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Original scientific paper

Research on Digital and Intelligent Innovation Transformation Strategy of International Chinese Language Education Reshaped by Generative Artificial Intelligence

Vancuong KIM, Duwen LU*

Abstract: Generative artificial intelligence possesses outstanding language recognition and generation capabilities. It can automatically create diverse data forms based on user input instructions and is widely applied in multiple aspects of international Chinese language education, including student recruitment promotion, classroom teaching, educational administration management, and learning assessment. First of all, it is necessary to clarify the core connotation of the independent knowledge system of international Chinese language education, systematically explain the significant meaning of constructing this system from three dimensions: contemporary development needs, historical evolution context, and global perspective, and analyze its key constituent elements. On this basis, innovative construction strategies in the process of digital and intelligent transformation are proposed: oriented by practical problems, promote the systematic construction of an autonomous knowledge system for international Chinese language education. Based on the fine traditional Chinese culture, enrich its ideological connotation and cultural value. Oriented towards the practical application of Chinese, strengthen the functional attributes of this system in terms of language services. Driven by digital transformation, promote its continuous innovation and dynamic development. In addition, through literature review and in-depth interviews with students, internal and external factors influencing the participation in online videos of international Chinese language education were identified. A participation influencing factor model based on the Interpretive Structure Model (ISM) and the Cross-Influence Matrix (MICMAC) was constructed to clarify the hierarchical relationship and mechanism of action among various factors, including direct factors, indirect factors, and fundamental factors. Furthermore, it provides countermeasures and suggestions for video designers and learners respectively in terms of production and learning. The introduction of generative artificial intelligence technology can achieve the automated production of digital resources for international Chinese language education. Efforts should be made to build a dedicated generative artificial intelligence system for the field of international Chinese language education, integrate multi-source data resources in this field, and develop intelligent generation assistants that can be embedded in various application software, so as to enhance the intelligent level of teaching resource development and application.

Keywords: Chinese language education; digitalization; generative artificial intelligence international; intelligence innovation and transformation; knowledge system

1 INTRODUCTION

Since OpenAI launched ChatGPT-3.5 at the end of 2022, Generative AI (Artificial Intelligence) has gradually become a key force driving the development of the artificial intelligence field, attracting global technology companies to increase their R&D investment, thus contributing to a fierce competitive situation in the large language model market. Among the numerous current models, there are not only international representatives such as ChatGPT, Bard, and Claude, but also advanced domestic systems like WenxinYiyan, iFlytekXinghuo, and TongyiQianwenPangu have emerged. Among them, OpenAI'sChatGPT and Baidu's WenxinYiyan are particularly notable. Generative artificial intelligence differs from traditional processing mechanisms based on rules or templates. It can understand and generate multimodal information such as text, images, and audio without relying on pre-set structures. The output content not only conforms to the context but also has a high degree of innovation. This ability makes it demonstrate significant application value in the field of education, especially in the digitalization and intelligence process of international Chinese language education.

In the international Chinese language education community, generative artificial intelligence such as ChatGPT has sparked multi-faceted discussions, which can be summarized into three major topics: The first is the development opportunities it brings. Most scholars affirm the application prospects of this type of technology in international Chinese language teaching [1-4], such as believing that ChatGPT can help enhance students' enthusiasm for autonomous learning, strengthen teachers' information technology literacy, promote the development and upgrading of teaching resources, and drive the update of intelligent Chinese language teaching products [5]. Another study emphasizes that it has application potential throughout the entire process of "teaching - learning - evaluation" [4]. Of course, these advantages can only be truly demonstrated through rigorous teaching design and practical verification. The second is the potential risk issue of generative artificial intelligence. It mainly includes inconsistent quality of generated content [6-7], risks of privacy and data leakage [6], weakened subjectivity of teachers [7], and dependence of teachers and students on the use of technology [4], etc. In the face of these problems, educators should maintain a rational attitude, prudently introduce technological tools, and formulate corresponding risk prevention strategies to ensure the positive benefits of technology application. The third type of discussion involves practical implications and development strategies. Existing studies have put forward a number of suggestions for promoting the implementation of generative artificial intelligence in international Chinese language education. As Pan Haifeng proposed, the applicability and effectiveness of large language models should be enhanced by strengthening domain adaptation and scenario integration, and combining them with the professional knowledge and actual teaching needs of international Chinese language education.

Overall, the current achievements are more focused on theoretical discussions and the outlining of development visions. Although they are helpful for understanding the application prospects of generative artificial intelligence, with technological updates, its initial limitations will be continuously broken through. This requires us to continuously update our understanding of this technology, deeply grasp its internal mechanism and development trends, strengthen empirical research and case accumulation, and thereby provide specific and operational practical paths for the digital and intelligent transformation of international Chinese language education. When

considering how to integrate emerging technologies into international Chinese language education, the first step should be to accurately understand the core characteristics and development logic of the technology. At present, there are still multiple interpretations of the definition and classification of generative artificial intelligence in the industry. Clarifying its conceptual boundaries and type characteristics can help improve application efficiency and promote innovation and breakthroughs in international Chinese language education. For instance, by differentiating the differences between generative and discriminative artificial intelligence, the advantages of the former in creative content generation can be more clearly presented, laying a theoretical foundation for in-depth exploration of educational applications. The first part of the article is the introduction, and the second part is the related work. The third part constructs an autonomous knowledge system for international Chinese language education and a prediction model for educational video participation. The fourth part is simulation verification, and the fifth part is conclusion.

2 RELATED WORK

Generative artificial intelligence is a type of technology that relies on deep learning algorithms and can independently generate content (such as text and images) that simulates human intelligence output based on diverse and complex input instructions (such as natural language questions or commands). According to the views of experts from the international IT research and consulting the firm Gartner [8], this technology, by analyzing large-scale data to grasp the representation paradigms of artificial products, creates brand-new achievements that not only maintain semantic relevance to the training corpus but also possess uniqueness. Such generated products can be used for legitimate purposes, but there is also the possibility of being misused or abused. Specifically, generative artificial intelligence can be applied to generating various types of content, including text, images, videos, audio, 3D (3 Dimensions) models, program codes, synthetic data, business processes, and physical prototypes. Its application scope has also expanded to cutting-edge fields such as art production, drug research and development, and the development of new materials. The well-known online education platform Coursera also demonstrated [9] that generative artificial intelligence enables users to generate new forms of results by inputting diverse instructions, including text, audio and video materials, programming codes, 3D modeling, and other types of digital content. This system can achieve continuous learning and model evolution based on existing network texts and synthetic data. As the training volume continues to expand, its generation performance also keeps improving. One of the key reasons for the rapid promotion of this technology lies in its support for natural language human-computer interaction, significantly expanding the breadth of application scenarios. At present, generative artificial intelligence has been deeply integrated into various tasks such as writing assistance, scientific research analysis, software development and creative conception [10].

All the above-mentioned definitions highlight the characteristics of generative artificial intelligence at three key levels: basic principles, core functions and application fields. Firstly, its fundamental principle is based on continuous training and model tuning driven by big data, relying on deep learning frameworks to continuously improve the quality of the generated content. Secondly, its core function is mainly reflected in "the creation of new content", covering a wide range of forms from traditional text, images, audio and video to code, synthetic data, process design and physical prototypes. Thirdly, this technology has demonstrated remarkable cross-disciplinary applicability and has shown significant potential in multiple fields such as art, education, programming, industrial design, and scientific research. It should be particularly noted that within the framework of generative artificial intelligence, "generating new content" and "generating new data" are often regarded as synonymous concepts. This is because all output forms (such as text, images, and code, etc.) exist in the form of data in the computing system. In conclusion, generative artificial intelligence is an AI system based on vast training datasets and complex computing models, capable of automatically generating various types of content, including text, images, code, music, videos, and games, in response to different scenarios and requirements.

This technology has demonstrated a profound influence in international Chinese language education. Its outstanding language understanding and generation capabilities can serve all process links including enrollment, teaching, management and testing [11]. In the process of student recruitment promotion, generative artificial intelligence is mainly applied in two major directions: the generation of multilingual promotional materials and the customization of personalized services. With its efficient natural language generation capabilities, enrollment information can be quickly translated into multiple languages and optimized specifically for the cultural backgrounds and expression habits of different countries and regions [12]. Not only that, this technology can also break through the limitations of static graphics and text, automatically generating dynamic multimedia materials suitable for multiple languages, such as video introductions and animated graphics and text, significantly enhancing the dissemination effect of enrollment activities.

In terms of personalized services, relying on deep learning and user profiling modeling, generative artificial intelligence can generate highly customized enrollment consultation and support plans based on potential students' interest preferences, educational experiences, and language abilities [13]. For instance, with the help of an intelligent dialogue system, real-time responses can be given to students' various inquiries regarding information about institutions, course Settings, scholarship policies, etc. This comprehensive, precise and efficient service model will not only enhance the efficiency of enrollment management, but also optimize students' initial learning experience, further increasing the affinity and appeal of international Chinese language education.

In teaching implementation, generative artificial intelligence is gradually transforming traditional teaching methods by automatically generating language, images and interactive content, and expanding into multi-modal and highly interactive application scenarios [14, 15]. This system can automatically generate diverse and novel

teaching resources based on course objectives and syllabuses, including graphic and textual courseware, real-world context dialogues, narrative texts, and interactive scenario simulations, etc. For instance, generate daily language practice and pronunciation demonstration audio for beginner learners, and produce deep learning materials covering the analysis of ancient poetry, the evaluation of literary works, and the extension of cultural background for advanced students [16, 17].

In addition, generative artificial intelligence can also play the role of a "personalized mentor", providing tailored learning support for different students [18, 19]. For instance, the output difficulty is dynamically adjusted based on the learner's actual level, and training plans for listening, speaking, reading and writing skills are designed for them. This technology can also enhance cultural immersion through role-playing and scenario simulation, such as simulating conversations with historical figures and integrating classic literary plots, significantly boosting learning motivation and participation [20].

In terms of management and operation and maintenance, generative artificial intelligence, with its capabilities in natural language generation and data analysis, provides educational institutions with high-efficiency and low-cost intelligent management tools [21, 22]. This system can automatically generate reasonable course arrangement plans based on the allocation of teaching staff, course requirements and the characteristics of student groups, improving the efficiency of resource utilization while reducing the burden of manual scheduling [23]. In addition, the generated notifications, emails and announcements can be seamlessly produced and published in multiple languages, ensuring that information such as academic arrangements and urgent matters accurately and promptly reaches students worldwide [24].

In terms of academic data management, this technology demonstrates powerful data processing and analysis capabilities, generating personalized learning reports by integrating learning behavior data such as learning progress, classroom performance and feedback information [25]. Teaching administrators can leverage data to gain insights into students' needs and course outcomes, thereby scientifically adjusting teaching plans and strategies. This data-driven management model not only enhances the effectiveness of decision-making but also provides a crucial basis for institutions to optimize resource allocation and comprehensively improve the quality of education.

In the evaluation and testing phase, generative artificial intelligence is driving language assessment towards an intelligent and adaptive direction. In terms of test question generation, this system can dynamically construct a rich variety of assessment questions with relevant content based on teaching objectives and students' levels, comprehensively covering core language ability modules such as listening, speaking, reading and writing [26, 27]. Such real-time generation mechanisms effectively enhance the adaptability and diversity of the assessment, avoiding the problems of repetition and rigidity in traditional question banks.

During the evaluation and feedback stage, this technology also performs outstandingly, capable of real-time scoring of oral responses or written compositions and providing structured diagnostic feedback [28, 29]. For instance, in oral English assessment, it can not only identify pronunciation deviations but also output correct examples through speech synthesis to assist students in making improvements. In addition, personalized learning plans are automatically generated based on the test results to help students identify their weak points and plan improvement paths. This dynamic and personalized assessment feedback mechanism not only alleviates the burden of teachers' marking but also significantly enhances students' learning outcomes and autonomy.

3 CONSTRUCT AN AUTONOMOUS KNOWLEDGE SYSTEM FOR INTERNATIONAL CHINESE LANGUAGE EDUCATION AND A PREDICTION MODEL FOR EDUCATIONAL VIDEO PARTICIPATION

3.1 The Main Components of the Autonomous Knowledge System for International Chinese Language Education

The autonomous knowledge system of international Chinese language education, along with its disciplinary system, academic system and discourse system, is not parallel to each other or forms a simple inclusion relationship, but rather forms a complex system connection with organic interaction and deep mutual construction. The disciplinary system, academic system and discourse system are not only relatively independent and each has its own focus, but also interpenetrate and support each other in terms of content construction, functional positioning and practical paths, jointly integrating into the overall process of building China's independent international Chinese language education knowledge system. From a macro-level overall planning perspective, the autonomous knowledge system is a highly condensed and concentrated embodiment of the discipline, academic and discourse systems. The top-level design has led the coordinated advancement of the "three systems", clarified their development directions. From the perspective of practical paths, optimizing the disciplinary system, strengthening the academic system, and innovating the discourse system are precisely the core strategies and priorities for systematically promoting the construction of an independent knowledge system at present. By comprehensively promoting the multi-dimensional construction of the "three major systems", a solid theoretical foundation can be laid for the independent knowledge system and sufficient practical support can be provided, thereby promoting its continuous optimization and sustainable development.

The core foundation of the international Chinese language education discipline system lies in the production and integration of autonomous and original knowledge. The autonomous knowledge system, through the integration, breakthrough and expansion of existing theories, forms concepts with symbolic significance, original theories and systematic knowledge frameworks, injecting continuous impetus into the disciplinary system, promoting the all-round progress of international Chinese language education in knowledge production, theoretical innovation and method evolution, and helping to build a disciplinary paradigm with distinct Chinese characteristics. Correspondingly, the disciplinary system also provides

structural support for the autonomous knowledge system. It promotes the intersection and integration of interdisciplinary knowledge by defining the basic categories, theoretical systems and research paths of disciplines, facilitating the generation of original knowledge and the continuous update of knowledge systems, thereby making the autonomous knowledge system more systematic, rigorous and scientific.

The autonomous knowledge system of international Chinese language education provides theoretical sources and development nourishment for the construction of the academic system. The academic system is always rooted within the framework of a specific autonomous knowledge system. In this field, through in-depth exploration and critical reflection on multi-disciplinary knowledge such as linguistics, cultural studies, education, and regional and country studies, a knowledge system with both Chinese characteristics and independent innovation capabilities is constructed. This not only helps to strengthen the theoretical support and methodological awareness of scientific research but also ensures the consistency and continuity of academic research. Conversely, the academic system also expands the disciplinary perspective by standardizing research methods, adhering to academic ethics, and establishing research standards. It uses theoretical accumulation and empirical research as means to ensure the rigor and effectiveness of academic achievements, providing solid theoretical support for global Chinese language education. This promotes the development of the autonomous knowledge system towards a more scientific, standardized, and innovative direction.

The independent knowledge system and discourse system of international Chinese language education constitute a dialectical unity relationship of content essence and external expression, and the two are interdependent and inseparable. On the one hand, an autonomous knowledge system must rely on the corresponding discourse system to achieve effective dissemination and acceptance. As a key medium for knowledge exchange and dissemination, whether the discourse system is normative and systematic, directly affects whether the autonomous knowledge system can be accurately, comprehensively and influentially interpreted and promoted, thereby enhancing the discourse power of the Chinese language in the international context. On the other hand, the construction of the discourse system itself must also take the autonomous knowledge system as its substantive connotation and theoretical foundation. Building a mature, systematic and logically consistent autonomous knowledge system, and deeply grasping its inherent evolution laws and theoretical framework, is the prerequisite and foundation for establishing a scientific, complete and internationally communicative discourse system.

3.2 An International Chinese Education Video Participation Prediction Model Based on Dynamic Graph Neural Network

The overall architecture of the model is shown in Fig. 1, which consists of three core components: the dynamic graph construction layer, the spatio-temporal feature extraction layer, and the linear output layer. The dynamic graph construction layer utilizes the video metadata features (including dynamic and static attributes) provided in the dataset to construct the video dynamic graph structure, which will serve as the input and output basis for the subsequent model training and testing phases. The spatio-temporal feature extraction layer, as the key module of this video engagement prediction model, adopts a variety of dynamic graph neural network models with relatively mature architectures to learn the spatio-temporal correlation features contained in the video dynamic graphs and obtain the high-order feature embedding representations of each video. Subsequently, the graph embedding features extracted by this layer will be input into the linear output layer to predict the engagement metrics of the video on a specific date after its release. To achieve the best performance, this study will adopt multiple training strategies to optimize the model and obtain the model with the best final prediction effect through a complete training process.

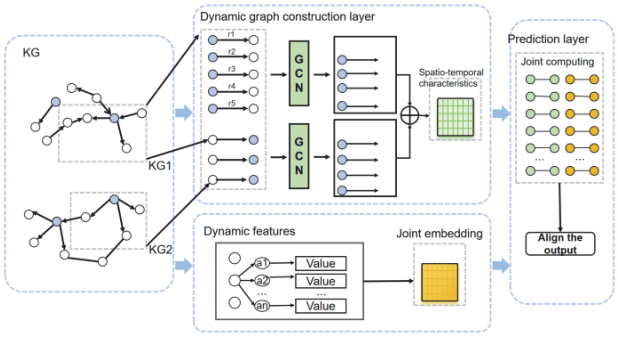

Figure 1 Architecture of an international Chinese online education video engagement prediction model based on dynamic graph neural networks

The abbreviations are shown in Tab. 1.

Table 1 Abbreviations

Abbreviations	Full name
3D	3 Dimensions
AI	Artificial Intelligence
SOM	Self-Organizing Map
SIOM	Server Input/Output Module

The cosine value between the angles of two vectors in a vector space is used as a measure of the magnitude of the difference between two individuals. The closer the cosine value approaches 1 and the Angle approaches 0, the more similar the two individuals are. The closer the cosine value approaches 0 and the Angle approaches 90 degrees, the less similar the two individuals are. The formula for calculating cosine similarity is:

$$\cos\theta = \frac{A \cdot B}{|A| \cdot |B|} \tag{1}$$

The Euclidean distance is a commonly used metric for measuring the distance between two points A, B in space, which measures the absolute distance between two points in an N-dimensional space. The formula for calculating the Euclidean distance is:

$$d = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \tag{2}$$

It is used to measure the correlation between two quantities, with a value range of [−1, 1]. The calculation formula of Pearson similarity is:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{3}$$

After constructing the dynamic graph input data based on video data, these data will be input into the spatio-temporal feature extraction layer of the second part of the prediction model to extract the spatio-temporal features of the dynamic graph and learn to obtain the embeddings of the features contained in the video dynamic graph. The spatio-temporal feature extraction layer attempts to use five relatively mature dynamic graph neural network models at present to effectively learn the video graph structure information and time series information contained in the video dynamic graph data, including the dynamic and static feature information of the video and the relationship information between videos, etc.

Naive Bayes adopts the "attribute conditional independence assumption": for known categories, it is assumed that all attributes are independent of each other, that is, they independently affect the classifier results. This overcomes the obstacle that the class conditional probability $P(x/c)$ is difficult to estimate directly from a limited number of training samples. Suppose there are N possible category markers, namely $y = \{c_1, c_2, ..., \text{If } cN\}$, then the formula for the posterior probability is:

$$P(c \mid x) = \frac{P(c)}{P(x)} \prod_{i=1}^{d} P(x_i \mid c) \tag{4}$$

Here, d represents the number of attributes, and x_i is the value of x on the i-th attribute. The corresponding Bayesian judgment criterion:

$$h_{nb}(x) = \text{argmax} P(c) \prod_{i=1}^{d} P(x_i \mid c) \tag{5}$$

Train a base learner from the initial training set, then adjust the distribution of training samples based on the performance of the base learner to pay more attention to the misclassified samples, and then train the next base learner based on the adjusted sample distribution. Repeat until the number of base learners reaches the pre-specified value T, and finally perform a weighted combination of T base learners. Adaboost can usually significantly improve performance, but sometimes it may overfit. The specific description is as shown in Tab. 2.

Table 2 AdaBoost Ensemble Learning Algorithm

Input: Training set $D = \{(x_1, y_1), (x_2, y_2), ..., (x_m, y_m)\}$;
T: Number of training rounds.
1. $D_1(x) = 1/m$
2. for $t = 1, 2, ..., T$ do
3. $h_i = \xi(D, D_t)$;
4. $\xi_i = P_{x-D_i}\left(h_i(x) \neq f(x)\right)$
5. If $\xi > 0.5$ then break
6. $\alpha_i = \frac{1}{2}\ln\left(\frac{1-\xi_i}{\xi_i}\right)$
7. $D_{i+1}(x) = \frac{D_i \exp\left(-\alpha_i f(x) h_i(x)\right)}{Z_i}$
8. end for
Output: $H(x) = \text{argmax} \sum_{i=1}^{T} \prod \left(h_i(x) = y\right)$

3.3 Analysis of the Importance and Clustering of Video Features in International Chinese Online Education

Based on the mining of the correlation among the three elements of SOM (Self-Organizing Map), the study further explores the differences in research scenarios of the combination strategies of different analysis methods. Due to the small sample size of research scenario $S1$ (highlighting the learner-centered approach), association analysis cannot be conducted. Therefore, the study first mined the association rules of different analysis methods in research scenarios $S2$ and $S3$ respectively, as shown in Tab. 3. Similarly, confidence level (conf) and lifting degree (left) were selected as the measurement basis. Secondly, descriptive statistics on the usage of corresponding analysis methods for different research scenarios and research objectives were conducted.

Table 3 Association rules of analytical methods in different research scenarios

Association rules	Research scenario	Confidence	Improvement	Association rules	Research scenario	Confidence	Improvement
$E \rightarrow A$	$S2$	1	1.22	$G \rightarrow A$	$S3$	1	1.32
$F \rightarrow A$		0.85	1.04	$B, G \rightarrow A$		1	1.31
$A, C \rightarrow B$		0.68	2.34	$D \rightarrow A$		0.88	1.17
$B \rightarrow C$		0.62	2.2	$C \rightarrow B$		0.78	1.4
$C \rightarrow B$		0.61	2.1	$B \rightarrow A$		0.68	0.92

The results of the correlation analysis show that in the research focusing on the interaction scenarios between teachers and students, network analysis and sequence analysis are often combined with classical statistical analysis methods, and the combined application of classical statistical analysis, deep learning analysis and machine learning analysis demonstrates a strong correlation. In research that focuses on the interaction between learners and situations, the combination of interpretability analysis, machine learning analysis, and classical statistical analysis has the highest degree of correlation. Meanwhile, all artificial intelligence-based analysis methods (i.e., interpretability analysis, deep learning analysis, and machine learning analysis) show a relatively close correlation when combined with classical statistical analysis. The three-dimensional composite

diagram further indicates that the analytical methods adopted for practical cases with different research objectives in the same scene do not vary much. However, the analytical methods adopted in cases aimed at solving similar educational problems in different contexts show significant differences. This phenomenon is likely due to the considerable variations in the types and scales of learner and learning context data available in different contexts. The three-dimensional analysis results are shown in Fig. 2.

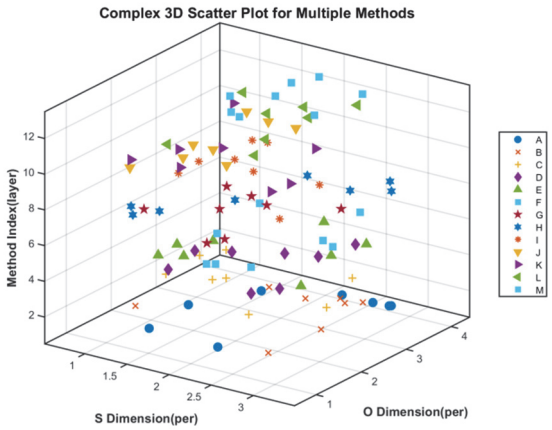

Figure 2 Three-dimensional relationship diagram of the three elements of SOM

To deeply explore the intrinsic connection between research scenarios and analysis methods, this study, based on 110 learning and analysis practice cases supported by intelligent technologies, and referring to the fully connected network structure, constructed a SIOM (Server Input/Output Module) relationship chain model containing four layers of elements. This model takes the research scenario as the input layer, the analysis method as the output layer, and the data type and research objective as the intermediate hidden layer, forming a relationship chain that runs through the entire process. The numbers on the chain represent the quantity distribution of the corresponding research. By leveraging the results of correlation analysis, typical combination patterns among scenarios, goals, data and methods in current learning analysis practices can be identified. For instance, in the experimental teaching scenario based on augmented reality (emphasizing the dominant position of learning), research cases aimed at analyzing the impact of VR operation sequences on learning outcomes are typically explored by collecting VR interaction logs, pre and post-test scores, as well as learning effect questionnaires and structured interview data, and comprehensively applying descriptive statistics, difference tests, and content analysis methods. In the online learning context based on the e-book system (emphasizing the interaction between teachers and students), the practice aimed at achieving precise teaching usually relies on the records of online learning behaviors and the final exam results of the course. Firstly, deep learning algorithms are used to identify learning patterns, then cluster analysis is conducted to classify learner types, and finally the results of descriptive statistics and difference analysis are combined. Provide personalized resource recommendations and teaching content adaptations for learners of different categories, as seen in Fig. 3.

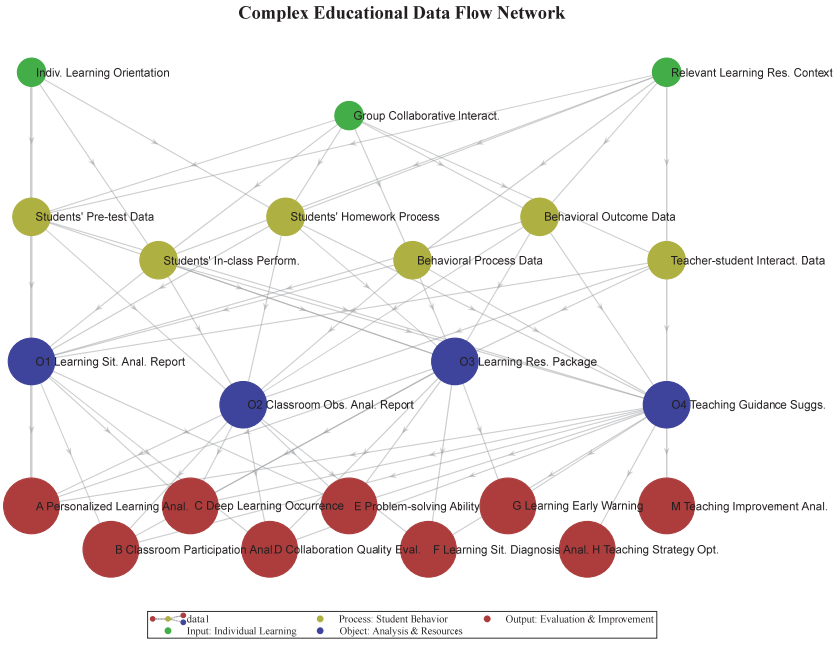

Figure 3 SIOM relationship chain

On this basis, the classification thresholds of all the rules in the rule set are sorted and integrated, and the decision tree algorithm is integrated to determine the judgment thresholds applicable to the early warning of movement and classroom behavior respectively. For each type of behavior, two threshold nodes are set, which are then divided into three intervals, corresponding to three behavioral levels respectively. Taking the number of movements as an example, less than 9.1 times is considered "not meeting the standard", 9.2 to 15.5 times is regarded as "good", and more than 15.5 times is "excellent". By clearly defining the threshold intervals corresponding to behavioral levels, the operability and objectivity of behavioral judgment have been enhanced, providing a

quantitative basis for formulating effective behavioral early warning strategies. To further reveal the underlying patterns of behavioral changes, this study conducted A mean statistics of the characteristic values of exercise and classroom behavior on a weekly basis, and based on the above-mentioned early warning threshold intervals, drew behavioral early warning graphs for two types of students, *A* and *B*, for a period of 12 weeks respectively. In the figure, the depth of color is used to visually represent the behavior level. The lightest area of color represents "not up to standard", and the darkest area represents "excellent", as shown in Fig. 4 and Fig. 5.

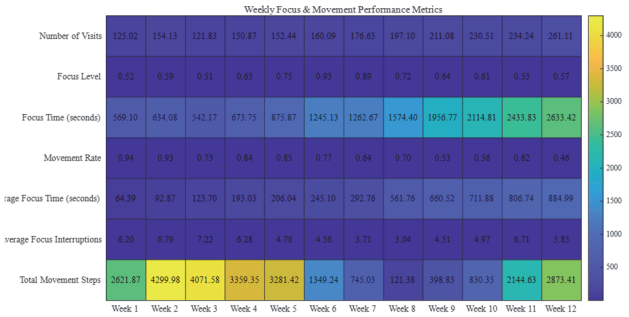

Figure 4 12-week warning chart of movement and classroom behavior characteristics of class *A* students

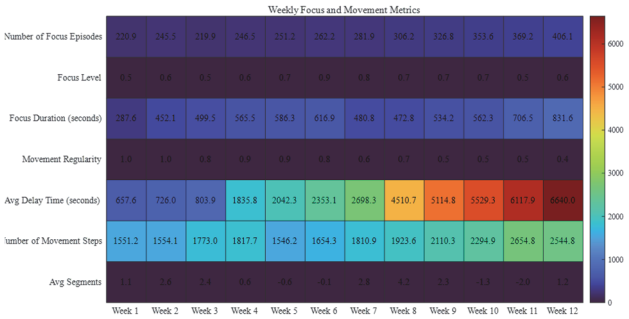

Figure 5 12-week warning chart of movement and classroom behavior characteristics of class *B* students

It is necessary to determine what generative artificial intelligence should and should not do to ensure its reasonable use. At the same time, it is necessary to clearly recognize that the essence of generative artificial intelligence is merely an auxiliary tool, while students' subjectivity and independent thinking ability are the core of education. Students should not be overly dependent on generative artificial intelligence to directly obtain answers. We should not allow "people to develop from physical dependence on machines to mental dependence", nor should "people's physical and mental functions decline". [13] Therefore, it is necessary to rely on technical means to regulate the use of generative artificial intelligence, so that it can play its auxiliary role to the greatest extent without hindering the development of students' abilities.

To effectively prevent the abuse of technology by students and curb plagiarism and cheating, innovative functional designs should be adopted in the functional design process to stimulate students' interest in active learning, guide them to deeply understand knowledge, and cultivate their problem-solving abilities. The principles of functional design include the following aspects: First, avoid directly providing answers. Virtual mentors should encourage students to find answers on their own through heuristic dialogues, thereby stimulating their ability to think actively. Second, monitor the learning process. The communication information between students and virtual tutors will be recorded and authorized for teachers and parents to view. In this way, teachers and parents can closely monitor students' learning situations, thereby reducing the possibility of students cheating. Third, design personalized learning plans, tailor learning plans for each student to ensure that they study according to their actual level and pace, thereby eliminating their motivation to cheat. To develop dedicated generative artificial intelligence, it is necessary to extensively collect and organize various types of data in the field of international Chinese language education, such as textbooks, course resources, examination information, learning behavior data, and corpora. Then, standardize such data and build a large-scale, standardized, and quality-controllable data cluster. During the collection process, it is also necessary to pay attention to protecting data privacy and avoiding issues such as copyright disputes.

The aggregation of data resources requires the joint efforts of all parties. The Confucius Institute Headquarters of the Ministry of Education can fully play its leading role, mobilize the enthusiasm of different institutions and enterprises, establish a data sharing and cooperation mechanism, and jointly build a high-quality international Chinese language education data cluster. To effectively aggregate international Chinese language education data resources, the following measures can be taken: Firstly, establish a unified data platform that provides functions such as storage, release, and exchange, facilitating the aggregation and sharing of data; Secondly, establish standard norms to ensure data quality and reliability; Secondly, establish an incentive mechanism to encourage more institutions and individuals to contribute data and expand data sources.

In conclusion, the development of generative artificial intelligence specifically for international Chinese language education is a forward-looking and innovative technological project, which will bring about tremendous changes and development to the field of international Chinese language education. Of course, we should also be clearly aware that this is a long-term project. To achieve this goal, many challenges still need to be overcome, such as insufficient data, incomplete knowledge graphs, and complex model training. These problems need to be solved through continuous exploration in the future.

4 SIMULATION VERIFICATION

Single-feature analysis uses the SHAP algorithm to analyze the online teaching engagement prediction model based on machine learning random forest regression, and respectively obtains the impact of individual feature changes on video engagement. The following will analyze the impact of individual features on video engagement from various dimensions.

Among the three features covered by the comprehensibility dimension, the coverage and occurrence rate of pause words have the most significant impact on participation, while the influence of ease is relatively secondary. As can be seen from Fig. 6a, when the coverage rate of pause words is higher than 0.6, its SHAP value is

positive, indicating that when the proportion of pause words in the teacher's teaching text exceeds 60%, it has a positive impact on video engagement. Moreover, as this coverage rate continues to increase, the engagement rate also rises accordingly. Pause words play a significant role in regulating the pace of teaching and to a certain extent, promote students' understanding of the content. Therefore, for learners who pay more attention to the comprehensibility of the teacher's explanation, a higher coverage rate of pause words usually means a higher level of participation. In addition, the difficulty level of the course content also affects students' comprehension effect and learning motivation, which in turn influences their participation in the video. Content of lower difficulty can help students gain a sense of achievement more easily during the learning process, thereby enhancing their learning motivation and improving their interest and efficiency in learning. As can be seen from Fig. 6b, when the ease exceeds 90, the SHAP values are mostly positive, indicating that the easier the video teaching content is, the higher the participation rate will be.

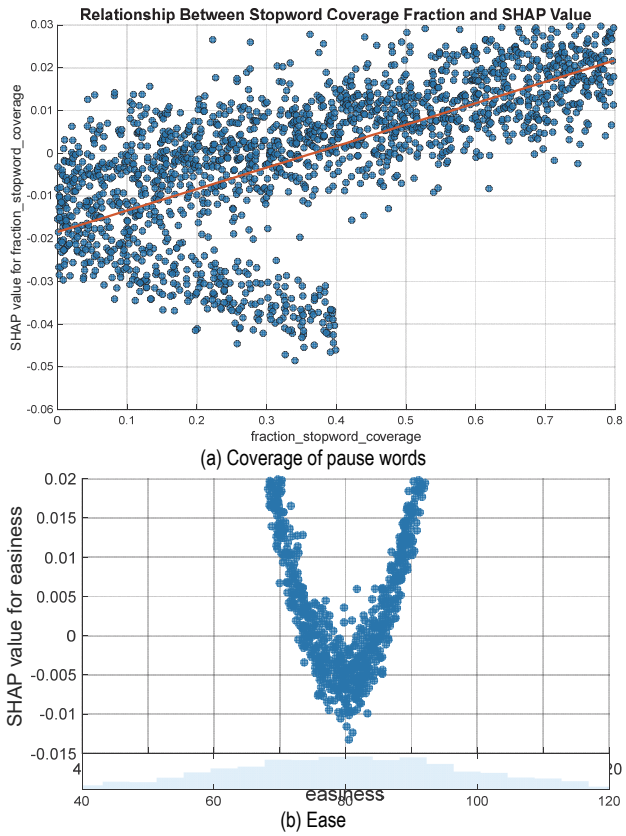

Figure 6 Analysis of the impact of individual features of the understandability dimension based on the SHAP algorithm on the engagement of online education

In the topic coverage dimension, the features covered mainly involve quantitative attributes such as video titles and text manuscripts, among which video length is the most significant factor affecting engagement. As shown in Fig. 7a, when the video length is less than 2000, its SHAP value tends to be positive, and the shorter the video, the higher the participation. This result indicates that students are more inclined to watch shorter teaching videos in full, while overly long videos have an adverse effect on engagement. Previous studies have also pointed out that short videos usually have a higher level of engagement because they require teachers to plan their teaching content more precisely and improve their expression efficiency, thus often having better content quality and attracting a higher level of participation. As can be seen from Fig. 7c, the impact of document word count of different lengths on engagement is not consistent, with both positive and negative effects. The word count of a document may indirectly affect engagement performance by influencing the duration of the video. Subjectively speaking, the role of the title's word count is often instantaneous. It may be a key factor in attracting students to click and watch, but its influence on sustained viewing behavior is relatively weak. However, as shown in Fig. 7d, when the video title is less than 2.5 characters or more than 15 characters, it has a positive impact on engagement. Titles with a length in the middle range, however, show uncertainty in their impact, having both positive and negative effects. Although there are no relevant studies that clearly support this finding at present, based on the results of this study, it is still recommended that video producers use shorter or longer titles to enhance the engagement performance of their videos.

Document entropy can be used to estimate the cohesion of a document, and documents with lower entropy tend to have a more single topic. It can be seen from Fig. 7b that when the document entropy is low, its impact on engagement is both positive and negative. However, when the document entropy is greater than 8, the larger the value, the more positive the impact on engagement. From this, it can be known that the content of teaching videos is not limited to a single theme. Appropriate theme expansion and the use of more diverse content can better stimulate students' participation.

Among the dimensions of video presentation methods, the teaching speed, silence rate, and whether the video is segmented are all worth discussing. It can be seen from Fig. 8a that when the speaking speed is greater than or equal to 4, the SHAP value is positive. At the same time, it can be observed that a high SHAP value occurs between 4 and 5 words per second, which can be determined as the speaking speed corresponding to the best engagement. Meanwhile, a speaking speed greater than 4 also has a positive effect on engagement. Students are more inclined to participate in videos with relatively faster speaking speeds. Of course, the speaking speed should not exceed the normal range that humans can understand. This finding is also in line with the assertion in the research that increasing the speaking rate in lecture videos may lead to a peak in video interaction due to confusion or curiosity.

A certain amount of silence during teaching can provide students with more space for thinking, which is consistent with the role of pause words. Therefore, it can be seen from Fig. 8b that a silence rate of 0.4 or more is relatively ideal and has a positive effect on participation. Although the importance weight of whether a video is segmented is very low, its impact on engagement is distinct. As can be seen from Fig. 8c, the impact of unsegmented videos on engagement is negative, while most segmented videos have a positive effect on engagement. Segmented videos can be effectively controlled in terms of length, thereby influencing the engagement of teaching videos.

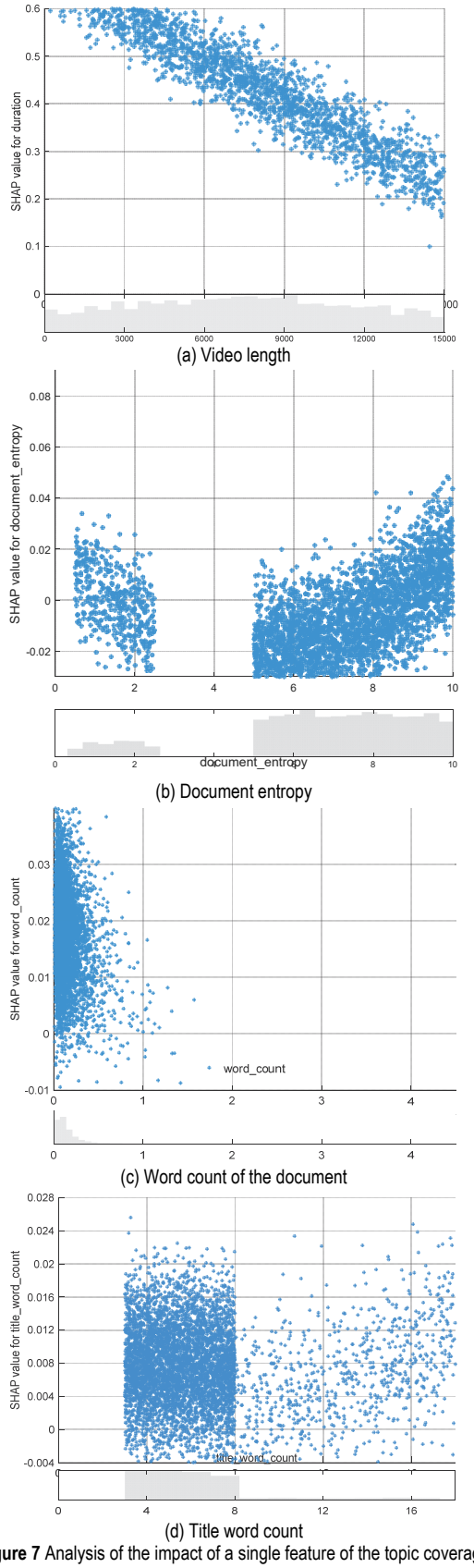

Figure 7 Analysis of the impact of a single feature of the topic coverage dimension based on the SHAP algorithm on the engagement of online education

It is obvious that as can be seen from Fig. 8d, when the freshness is greater than 16000, the SHAP value is positive, that is, the closer the release time of the video, the higher the participation rate. However, videos with a relatively long release time may have a SHAP value close to 0 due to the reduction of their existing traffic, that is, the participation level is almost not affected by the release time. Videos with freshness in the middle have a lower level of engagement. So students still tend to choose more novel teaching videos to participate in, perhaps thinking that the authority of newly released content is also higher.

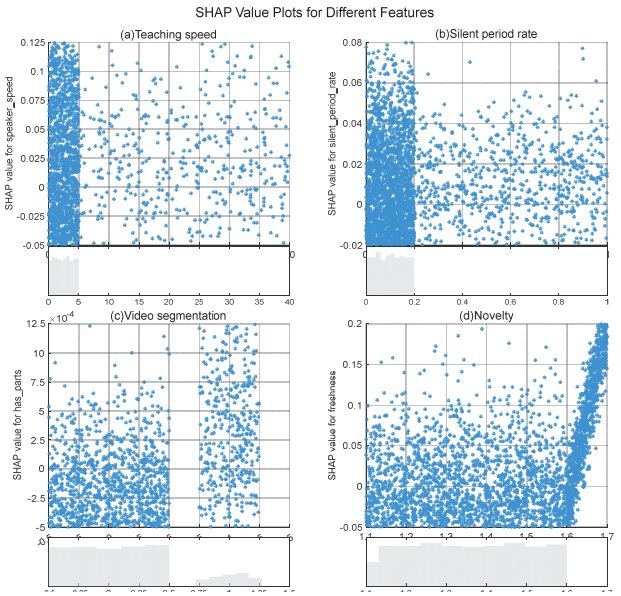

Figure 8 Analysis of the impact of individual features of the representation mode dimension based on the SHAP algorithm on the engagement of online education videos

Based on the above analysis of the importance of features and the impact of each feature on engagement, this study proposes guidance suggestions for video production from multiple aspects, mainly including the following: 1) The length of teaching videos should be controlled within 30 minutes, and the content can be organized in segments to ensure that each video is of moderate duration. While shortening the video duration, it is necessary to plan and design the teaching content more meticulously to achieve the quality requirement of being "short but precise". 2) The difficulty of the teaching content should be reasonably controlled. It is recommended that the proportion of the more difficult part does not exceed 60%. Video producers should, on the premise of achieving teaching objectives, minimize the difficulty of the content as much as possible to maintain students' learning motivation. 3) Teachers should keep their language engaging when giving lectures. Research shows that moderately increasing the speaking speed can help enhance students' enthusiasm for learning. However, during the explanation process, pause words should be used reasonably or appropriate pauses should be made to enable students to keep up with the teacher's train of thought and promote the digestion of content, thereby enhancing their acceptance and understanding of online educational videos and ensuring their effective participation. After the video feature dimensionality reduction is completed, cluster analysis can be conducted on the video based on the three types of features obtained from the dimensionality reduction. During the clustering process, the number of categories needs to be determined first. In this study, the commonly used elbow method was adopted, and the number of video clusters was determined to be 4 categories. The data was also normalized before clustering. In this study, the *k*-means clustering algorithm

was used to cluster the video data, and the results are shown in Fig. 9. The clustering effect is good. Except for a few outliers, the vast majority of sample points can be clustered in the corresponding categories, and the boundaries between each category are clear, presenting a good degree of separation.

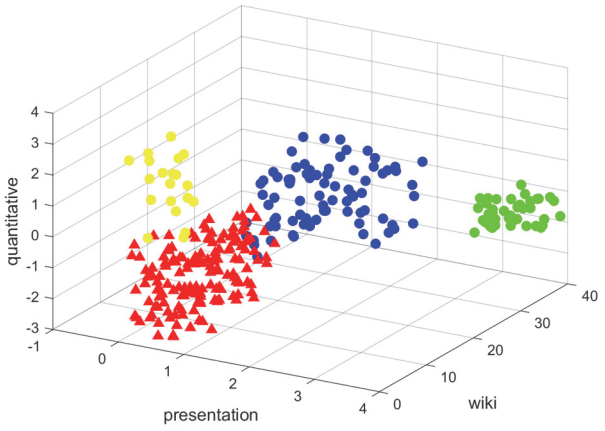

Figure 9 Video *K*-means clustering results

According to the data in Fig. 10, 71.55% of the surveyed pre-service international Chinese language teachers believe that the large volume of knowledge is the greatest advantage of generative artificial intelligence, followed by those who chose "being able to provide ideas", with 69.83% The following in sequence are "text generation that meets requirements", "Personalized and customized content generation", "rich creativity", "quick response" and "image generation", accounting for 59.48%, 54.31%, 51.72%, 50.86% and 50.86% respectively. The number of people who think that the knowledge of generative artificial intelligence is highly specialized is the smallest.

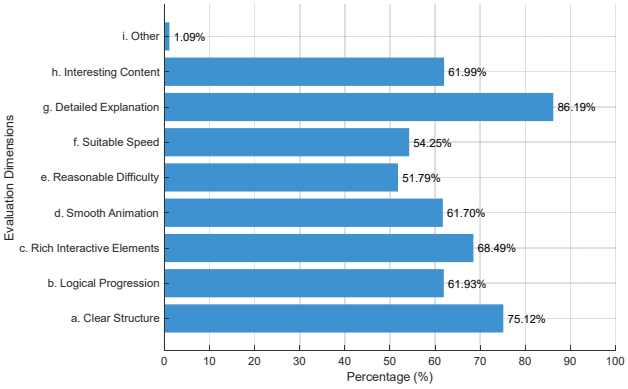

Figure 10 Statistical Chart of the advantages of generative Artificial intelligence

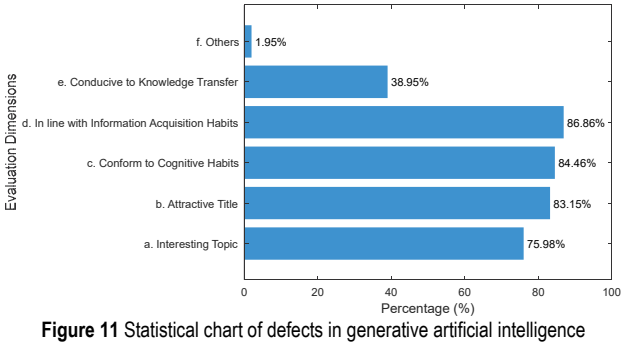

Figure 11 Statistical chart of defects in generative artificial intelligence

"Others" can be filled in and answered openly. One person pointed out that the image generation of the generative artificial intelligence was incorrect. The possible reasons have been explained to some extent in the previous text and will not be repeated here. As can be analyzed from the data in Fig. 11, 64.66% of the respondents believe that generative artificial intelligence has significant limitations in specialized fields, ranking first in terms of deficiency. This is basically consistent with the situation in the previous question regarding the strength of expertise in generative artificial intelligence knowledge. The number of people who believe that "logical reasoning ability has certain limitations", "emotional deficiency" and "data errors and deviations" are relatively close, accounting for 59.48%, 61.21% and 57.76% respectively. Only 33.62% think that the content is not timely enough. In conclusion, when using generative artificial intelligence, careful review should be conducted in terms of data, logical reasoning, and professional content.

5 CONCLUSION

Based on the aforementioned cases and analyses, it can be known that generative artificial intelligence shows broad application prospects in the field of language learning, and its development process is urgent and cannot be delayed. By analyzing the engagement prediction model with interpretable machine learning algorithms, the influence mechanisms of various video features on engagement can be identified. Meanwhile, by conducting feature dimension reduction and clustering processing on video data and combining it with statistical analysis, the differences in video engagement under different feature combinations can be revealed, thereby providing a certain degree of reference basis for video producers regarding high-engagement video types. Facing the above challenges, the future development is still full of opportunities: personalized learning experiences will continue to deepen, interactive and immersive teaching methods will be constantly enriched, and the system for cultivating cross-cultural communication skills will also be increasingly improved, jointly promoting the systematic transformation of international Chinese language education. In addition, artificial intelligence technology will promote the refined optimization and efficient reuse of teaching resources, significantly enhancing the efficiency of resource utilization. The continuous improvement of real-time feedback and evaluation mechanisms will also effectively enhance the overall effectiveness of international Chinese language teaching and learning. It is precisely these challenges and prospects that jointly shape the theoretical framework and practical direction of generative artificial intelligence in the digital and intelligent process of international Chinese language education. International Chinese language education programs not only serve as a bridge for cross-cultural communication, promoting the global dissemination of the Chinese language and mutual understanding among countries, but also play a positive role in educational innovation and responding to global educational changes. The development of globalization and digitalization has provided a broad space for international Chinese language education.

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Contact information:

Vancuong KIM
College of Liberal Arts,
Southwest University, Chongqing, 400715, China

Duwen LU
(Corresponding author)
International Communication College,
Jilin International Studies University, Changchun, 130117, Jilin, China
E-mail: lldwwgz@126.com