



A Review of the Current Status and Development of Using Information Technology and Chinese Character Learning APPs in Teaching Chinese Characters to Foreign Learners

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Abstract. The use of information technology and apps in the field of teaching Chinese characters to foreigners has developed significantly over the past three decades. This paper reviews the current status of the use of information technology and Chinese character learning apps in teaching Chinese characters to foreigners over the past thirty years and its future development. The current review first discusses the current status of teaching Chinese characters to foreigners in the last thirty years followed by an overview of the current status of teaching Chinese characters to foreigners based on information technology and apps for future development. Then it probes into the possible roles of the language model in the teaching of Chinese characters to foreigners. Last but not least, it combines comprehension-based learning and the Chinese character network to give insights into teaching technology and app development. Based on review above, a practical program design for Chinese Character learning: Opti-Hanzi, is attached to the article.

Keywords: Teaching Chinese Characters to Foreigners; Information technology; Language Model; Comprehension-based learning.

1 Introduction

As China continues to rise in international affairs, the importance of Chinese as a language for international communication has heightened. Teaching Chinese characters, integral to understanding Chinese language and culture, is essential for foreigners. Research can improve teaching methods, fostering efficient character mastery and enhancing cross-cultural communication, thereby strengthening China's international relations. However, the emergence of information technology and Chinese character learning apps offers innovative solutions to this challenge. This review aims to review the use of information technology and apps in teaching Chinese characters to foreign learners, exploring their integration into language teaching pedagogy and their impact on learner motivation, engagement, and proficiency. Furthermore, combining with comprehension-based learning and the Chinese character network, this review delves

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into the challenges and future directions in leveraging technology to enhance Chinese character learning for foreign learners, considering factors such as accessibility, usability, user experience, and cultural adaptation. It aims to provide a roadmap for educators, researchers, and developers interested in harnessing technology to support Chinese language learning in an increasingly interconnected world.

2 Research on the Current Situation of Teaching Chinese Characters

In the teaching of Chinese characters, the use of effective teaching models and teaching methods can greatly improve the efficiency and quality of teaching Chinese characters in the classroom, so the research on teaching models and methods of teaching Chinese characters has attracted a lot of attention. Since 1950s, the question of whether to adopt the "integration of oral and written" or "separation of oral and written" teaching mode in Chinese language teaching has been debated among academics for a long time. With the development of Chinese language education for foreigners, substantial studies on Chinese character teaching methods had focused on three aspects of the "Chinese Character Component Teaching Method": motivation, structure, and phonetics ^[3].

2.1 Research on Teaching Chinese Characters in Non-Chinese Characters Cultural Circle for International Students

There are abundant studies focusing on teaching of Chinese characters in non-Chinese Character Cultural Circles. Most of them provided suggestions for the teaching of Chinese characters to international students in non-Chinese Character Cultural Circles. For example, Li (2023) proposed a series of principles and strategies for teaching Chinese characters to international students in the non-Chinese character circle at the primary stage by combining Piaget's schema theory with recognizing and writing Chinese characters ^[12]. Zhou (2022) investigated and analyzed the online Chinese character learning and teaching situation of international students at the beginning stage of the non-Chinese character cultural circle ^[33]. He summarized the problems and difficulties of online Chinese character learning for international students with no basic knowledge of Chinese characters and found that novice teachers have ambiguous concepts of Chinese character theories such as "Chinese character motivation" during the process of teaching Chinese characters. Accordingly, he put forward the following suggestions: novice teachers should continue to explore online resources for teaching Chinese characters, such as "Oxford University Chinese Teaching Center," "Duolingo App," etc. They should also improve their intermediary language proficiency and cope with the challenges of teaching Chinese characters in online classes, such as unstable networks.

Observations of international students from non-Chinese character cultural backgrounds revealed specific focuses in their Chinese character learning strategies. These included integrating characters with culture, addressing associations and errors in

character sound and shape, and emphasizing teachers' teaching methods. Teachers were required to incorporate cultural awareness into character teaching and utilize new technologies to improve teaching efficiency. Efforts were also made to reduce students' orthographic errors, with teaching tailored to individual backgrounds and language proficiency levels.

2.2 Quality of the Chinese Character Assessment System

Xiong and Peng (2013) suggested that with the support of digital technology, computer-assisted assessment had become an effective means to improve the efficiency and quality of Chinese character assessment^[26]. It suggested achieving personalized resource recommendations and supporting multi-terminal usage. These improvements also benefited assessment systems in teaching Chinese characters to foreigners by providing digital resources. Zhang et al. (2022) examined Chinese character assessment by testing 162 CSL learners with different L1 backgrounds and Chinese proficiency levels^[30]. Compared with the phonetic method, the semantic method, and the pronunciation and meaning method, it was concluded that the semantic method has better character test quality than the other two methods. The conclusion was different from Chan's (2020)'s^[2]. They took second-language kindergarten children as survey subjects who performed best in the pronunciation and meaning method. This contrast implied that the Chinese character assessment system worked differently for different groups with proficiency of L1, even different ages. Therefore, the quality of the Chinese Character Assessment System still needs to be reexamined. It can improve its development and application based on information technology.

To summarize, previous research on teaching Chinese characters to foreigners provided insights and raised questions about Chinese character learning based on information technology and apps. Implications included personalized learning, interactivity, real-time feedback, multimedia support, and cross-platform learning. However, there were still deficiencies in the process of teaching Chinese characters to foreigners with information technology, awaiting improvement in the future. Issues included: uneven skill levels, validation of effectiveness, personal privacy and data security, teacher training and support: Teachers need to be provided with adequate training and support to effectively use IT tools to guide students in effective learning.

In future research and applications, there was a need to continue to delve deeper into the potential of IT in teaching Chinese characters to foreigners to solve related problems to improve the effectiveness and quality of Chinese character learning.

3 Implications of the Current Situation of Teaching Chinese Characters to Foreigners based on Information Technology and Apps for Future Development

In the age of rapid social informatization, network technology is advancing, facilitating interactive teaching and learning activities worldwide through the widespread use of mobile devices and multimedia technology. This trend promotes educational inno-

vation and emphasizes the role of modernized information technology in teaching. In line with this trend, Chinese language education has also embraced technological advancements. This review explores the characteristics, current shortcomings, and future directions of using information technology in teaching Chinese characters in Chinese as a foreign language.

Jin, H. (2006) demonstrated the effectiveness of multimedia presentations in improving teaching and learning ^[8]. Wang (2014) advocated that computer animation was beneficial for learners to make mental connections, understand the origins of Chinese characters, and enhance long-term memory ^[23]. In the context of computer-assisted learning, Hong & Hsiu-Jen (2014) pointed out that technology played an important role in enhancing the strokes, stroke order, and synonyms, and simplifying the learning format of Chinese characters, which was conducive to the establishment of connections between the elements of Chinese characters ^[29]. The authors designed the REEE model of Chinese character teaching, which is divided into four phases, but its validity needed to be verified through qualitative and quantitative studies.

Several studies had explored students' responses to the use of digital tools for teaching Chinese characters, with divergent learning outcomes. For example, McLaren & Bettinson (2016) reported positive attitudes among college students toward Skritter, a web-based character learning service and application, which suggested that these digital tools promoted student engagement, enhanced their motivation, and allowed for a wide range of learning strategies ^[17]. However, challenges remained in adapting spatial repetition-based learning of Chinese characters to the typical classroom schedule. Nevertheless, in Lam et al.'s (2017) study of students' perceptions of Quizlet, many students expressed reluctance to use the app outside of class ^[10]. Guan et al. (2011) stated that some teachers and students were concerned that typing or learning through digital or online tools generally did not replace handwriting in helping learners build spatial-motor memory and mental representations of refined Chinese characters ^[4]. In other words, students' affective responses to digital text learning tools may vary depending on personal preference and the tool itself.

The above review suggested that there was a relative lack of research on teaching Chinese characters online before 2020. Influenced by the outbreak of COVID-19 in 2019, online teaching had become a regular mode of teaching Chinese as a foreign language. The academic community had increased the research on online teaching of Chinese as a foreign language, such as the research on teaching Chinese as a foreign language based on the Tencent conference (2021) ^[1], and the research on classroom interaction of online teaching of Chinese as a foreign language in the post-epidemic era (2022) ^[32]. Huo (2022) investigated the causes, characterization, and functions of the multi-contextual system local model of online teaching of Chinese as a foreign language in the post-epidemic era ^[7]. It could be seen that as the demand for online teaching of Chinese as foreign language increases, the research had become more specialized. The integration of pedagogy, linguistics, and other multidisciplinary disciplines for auxiliary analyses was in stark contrast to the state of research in the same field before 2020. The epidemic and post-epidemic era had also provided new ideas and put forward new requirements for teaching Chinese characters as a foreign language. In Wang's (2023) survey, with the assistance of technological tools, students

could control the content and pace of their presentations. After submitting the task, students could still review the exercises. Due to the establishment of a fixed order of learning, students could successfully study on their own even when the teacher was not present in school ^[22]. Zhu (2023) focused on the application of micro-videos in teaching Chinese characters to foreigners ^[34]. She concluded that students could previewed by watching micro-videos before class, enhanced their understanding of Chinese characters by watching micro-videos during class, and reviewed and consolidated by watching micro-videos after class, thus maximizing the use of micro-videos and improving students' learning efficiency. There was also some technology served phonetics specifically. Liang et al. (2022) proposed an automatic speech recognition system for Chinese words, utilizing Pinyin as a constraint during decoding within a multi-task learning framework. The primary task is Chinese character target automatic speech recognition (ASR), while Pinyin target ASR serves as the auxiliary task. Experimental results demonstrate that the proposed model achieves better recognition performance, reducing the word error rate (WER) by 2.24% ^[13].

In the research on the application of information technology in teaching Chinese as a foreign language, there were also researchers focusing on the characteristics, shortcomings, and upgrading suggestions of Chinese character teaching apps. Chinese Character Learning App is to make Chinese Character Teaching Resources into application programs and promote and develop them through an APP platform. Users can purchase or download APP teaching resources from the app store to use them through the Internet. Some apps can also continue to be used without the Internet. Jie et al. (2014) focused on an iPod Touch app: Mobilese ^[15]. The app included personalized learning functions such as "personal collection," which could be used for self-directed individual learning, game-based learning, and group learning. As it was initially developed for primary school students, its operation was simple and suitable for most people. According to the characteristics of Chinese characters, the change of fonts in the application led to the change of strokes and shapes of Chinese characters, which was confusing for beginners of the second language. Therefore, the following improvements were proposed from the learners' perspective: the font of the app should be consistent with textbook fonts and should be adjusted according to regional differences in the requirements for teaching Chinese characters. Clear evidence had been found in the study measuring the efficacy of mobile-assisted gaming in facilitating the learning and review of Chinese characters (Kan & Owen, 2018) ^[9]. All these studies suggested that increased engagement and interactivity in the context of individual and group learning were strongly associated with the learning environment of app mobile-assisted games. Hu (2019) summarized the current state of the resources of current Chinese Character Learning apps and analyzed the strengths and weaknesses of four currently popular Chinese Character Learning apps: Pleco, trainChinese, Hello Chinese, and ChineseSkill ^[6]. In terms of character pronunciation, learners used apps to search for and listen to Chinese character pronunciations, practicing them repeatedly to correct mispronunciations. For character writing, apps showed stroke orders and provided tracing features, making practice less monotonous. They also offered vocabulary lists and example sentences for better understanding. However, most apps focused more on vocabulary than on the characters themselves. Few apps explained

character structures or radicals, leaving learners to rely on rote memorization. Of course, to accomplish this part, designers need to build a powerful database to support it. The RETAIN model proposed by Gunter et al., University of Pennsylvania, is intended to correct the neglect of instructional design principles in game design ^[21]. The model is composed of six parts: Relevance, Embedding, Transfer, Adaptation, Immersion, Naturalization. Lu (2023) pointed out that an in-depth understanding and active application of this model could promote the scientific design, development, and evaluation of educational games, facilitating more effective learning for learners and transforming the teaching and research of subjects and curriculum learning methods ^[16]. Using the RETAIN model as a theoretical basis to discuss the design framework for Chinese character education games as a foreign language could assist game developers in designing relevant games accordingly. Wang, Lam, & Xiao (2023) conducted research on the application of Memrise app to learn Chinese characters ^[24]. Research found that the Memrise application effectively improved the performance of Chinese students, Iranian students, foreign language study for Indonesian students, and Turkish students. Besides, the study confirmed that the Memrise app could enhance middle school students' motivation to learn Chinese as a foreign language in general. After utilizing Memrise as a flashcard application for a period of time, users found its comprehensive memory system effectively facilitated the oscillation of vocabulary between short-term retention and long-term memory, making it suitable for prolonged usage. Through users' experience with the Premium subscription, they were provided with detailed data pertaining to memory curves, cycles, and retention rates; however, it had limited utility in directly aiding the learning of Chinese characters themselves. The Open University invented a free Chinese learning app: Chinese@OU ^[19]. The app addressed three challenges—character complexity, matching form with pronunciation and meaning, and forming sentences—on one screen with interactive activities. It offered detailed feedback and assessments for personal improvement.

In conclusion, information technology and apps for teaching Chinese characters to foreigners had taken shape and were constantly being innovated and developed. Although the application of information technology and application programs in teaching Chinese as a foreign language has achieved remarkable results, it still needs to be continuously improved and perfected. Problems and deficiencies left behind and emerging in the renewal process needed to be addressed urgently and supported by more sophisticated technologies. Application development and update still need to be strengthened. Developers should pay more attention to user experience and personalized needs, optimize interface design, and enhance the usability and attractiveness of applications.

4 The Possible Role of Language Megamodeling in Teaching Chinese Characters to Foreigners

4.1 Large Language Model (LLM)

In the era of large AI models, the Large Language Model (LLM) emerged with the advent of Chat Generative Pre-trained Transformer (ChatGPT), garnering widespread attention. However, there was a dearth of research on its application in education, particularly in teaching Chinese characters to foreigners.

Wu et al. (2023) mainly explored the challenges faced by large-scale language models in the application of higher education^[25]. They aimed to guide teachers and students of higher education institutions to treat the models objectively in the process of curriculum teaching, academic research, the cultivation of students' higher-order thinking skills, and education digital transformation. Rao et al. (2023) developed distributed model construction technology represented by federated learning^[20]. They established a national knowledge data open mechanism and improved the open and efficient language data exchange market as soon as possible. They advocated to improve Chinese language concepts and terminology, and to make Chinese language resources in the field bigger and more comprehensive.

4.2 Multimodal Modeling

Multimodal models refer to machine learning models that can process and integrate many different types of information from images, text, and speech. They aim to understand and solve problems by integrating data from different modalities. For example, they can simultaneously analyze image and text inputs, improving task performance. Currently applied across fields like natural language processing, computer vision, and speech processing, these models offer a comprehensive approach to handling complex real-world data, enhancing task understanding and processing.

Liu et al. (2021) designed and developed a multi-modal web application as a writing platform and auxiliary teaching tool, utilizing second language oral comprehension and pinyin spelling knowledge to overcome the difficulties faced by Chinese language learners in learning and communicating Chinese characters^[18]. Zhao et al. (2023) explored the impact of model construction methods and human feedback-based reinforcement learning on big language models^[31]. They analyzed the key scientific problems encountered in the current multimodal big model construction process and explored the future development ideas of multimodal big models by drawing on the technical solutions of ChatGPT. Han, Liu, & Sun (2019) examined the application of multi-modal methods in classroom teaching by three Chinese teachers. The data showed that the uniqueness of the Chinese written form and the digital classroom environment provided an opportunity for these teachers to fully participate in multimodal teaching in their classrooms^[5]. The study also found that the meaning created by teachers through multiple modalities did not always equate to the meaning perceived by students due to their social and cultural differences. Lou (2024) analyzed multimodality from the perspective of external dissemination of Chinese characters

[14]. She stated that the use of multimodality in teaching is to express complex Chinese character strokes, structures, culture and other knowledge in a more intuitive form, while improving teaching interest and achieving the optimization of teaching information dissemination.

The multimodal model for teaching Chinese as a foreign language enhanced learning by leveraging mobile technology's interactive features and flexibility. Teachers tailored lessons to students' diverse backgrounds and needs, optimizing results through a variety of teaching methods and material.

To summarize, the effects of large-scale language modeling in teaching Chinese characters in Chinese as a foreign language were as follows. The Big Model of Chinese Characters aided in teaching and learning Chinese characters through various means: (1) It facilitated accurate testing and assessment, enabling teachers to understand students' progress and customize instruction accordingly. (2) By analyzing students' learning data, it identified their needs and preferences, allowing teachers to adjust teaching strategies accordingly. (3) The model optimized learning styles based on individual performance, providing tailored resources and activities. (4) It offered instant feedback to both teachers and students, enhancing learning experiences.

Despite its benefits, the Big Model of Chinese Characters posed potential drawbacks: (1) Students might become overly reliant on technology, diminishing their independent learning abilities. (2) Privacy and data security concerns arose due to data collection and analysis. (3) Standardized teaching approaches might overlook individual differences. (4) Technological disparities among students could lead to unfair treatment. (5) Detailed feedback might cause excessive anxiety. (6) Traditional teaching aspects, such as human interaction, could be lost. Achieving a balance between technology and traditional methods was crucial to ensure effective and holistic student development. The issues above might have been tackled by "Comprehension-based learning" and "Chinese Character Networks."

5 Implications of Comprehension-based Learning and Chinese Character Networks for Foreign Chinese Character Teaching Technology and App Development

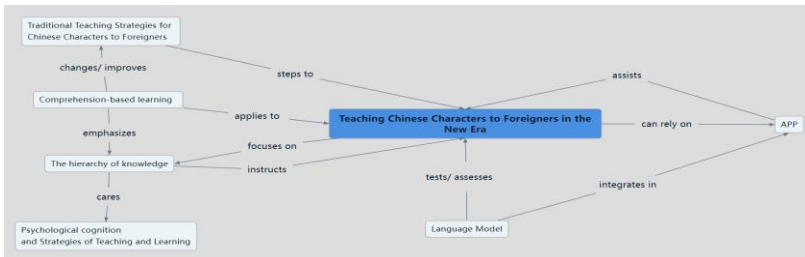


Fig. 1. A relationship diagram of Comprehension-based learning, language model, and applications centering on teaching Chinese characters to foreigners in the new era.

5.1 Theoretical Analysis

Comprehension-based learning prioritizes deep understanding and active engagement over rote memorization. Chinese Character Networks, alongside big models, information technology, and apps, facilitate this approach. Chinese Character Networks serve as comprehensive repositories of character information, aiding students in grasping cultural and linguistic nuances. Big models offer personalized learning suggestions, dynamically adjusting paths to optimize outcomes. Apps provide interactive learning experiences, integrating technology to foster motivation and deepen comprehension. Together, these tools support comprehension-based learning by tailoring assistance to students' needs and providing accessible learning resources. (See Figure 1).

As early as 2007, Chinese character structure analysis based on complex networks utilized complex network theory to model Chinese character networks^[11]. The statistical properties of the network were analyzed, and the Chinese character structure features found reflected the combinatorial nature of Chinese characters. The bipartite graphical model was used to generate non-Poisson distributions and separated mixtures as an empirical network, effectively explaining the origins and formation of phonological semantic features. Based on the formed network awareness of Chinese characters, Xiao et al. (2013) systematically utilized the internal coherent structure of Chinese characters to form an efficient learning strategy, Distributed Node Weight (DNW)^[27]. The article suggested that when designing listening, reading, and writing materials, it was important to take advantage of both the logical relationships between Chinese characters and the optimal learning sequences found by analyzing a network of Chinese characters with the same relationship. Only through network analysis could the full picture of these networks of structural relationships be captured. Based on the theory of Chinese character configuration, Yu (2020) analyzed the relationship network of Chinese characters, examined the network characteristics of Chinese characters by applying the theory of complex networks, and designed a software for Chinese character learning^[28]. The Chinese character comprehension-based learning system utilized algorithms such as the Chinese character map, learning sequence, and detection to understand character structures, meanings, and word formation. This method simplified the learning process by following the laws of character formation, reducing difficulty and cost, and aiding learners in constructing their cognitive systems more easily.

Hence, information technology and apps for teaching Chinese characters can be designed based on the character map. They should start with teaching basic characters, and then gradually introduce more complex structures. Learners can learn and master characters through an optimal sequence, exploring all routes with each character as an intersection point. This approach disperses learning and expands learners' Chinese character reserves.

5.2 Program Design

Title: Opti-Hanzi -Your Optimized Chinese Character Learning Companion

1. Introduction

Opti-Hanzi is an innovative application that combines comprehension-based learning with the extensive Chinese character network. Using advanced technologies like ChatGPT, it offers personalized learning pathways for efficient learning. Through data analysis, Opti-Hanzi continuously adapts, providing tailored feedback to each learner.

(2) Programming (See Figure 2):

1. User Authentication and Profile Creation:

- Users create an account or log in to Opti-Hanzi.
- Personalized profiles are established, capturing user preferences, learning goals, and past performance data.

2. Comprehension-Based Learning Module:

- Opti-Hanzi employs comprehension-based learning methodologies, focusing on understanding rather than rote memorization.
- Users engage with Chinese characters through interactive lessons, exercises, and real-world applications.
- The program utilizes a variety of multimedia resources, including text, audio, and visual aids, to enhance comprehension.

3. Chinese Character Network Integration:

- Opti-Hanzi taps into the vast network of Chinese characters, analyzing their relationships, components, and usage patterns.
- Through advanced algorithms, Opti-Hanzi identifies the most essential characters for each user based on their learning objectives and progress.
- The application generates optimal learning pathways, prioritizing characters that are foundational or frequently encountered in written and spoken Chinese.

4. Language Modeling and ChatGPT Integration:

- ChatGPT powers the conversational interface of Opti-Hanzi, offering users natural and engaging interactions.
- Users can ask questions, seek clarification, and receive explanations in real-time through conversational dialogue with ChatGPT.
- Language modeling capabilities enhance the learning experience by providing contextually relevant information and examples.

5. Personalized Feedback and Progress Tracking:

- Opti-Hanzi tracks user performance and engagement across various learning activities.
- Advanced analytics algorithms analyze user data to provide personalized feedback and recommendations.

- Users receive insights into their strengths, areas for improvement, and suggested study strategies, promoting continuous learning and growth.

6. Dynamic Learning Pathways:

- Opti-Hanzi dynamically adjusts learning pathways based on user progress, preferences, and feedback.

- Users are guided through a curated sequence of lessons, exercises, and assessments tailored to their individual needs.

- The program adapts in real-time to optimize learning efficiency and effectiveness, ensuring users stay motivated and engaged.

7. Community Engagement and Support:

- Opti-Hanzi fosters a supportive learning community where users can connect, collaborate, and share insights.

- Forums, discussion boards, and peer-to-peer interactions encourage collaboration and knowledge exchange among learners.

- Expert moderators and language educators provide additional support and guidance to users, enhancing the overall learning experience.

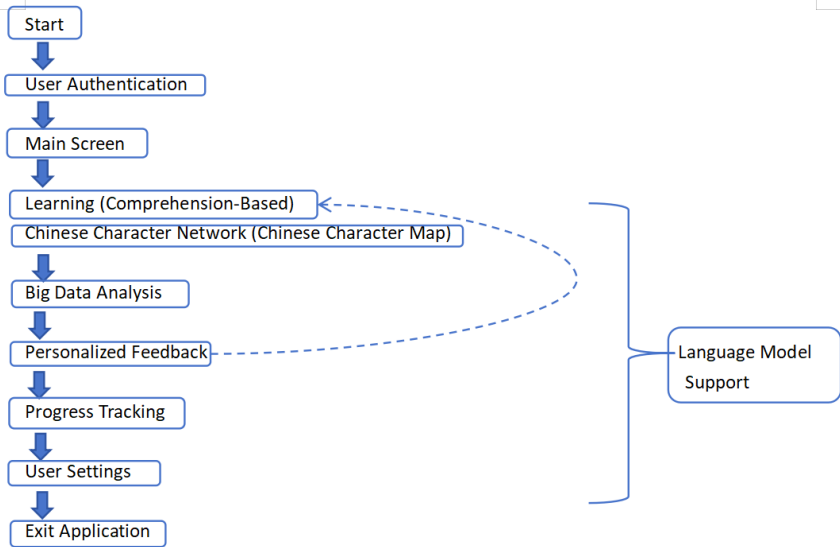


Fig. 2. Programming of Opti-Hanzi

2. Summary:

Opti-Hanzi represents a paradigm shift in Chinese character learning, leveraging the latest advancements in comprehension-based learning, Chinese character network analysis, language modeling with ChatGPT, and big data analytics. By offering personalized learning pathways, interactive experiences, and tailored feedback, Opti-Hanzi empowers users to master Chinese characters effectively and efficiently, paving the way for proficiency in the Chinese language.

6 Conclusion

Traditional research on teaching strategies for teaching Chinese characters to foreigners mainly focused on motivations, components, character sounds, and cultural connotations of Chinese characters. This provided theoretical ideas and design logic for further research and development of information technology and apps. With the development of science and technology, information technology, multimedia, digital tools, and mobile apps became effective auxiliary tools for teaching and learning Chinese characters. Developers made full use of convenient and fast-updated information technology to design differentiated teaching modules, analyzed learners' learning situations of Chinese characters with big data, and assisted students by combining personalized learning and review with group facilitation or teacher-student facilitation. Additionally, although technological innovation and app development for teaching Chinese characters to foreigners were independent of traditional classroom teaching, they couldn't be detached from the classroom. The development of information technologies and apps was based on regional requirements for teaching Chinese characters, recommending the use of local teaching materials, and unification of fonts and assessment standards to better serve the classroom, learners, and teachers. In the context of large-scale language modeling, the application of artificial intelligence, ChatGPT, and other technologies improved the accuracy of Chinese character teaching procedures. AI analysis and explanation reduced labor costs and improved teaching efficiency. Although the application of information technology and application programs in teaching Chinese as a foreign language had achieved remarkable results, it still needed to be continuously improved and perfected. Finally, the paper proposed applying comprehension-based learning of Chinese characters to the new Chinese character teaching technologies and apps, with the built-in Chinese character network, Chinese character maps, and the optimal learning order of Chinese characters analyzed by comprehension-based learning. This approach reduced the difficulty of Chinese character learning and effectively increased learners' Chinese character reserves. This combination not only focused on the initiative and participation of students, but also made full use of the rich resources and interactive platforms provided by the Chinese character network, providing a direction for the development of more advanced and effective applications for teaching Chinese as a foreign language.

Statement of Conflict of Interest

No conflict of interest is present in this work.

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