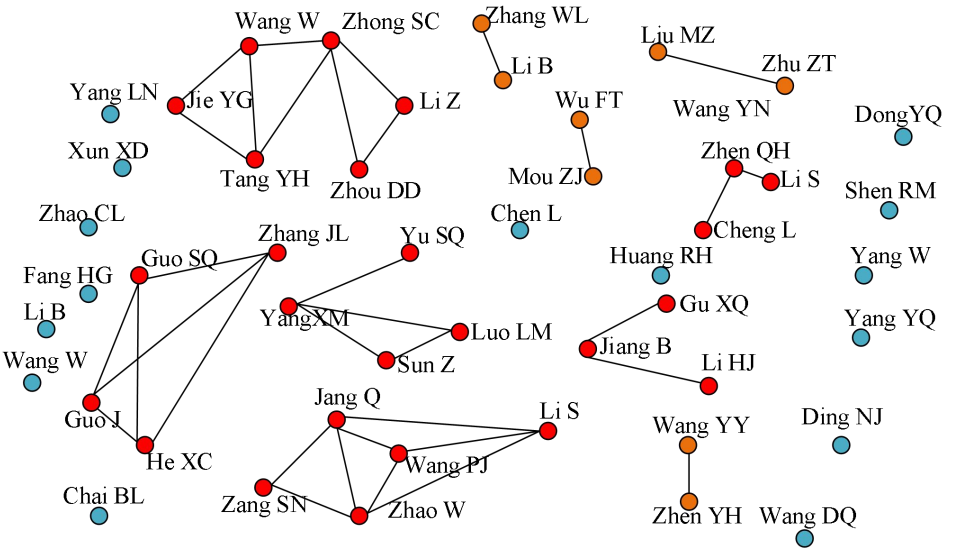

Figure 2 Author co-occurrence map

(2) Institutional co-occurrence mapping

In order to analyze the posting of institutions as well as their collaboration, the study generates an institutional co-occurrence mapping for personalized learning research. In this paper, the institutional co-occurrence mapping is converted into a table form for easy understanding, and the high-yielding institutions of personalized learning research under the collaboration of digital technology are obtained as shown in Table 1. The high-yield institutions of personalized learning research in China mainly consist of research cooperation teams from educational research institutes in South China, East China, Beijing, and Beijing Normal University. There are 1056 nodes and 457 connecting lines in the institutions' cooperation network, and the overall density of the network is only 0.0014, which indicates that China's personalized learning research team is scattered, the authors from different institutions cooperate less, and the research is more dispersed.

Table 1 Highly productive institution for personalized learning research

Serial number	Research institution	Number of publications/articles	Region
1	South China normal university	23	Guangzhou

2	East China normal university	11	Shanghai
3	Beijing normal university	9	Beijing
4	Shanghai normal university	7	Shanghai
5	Northeast Normal University	7	Jilin
6	Tsinghua University	6	Beijing
7	Shaanxi Normal University	6	Xian
8	Beijing Normal University	5	Beijing
9	Jiangsu Normal University	5	Jiangsu
10	Jiangnan University	5	Jiangsu
Institutional cooperation network			
	Node	Wired	Density
	1056	457	0.0014

B. 3.2 Analysis of research hotspots

1. 3.2.1 Research analysis based on keyword co-occurrence

A research hotspot is a research topic that can attract the majority of pedagogues to conduct at a certain period of time, and it is also an issue that has been commonly researched by closely related literature. Keywords, as an important part of constituting academic papers, can sharply reflect the research hotspots in a certain field, and the key points of the research in the field of personalized learning can be understood by generating a keyword co-occurrence mapping using CiteSpace visualization software.

The keyword co-occurrence mapping of research in the field of personalized learning in China from 1999 to 2024 is shown in Fig. 3. 1651 pieces of literature in Refworks format were identified and processed by CiteSpace, and the time slice was set to one year, which ultimately resulted in the keyword co-occurrence mapping of research in the field of personalized learning under the synergy of digital technology in China from 1999 to 2024, and the map produced a total of 725 nodes and 1842 connecting lines. The size of the nodes indicates the frequency of keyword occurrence, the larger the node, the higher the frequency of the keyword.

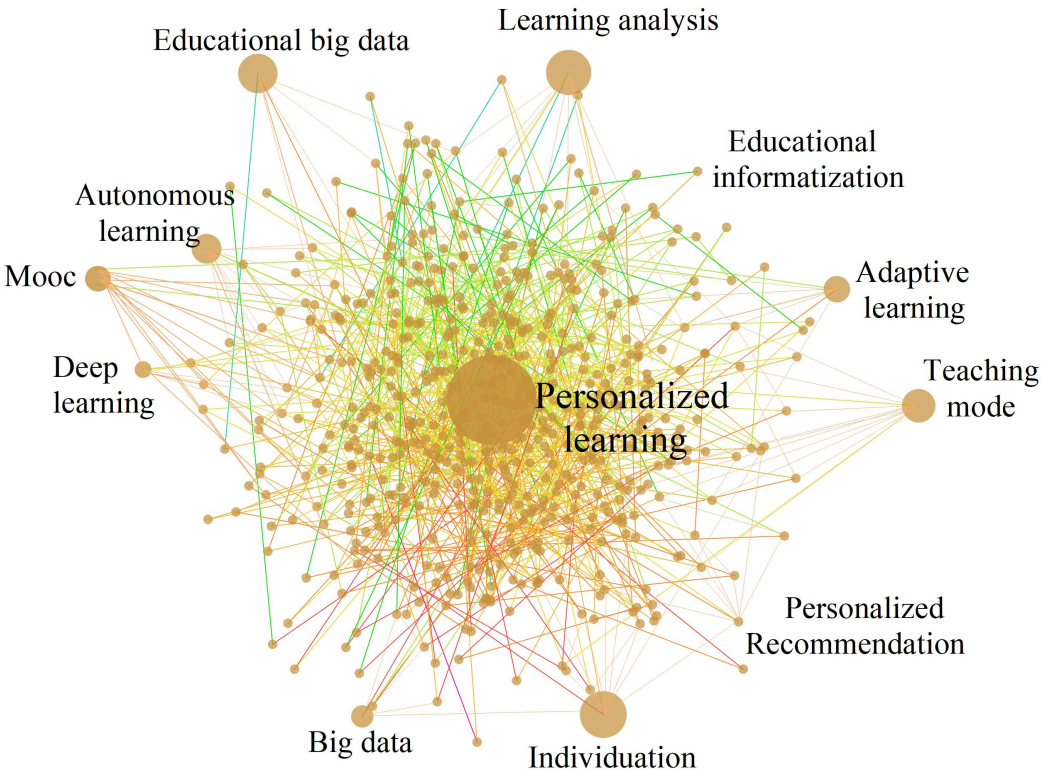

Figure 3 Collinear map of research keywords in the field of personalized learning (1999~2024)

Table 2 shows the statistics of high-frequency keywords in the field of personalized learning research in China from 1999~2024, and the highest frequency in the field of personalized learning research from 1999~2024 is "Personalized learning" 325 times. This is followed by "Individuation" with 101 occurrences. In third place was "Learning analysis" with 37 occurrences. Mediation centrality is a metric used to measure the importance of a node's position in a network, and mediation centrality can reveal the structure and dynamic nature of a domain. The conditions to be met for hot keywords are that the mediation centrality is greater than 0.1 and the frequency is greater than 10. Therefore, the hot keywords in this study are "personalized learning", "Individuation", "learning analysis" and "educational big data", respectively, indicating that these fields are hot topics in personalized learning research in the past 1999~2024.

Table 2 High frequency keywords in domestic personalized learning research (1999~2024)

Serial number	Keywords	Frequency	Intermediation centrality
1	Personalized learning	325	0.63
2	Individuation	101	0.12
3	Learning analysis	67	0.21
4	Educational big data	61	0.22
5	Teaching mode	58	0.09
6	Autonomous learning	54	0.02
7	Adaptive learning	42	0.06
8	Mooc	36	0.04
9	Big data	33	0.04
10	Deep learning	31	0.05
11	Educational informatization	29	0.05
12	Personalized Recommendation	26	0.05

2. 3.2.2 Analysis of clustering-based studies

CiteSpace's keyword clustering can identify the hotspots and development trends of a certain research field. In order to analyze the structure of personalized learning research more clearly, the sample literature data were clustered by keywords and the keyword clustering map was generated. The Q value of keyword clustering in this study was > 0.5 and the S value was > 0.7, indicating that the clustering had practical research significance and the clustering effect was significant. Figure 4 shows the keyword clustering map of China's personalized learning research in the field of personalized learning in 1999~2024, and the top five clusters are "#0 Personalized learning", "#1 Individuation", "#2 Learning analysis", "#3 Educational big data", and "#4 Teaching mode" after analyzing the keyword tag clustering map, which is basically consistent with the search results for high-frequency keywords.

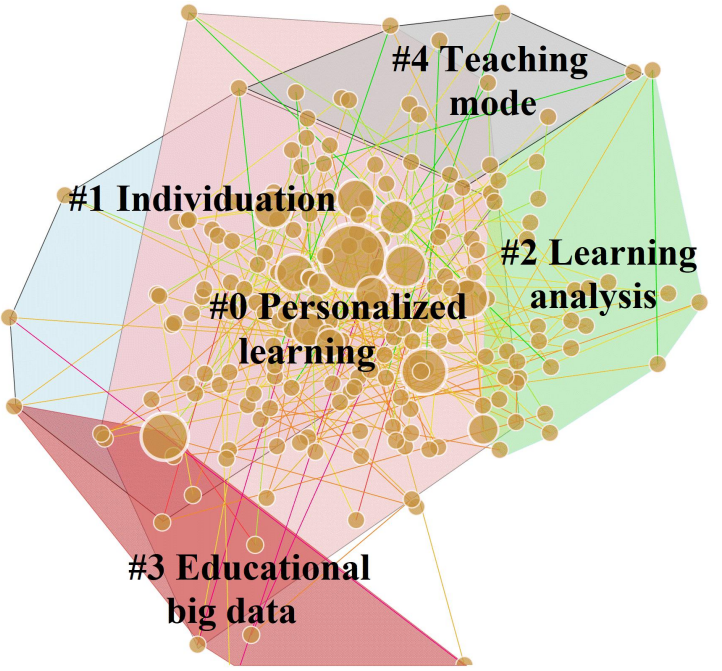

Figure 4 Research keywords in the field of personalized learning cluster graph (1999~2024)

C. 3.3 Specific mechanisms of digital technology for personalized learning

Through the above analysis of the keywords that appear in the top two frequencies in each cluster as well as the development dynamics of the research field in the timeline graph, it can be found that the experiential effects of digital technology synergistically facilitating personalized learning are mainly focused on the following aspects.

(1) Digital technology promotes innovative changes in the concept of personalized education

The development of digital technology will inevitably provide new paths and conditions for the change and innovation of personalized education teaching concepts. From informatization education to education and teaching in the era of big data, to the present era of digital transformation of education, the use of emerging technologies in different eras requires more cutting-edge

educational concepts as a guiding ideology. From E-Learning, open online courses to flipped classroom and smart classroom teaching, the constantly updating forms of education and teaching have changed people's understanding of education and also provided a variety of new forms of development for personalized learning. Data awareness, information technology literacy, and comprehensive literacy have been introduced into teaching and learning programs and have gradually become “must-haves” for personalized learning. The innovations and changes in educational concepts and teaching thinking reflect, to a certain extent, the opportunities and challenges faced by education in the context of digital transformation, and they are the hot spots in the field of personalized learning research. At the same time, personalized learning is also in the process of innovation and change of educational concepts, and increasingly has the characteristics and standards of learning in the digital era.

(2) Personalized Learning Resources and Recommendations Enabled by Digital Technology

The autonomy and flexibility features of personalized learning make learners have diverse learning behavior patterns and make teaching more accurate. The use of digital technology enables the identification of students' learning needs and interests, the development of personalized learning plans and guidance services to help them better master professional knowledge and skills, and to enhance their learning effectiveness and employment competitiveness. Through the application of intelligent technology and big data analysis, personalized learning platforms can tailor learning plans and recommend personalized teaching content for students based on their learning interests, levels and characteristics. Meanwhile, the personalized guidance service provides accurate assessment and feedback to students by monitoring their learning situation and performance, and provides targeted guidance and advice. At the same time, the analysis of learning behavior data through digital technology can discover the characteristics of learners, learning behaviors, and the relationship between the two, which in turn helps researchers better achieve personalized teaching.

(3) Openness and flexibility of digital technology for personalized learning

One of the important values of digital technology for personalized learning is to promote the openness and flexibility of learning, and an open and flexible learning environment is an important manifestation of digitally empowered lifelong learning. An open and flexible learning environment needs to break the closed and rigid model of traditional lifelong learning that is institution-centered, knowledge-oriented, and skill-centered, cultivate learners' innovative thinking, and stimulate their intrinsic motivation to learn [26]. At the same time, digital empowerment of lifelong learning also helps to break the traditional education test-centered "knowledge - skills" system, pay more attention to the overall development of people in the lifelong learning process and lifelong benefits.

(4) Digital Technology Enhances Personalization and Customization of Learning

The important value of digital empowerment for lifelong learning also lies in providing personalized learning support for learners. Digital technology can integrate learners' knowledge and experience, analyze and model their data, and provide personalized learning support services for learners.

In the environment of digitally empowered lifelong learning, learners can customize their own personalized learning programs according to their actual needs through various digital platforms, and determine a set of learning programs that are most suitable for them by analyzing and modeling their own personality traits, behavioral styles, proficiency levels, and other indicators. Learners follow the program to collect the learning resources they need and study according to the plan, learning efficiency can be effectively improved, and it is easier to obtain the desired learning results. Digital empowerment enables learners to obtain personalized and customized learning support services at a very low cost, enabling them to obtain better learning results and improve learning efficiency, which in turn stimulates their demand for continuous learning.

(5) Digital technology promotes intelligent assessment and feedback of learning effects

In traditional education and teaching activities, learners usually have to assess their learning outcomes through exams and tests. In

the context of digital empowerment, learners can make use of the intelligent assessment and feedback mechanism provided by online platforms to make a comprehensive assessment of their learning outcomes. Intelligent assessment can comprehensively evaluate learners' learning outcomes through online tests, online assignments, online discussions, online exams and other means. In the context of digital empowerment, evaluation standards are jointly developed by educators and learners:

On the one hand, educators can formulate evaluation standards for course content and evaluation standards for course instructional design.

On the other hand, learners can also participate in the design and teaching of course content and formulate evaluation criteria that meet their actual situation.

In the intelligent assessment process, learners can choose learning contents suitable for themselves according to their own learning needs and ability levels, and make personalized learning plans according to their own learning situation and actual results. Intelligent assessment and feedback mechanisms can not only provide a comprehensive understanding of learners' learning, but also provide targeted guidance and assistance for learners to better carry out independent learning. Specifically, educators can evaluate learners based on their learning behavior data on the platform, test scores, homework submissions, etc., and provide targeted guidance to learners based on their feedback.

The intelligent evaluation and feedback mechanism provides learners with timely, effective, comprehensive, objective, fair and actionable evaluation information, which is conducive to better independent learning. For example, secondary schools in many large cities have begun to use information-based teaching tools, and teachers can make comprehensive evaluations of students based on their learning behavior data and test score data on the platform. Teachers can also provide personalized guidance to students based on their learning behavior data and test score data on the platform. Through intelligent evaluation and feedback mechanisms, educators can better provide targeted guidance and assistance to learners.

(6) Digital technology promotes the visual display of personalized learning results

The visual display of personalized learning results is a way of displaying learning results in the form of text, graphics, charts, tables, etc., in order to more intuitively display the progress and results of learning. This kind of display can help learners and educators better understand the strengths and improvement points in the learning process, and at the same time give learners better feedback and motivation.

In the context of digital empowerment, learners can not only record their progress and gains in the learning process through the learning platform, but also record the difficulties and challenges they encounter in the learning process through the learning platform. Both educators and learners can learn about their performance in the learning process and the needs of learners through the learning records, and through the analysis of learners' learning records, they can understand the degree of learners' mastery of what they have learned.

In the visual display of learning results, common ways include but are not limited to the following:

Showing changes in test scores, task completion, etc. through line graphs.

Showing learners' scores in different abilities or skills through puzzles to help learners understand their strengths and room for improvement.

Show the distribution of learners' mastery of knowledge points through heat maps to help learners identify weak and strong points.

Generate detailed learning reports based on learners' learning data and performance, including learning hours, knowledge point coverage, self-evaluation, etc., providing learners with comprehensive feedback and guidance.

Through the visual display of learning results, learners can understand their own learning more intuitively and adjust their learning strategies based on the display results. At the same time, educators can also use these visual displays to better guide learners and provide targeted educational resources and support.

IV. 4. Conclusion

This study uses CiteSpace software to process the data information of a large number of related literatures to analyze the research hotspots, dynamics, and future development trends of personalized learning under the synergy of digital technology and other elements to obtain a clear understanding. From the perspective of research development, personalized learning research has different research hotspots in different periods, and mainly presents policy-driven characteristics.Before 2011, personalized learning research hotspots were mainly focused on distance education.From 2011 to the beginning of 2018, benefiting from the proposal of the "Outline of the National Medium- and Long-Term Educational Reform and Development Plan", accelerating the process of education informatization, the research themes in this stage are rich and varied. From 2018 to the present, artificial intelligence, intelligent education and intelligent classroom have become the hotspots of research. The hotspot and focus of domestic personalized learning research in the coming period will still focus on smart education and smart classroom under the integration of artificial intelligence and education and teaching, providing support services for personalized learning.

In summary, language education in the future should be optimized in the following aspects:

(1) Innovative personalized learning in language education

Through intelligent speech recognition technology, students can carry out personalized pronunciation practice and listening training. The system is able to give students timely feedback and suggestions based on their pronunciation accuracy and listening comprehension, helping them improve their pronunciation and listening level. Personalized Vocabulary Learning System can provide students with personalized vocabulary learning plans and exercises based on their vocabulary mastery and learning progress to consolidate and expand their vocabulary. Teachers can make personalized learning plans and teaching contents for students according to their learning goals, learning styles and learning habits, making learning more targeted and efficient.

(2) Build an intelligent learning environment

Take the Global Chinese Learning Platform as an example, which integrates artificial intelligence technology and Chinese learning resources to provide students with a personalized learning experience. Students can study, practice and test online, and get instant feedback and suggestions. The platform automatically generates personalized learning plans and recommended content based on students' learning and performance, helping them learn Chinese more efficiently.

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