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Artificial Intelligence Empowers International Chinese Language Education: Current Application Status and Future Prospects

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Abstract: With the growth of China's economy and the gradual rise of its status, more and more international friends have begun to learn Chinese. As an important language in the world, Chinese is gaining an increasingly solid position. International Chinese language education plays a role in spreading Chinese culture and realizing two-way communication between China and foreign countries. However, traditional Chinese language teaching models in China face many problems. These include insufficient teaching resources and overly rigid teaching methods, which fail to meet the learning needs of individual students. At present, artificial intelligence (AI) technology is developing rapidly and has begun to penetrate the field of education, with the field of international Chinese language education attracting particular attention. In recent years, AI's great potential in areas such as teaching content production, personalized learning, and writing guidance has become increasingly prominent. By using these technologies, teachers can import various materials to help students better understand the content of textbooks. AI also enables students to access personalized learning in a short period and assists them in writing revision. Therefore, these technologies can effectively help teachers improve teaching effectiveness, enhance students' learning experience, and break through the factors that affect teaching quality under the traditional teaching model [1]. Studying the current application status and development trends of AI in international Chinese language education is conducive to promoting the high-quality development of international Chinese language education. Learning from experiences and lessons can improve teaching design. Through optimized teaching, the quality of education and teaching can be continuously enhanced, thereby promoting the innovative and healthy development of international Chinese language education.

Keywords: Artificial intelligence; International Chinese language education; Intelligent teaching

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1. Analysis of the current application status of artificial intelligence in international Chinese language education

Domestically, the application scope of artificial intelligence (AI) in international Chinese language education is relatively broad and closely integrated with practice, showing the dual characteristics of "technology-driven" and "market-driven." At present, domestic research on the application of AI in the field of language education mainly focuses on the following areas: AI-empowered Chinese pronunciation and oral teaching, AI-empowered Chinese character and vocabulary teaching, and AI-empowered personalized learning and adaptive systems [2].

1.1. AI-empowered Chinese pronunciation and oral teaching

As the cornerstone of language learning, standard pronunciation is a prerequisite for effective communication. For learners of Chinese as a second language, initial consonants, vowels, and especially tones with a meaning-distinguishing function are core difficulties in the acquisition process and key focuses of teaching.

Intelligent speech technology mainly includes three major technologies: Automatic Speech Recognition (ASR), Text-to-Speech (TTS), and speech assessment. In Chinese pronunciation teaching, ASR technology converts learners' speech into text to provide real-time feedback. Speech assessment technology quantifies and scores the accuracy of learners' pronunciation by analyzing features such as their tones and prosody. Domestically, the FIF scoring system developed by iFlytek has achieved industrial application, which can comprehensively evaluate students' oral performance from four dimensions: pronunciation accuracy, stress, fluency, and content integrity. In addition, pronunciation error detection systems based on deep neural networks have become a domestic research focus. Zhang *et al.* used Deep Neural Networks (DNN) for acoustic modeling, significantly improving the accuracy of pronunciation error detection. Gan *et al.* adopted deep full-sequence convolutional neural networks and Connectionist Temporal Classification (CTC) technology to realize end-to-end pronunciation error detection and diagnosis. These technologies can accurately identify typical errors of learners in initial consonants, vowels, tones, etc., and provide targeted correction suggestions [3–5].

In terms of application platforms, a number of intelligent speech teaching platforms integrating "teaching, learning, practicing, and assessment" have emerged in China. For example, the "SAIT Chinese" platform developed by Beijing Language and Culture University has functions such as pronunciation demonstration, error correction, and learning progress tracking, and is matched with teaching resources such as Developing Chinese, featuring strong practicality. In addition, apps such as "Aha Chinese" and "e-Learn Chinese" also widely integrate speech recognition and assessment functions, supporting learners to conduct exercises such as follow-up reading, recording, and scoring. These platforms have achieved certain results in enhancing learning interest and pronunciation accuracy, but they also have problems, such as limited teaching resources and low accuracy in local error recognition.

Artificial intelligence has promoted the transformation of Chinese oral teaching from "teacher-centered" to "student-centered," realizing data-driven personalized teaching. By analyzing learners' speech data through big data, the system can generate personalized learning paths and feedback reports. Zheng analyzed the structure of oral teaching through a teaching calculation model, providing data support for teachers and realizing the transformation from "experience-based" teaching to "data-driven" teaching. In addition, the application of knowledge graph technology enables the system to recommend suitable learning resources and practice content according to learners' cognitive status and interest preferences, realizing "teaching students in accordance with their aptitude."

1.2. AI-empowered Chinese character and vocabulary teaching

The application of AI technology in the field of Chinese character and vocabulary teaching has formed a multi-dimensional and multi-level research pattern. Domestic scholars have conducted in-depth explorations from perspectives such as technology research and development, tool innovation, and teaching model reconstruction. In terms of Chinese character writing teaching, the application of AI has gone beyond simple character form presentation and entered a new stage of intelligent and refined evaluation.

In the aspect of Chinese character recognition, the research focus is on improving the ability to recognize complex character forms and multi-style writing. Ma and Xu proposed a stacked model-driven method to address the recognition challenge of calligraphic characters, which feature "large intra-class differences and small inter-class differences." This method uses ResNet-50 as the base model and significantly improves the accuracy of distinguishing similar-looking characters through secondary recognition. This strategy complements the ensemble learning (e.g., Soft-Voting) method adopted by Wang, collectively demonstrating the advantages of multi-model collaboration in addressing the complexity of Chinese character structures. In terms of intelligent evaluation, research has evolved from simple correctness judgment to a multi-dimensional quantitative assessment of writing quality. Wang automatically extracted deep stroke features through a pre-trained recognition model, avoiding the subjectivity of traditional manual feature design. He also constructed a comprehensive evaluation index (CR = 0.7TR + 0.3SR) by combining stroke similarity (TR) and structural similarity (SR). In terms of writing generation and control, research has begun to explore how to convert writing rules into executable physical actions. Min designed an intelligent input system for writing robots based on machine translation. It determines the stroke order through structural analysis and adopts normalized coordinate processing technology (e.g., coordinate transformation based on projection mean and standard deviation) to reduce writing deviations. Experiments were conducted on 200 Chinese characters using the CASIA-OLHWDB dataset, achieving a stroke order accuracy rate of 98% and maintaining high recognizability in multi-style writing, which verifies its effectiveness in automated writing [6,7].

In the field of vocabulary teaching, the core of AI empowerment lies in the planning of personalized learning paths based on the individual cognitive laws of learners, with its theoretical foundation mainly being the Spaced Repetition algorithm. Its core technology is the construction of a dynamic learner model. By continuously recording and analyzing learners' behavioral data—such as vocabulary answer accuracy, response time, and forgetting curves—the system builds a unique cognitive profile for each learner. Based on this model, adaptive learning systems (e.g., the core algorithm of Anki and its derivative applications) can accurately predict the optimal review time for each vocabulary item and push it at the memory critical point, thereby effectively combating forgetting and improving long-term memory efficiency. Furthermore, leading online Chinese teaching platforms (e.g., Wukong Chinese, Lingo Ace) deeply integrate this adaptive learning mechanism with rich multimedia resources, gamified design, and in-person teaching. The system can not only plan review rhythms but also dynamically adjust the difficulty and push order of learning content according to learners' weak points, realizing true "teaching students in accordance with their aptitude." For example, when the system diagnoses that a learner has persistent difficulties in a certain semantic field (e.g., "catering-related" vocabulary), it will automatically generate or push more relevant example sentences, situational dialogues, and even micro-courses to trace the source of knowledge points and provide remediation. This indicates that the role of AI in vocabulary teaching has transformed from a static tool to an intelligent tutor capable of providing contextualized and dynamic learning experiences.

1.3. AI-empowered personalized learning

Luo pointed out that Learning Path Planning (LPP) and Knowledge Tracing (KT) are two core technical pillars for solving the scalability challenge of "teaching students in accordance with their aptitude." Zhao further emphasized that "state awareness" must be achieved first before "path generation" can be discussed; otherwise, recommendations will lack a valid basis. Li's integrated framework proved that when KT, LPP, and Reinforcement Learning (RL) are placed in a unified Knowledge Graph (KG) context, the system can achieve both "personalization" and "consistency with educational logic" at both the curriculum-level and task-level scales.

In recent years, knowledge tracing models based on deep learning have demonstrated stronger performance. The Deep Knowledge Tracing (DKT) model proposed by Piech *et al.* treats knowledge tracing as a sequence prediction problem. It uses Recurrent Neural Networks (RNN) to output continuous knowledge mastery probabilities, which can more delicately reflect changes in learners' knowledge states. To further enhance the model's interpretability and ability to capture complex knowledge relationships, subsequent studies have developed models such as the Dynamic Key-Value Memory Network (DKVMN) and Graph Neural Network-based Knowledge Tracing (GKT) model. The DKVMN model explicitly stores and updates the mastery state of each knowledge point through an independent "value matrix"; the GKT model, on the other hand, models the structural relationships between knowledge points as a graph, enabling effective handling of dependencies between knowledge points. These advanced knowledge tracing models provide an accurate and dynamic data foundation for subsequent path planning, diagnosis, and remediation.

Based on accurate learner models, the system can plan personalized learning paths for different learners. This mainly relies on the integration of technologies such as knowledge graphs and knowledge tracing. Knowledge graph technology plays the role of a "navigation map" in this process. By constructing a structured semantic knowledge base, it clearly depicts the logical relationships, difficulty levels, and associations between Chinese language knowledge entities such as vocabulary and grammar points. For example, Cao *et al.* built a vocabulary knowledge graph based on the International Chinese Language Education Standards for Chinese Language Proficiency, and developed a vocabulary adaptive learning platform on this basis [8,9].

In practical applications, the system first evaluates the learner's real-time mastery probability of each knowledge point using models such as DKT and GKT through initial assessments or continuous data collection. Then, combined with the prerequisite relationships, difficulty levels, and other connections between knowledge points revealed by the knowledge graph, it calculates and recommends an optimal learning sequence for the learner. For instance, for a learner who has weak mastery of the "ba"-construction, the system may automatically recommend that they first consolidate relevant prerequisite knowledge points such as "localizers" before learning the core sentence pattern, thereby dynamically adjusting the learning content and difficulty. Leading online Chinese teaching platforms, such as Wukong Chinese and Lingo Ace, use such technologies in their backend systems to provide customized curriculum progression plans for global learners.

2. Risks and challenges faced

Currently, AI technology still faces various challenges and limitations in empowering Chinese character and vocabulary teaching. These limitations stem not only from the technology itself but also involve multiple aspects such as application scenarios, resource construction, and user acceptance. At the technical level, the recognition accuracy of speech and oral teaching systems still needs improvement. Existing intelligent speech technology is relatively sensitive to environmental noise, and its recognition accuracy for local phoneme features and tone values is not high, especially its performance in continuous speech streams and complex contexts remains unstable. For example, platforms like "Aha Chinese" still have issues with inaccurate tone recognition in practical applications; while "e-Learn Chinese" can comprehensively assess pronunciation, its feedback form is single and lacks the ability to dynamically evaluate pronunciation methods [10–14].

Second, there are still obstacles to the in-depth integration of technology and teaching, particularly in defining the boundaries of human-machine collaboration. Although AI language partners and intelligent correction systems can undertake part of the teaching tasks, practice shows that learners still have a strong preference for real-person interaction (e.g., most students still prefer to converse with real-person language partners). This reflects that current technology is still deficient in capabilities such as high-level cognitive guidance, emotional interaction, and cultural immersion. How to achieve complementary advantages between humans and machines, rather than simply replacing teachers, is an urgent problem to be solved. At the same time, whether teachers have sufficient data literacy and technology application capabilities to effectively use these systems has also become a major challenge in the promotion process.

In addition, personalized recommendation algorithms themselves have potential risks, with the "information cocoon" effect being the most typical. If the system only pushes content based on students' current interests and levels, it may limit the expansion of their knowledge horizons, making it difficult for them to access challenging content beyond their comfort zone. This may conflict with the goals of language education, which emphasize the cultivation of comprehensive abilities and cross-cultural literacy. Furthermore, the fairness and transparency of algorithms are also worthy of attention. If there are biases in the training data, it may lead to unfair or unexplainable recommendation results, affecting teaching fairness.

3. Future outlook

Currently, artificial intelligence is developing at a rapid pace. After the emergence of some representative large AI models, future international Chinese language education will certainly benefit from the implementation of more AI technology applications. A large number of innovative "AI + International Chinese Language Education" application products will emerge to serve more frontline teachers, learners, and educational decision-makers. In the process of providing services, teaching will become more intelligent, learning will be more tailored to needs, and educators will also be provided with a solid basis for decision-making. Of course, it must also be noted that while AI brings many conveniences to teachers, learners, and decision-makers, it also gives rise to more problems. These problems mainly stem from vulnerabilities and errors in both the tools themselves and the users. In the next stage of AI research, we must not only affirm the final results of "AI + International Chinese Language Education" but also deeply explore more existing problems and propose countermeasures. In summary, the future development of "AI + International Chinese Language Education" will, to a certain extent, open a new era of education. More breakthroughs and innovations will emerge in the future, bringing better learning experiences to every Chinese language learner around the world [15]. This review aims to synthesize current applications, critically analyze challenges, and discuss future trajectories, thereby contributing to the strategic integration of AI in this field.

Disclosure statement

The authors declare no conflict of interest.

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