

Artificial intelligence as a cognitive support mechanism for reducing the burden in learning Chinese: A qualitative study of learner experiences.

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Abstract

The rapid development of artificial intelligence (AI) is creating significant changes in the field of foreign language teaching and learning. AI can provide personalized feedback and support, and create interactive learning environments for learners. However, current research has not yet fully clarified how AI affects learners' cognitive processing, especially those learning Chinese as a foreign language, a language considered difficult to learn. This study investigates learners' experiences with AI's role in modulating cognitive load during Chinese learning from the perspective of Cognitive Load Theory (CLT).

This study uses a qualitative approach to understand students' perceptions and experiences in using AI to support their Chinese language learning. Data was collected from 235 university students learning Chinese as a foreign language through open-ended questions and analyzed using thematic analysis. The results reveal three main issues. First, AI assists learners in handling the complexity of Chinese characters by analyzing each character's components, making it easier for learners to recognize their structure and memorize them. Second, AI helps reduce the burden of external learning by integrating Chinese characters, pronunciation, meanings, and usage examples within a single learning environment. Third, AI provides step-by-step support and timely feedback, thereby promoting learners' self-learning abilities and knowledge building.

This research contributes to the field of technology-assisted language learning by extending the application of Cognitive Load Theory to AI-assisted Chinese language learning. Instead of viewing AI solely as a tool for providing information, the research emphasizes its role as a cognitive support mechanism, shaping how learners receive, organize, and process linguistic information.

Keywords: Artificial intelligence; Cognitive load theory; learning Chinese; Chinese characters; CALL; qualitative research.

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I. Introduction

The development of artificial intelligence (AI) is creating significant changes in the field of foreign language education, particularly through applications such as smart teaching systems, interactive chatbots, and adaptive learning platforms. These technologies expand the possibilities for personalizing learning, providing quick feedback, and helping learners access resources tailored to their individual needs (Zawacki-Richter et al., 2019). However, despite its technological potential, the question of how AI affects learners' cognitive processes remains under-researched.

Learning Chinese as a foreign language presents many cognitive challenges, particularly in acquiring and memorizing Chinese characters. Unlike alphabetic writing systems, Chinese characters require learners to process multiple elements simultaneously, including character shape, pronunciation, meaning, and writing structure (Shen, 2005). The combination of these elements creates a high level of complexity, forcing learners to mobilize many of their memory resources during the learning process.

Cognitive Load Theory (CLT) provides an important theoretical framework for explaining these difficulties. According to the CLT, human working memory has a limited capacity to process information; therefore, learning efficiency depends on controlling three types of cognitive load: intrinsic, extraneous, and germane (Sweller et al., 1998). In a learning environment, appropriate information organization can help reduce unnecessary cognitive demands and facilitate the building of lasting knowledge for learners.

Meanwhile, AI has the potential to transform how learners receive and process information. Functions such as analyzing the structure of Chinese characters, providing step-by-step explanations, offering instant feedback, and tailoring learning content can support learners in handling complex cognitive tasks. AI can help learners identify

radicals, associate character shapes with their meanings and uses, thereby breaking complex information into more manageable units.

Although research on AI in education is rapidly developing, much of the current research focuses on the level of technology adoption, effectiveness of use, or the ability to personalize learning (Zawacki-Richter et al., 2019). In the field of Chinese language learning, especially in learning Chinese characters, there is still a lack of research examining AI from the learner's cognitive perspective, such as how AI helps reduce cognitive burden, how learners experience that assistance, and how AI affects the knowledge-formation process.

Therefore, this study aims to explore the role of AI in regulating cognitive load among Chinese language learners by analyzing the experiences of 235 university students. Using qualitative research methods and thematic analysis, the study examines how learners perceive AI support in learning Chinese characters.

Three questions guided the research:

RQ1: How does the cognitive load affect Chinese language learners when learning Chinese characters in an AI-assisted environment?

RQ2: Which AI functions are perceived by learners as capable of reducing cognitive burden during the process of learning Chinese characters?

RQ3: How does AI affect the self-learning and knowledge-building process of Chinese language learners? By connecting AI, CALL, and Cognitive Load Theory, this research aims to offer a new perspective on the role of AI in supporting foreign language learning, especially for languages with complex writing systems such as Chinese.

II. Literature review

2.1 Loading cognitive skills and applying AI in learning Chinese

Cognitive Load Theory (CLT) is a theoretical framework that has greatly influenced research on teaching design and information processing in education. Sweller (1988) argued that human working memory has limited capacity; therefore, when learners have to process tasks exceeding this capacity, learning efficiency will be significantly reduced.

From this foundation, CLT has been developed into a model with three types of cognitive load: intrinsic, extraneous, and germane (Sweller et al., 1998; Paas et al., 2003). Intrinsic load is the inherent complexity of the learning content and the level of interaction between knowledge components. Extraneous load arises from suboptimal teaching design, making the knowledge acquisition process more complex. Meanwhile, germane load is the learner's cognitive effort. According to Paas et al., learning effectiveness depends on reducing extraneous load while optimizing germane load to support the meaningful knowledge formation process (Paas et al., 2003). Accordingly, effective teaching design needs to balance task difficulty and learner processing capacity.

In foreign language teaching, CLT is particularly suitable for explaining the difficulties learners face when processing multiple sources of information simultaneously. For Chinese, the internal load is considered very high due to the unique characteristics of its pictographic writing system. Learners must simultaneously process character shapes, pronunciation, and meaning, which places significant pressure on working memory.

Learning Chinese characters is often considered a challenging task for second-language learners because each character requires the integration of several elements, including visual form, pronunciation, semantic meaning, and internal structural relationships. When learners attempt to memorize characters without understanding the connection among these components, the processing demands placed on working memory may become excessive. As a result, learners may experience difficulties in recognizing and retaining new characters. From the perspective of Cognitive Load Theory, instructional support that organizes complex information into smaller and meaningful units can reduce unnecessary mental effort and improve learning efficiency. In addition, the way learning materials are presented plays an important role in controlling extraneous cognitive load, as poorly organized information may require learners to spend more cognitive resources searching for connections rather than constructing knowledge (Shen, 2005; Wong et al., 2011; Sweller et al., 2011). Poorly designed learning materials can increase unnecessary cognitive processing when learners have to integrate separated sources of information. According to Cognitive Load Theory, the split-attention effect occurs when learners divide their attention among multiple unconnected elements, increasing extraneous cognitive load. In Chinese language learning, presenting character forms, pronunciation, and meanings separately may place additional demands on working memory and reduce learning efficiency (Chandler & Sweller, 1991; Sweller et al., 2011)..

Mayer's (2005) multimedia learning theory provides further basis for designing more effective learning materials. According to Mayer, humans process information through two main channels: visual and auditory, and each channel has processing limits. When information exceeds these limits, cognitive overload occurs, reducing learning efficiency. Studies in the field of foreign language learning also show that cognitive load significantly affects vocabulary, grammar, and reading comprehension skills. Research on cognitive load suggests that reducing unnecessary mental effort can improve learning performance (Chen et al., 2018). This issue is particularly relevant in Chinese character learning, where learners need to process multiple elements, including stroke order, radicals,

visual form, and meaning. Without appropriate instructional support or well-organized learning materials, learners may experience difficulties in recognizing and memorizing characters (Shen, 2005; Sweller et al., 2011).

In recent years, artificial intelligence (AI) has been seen as a potential tool for reducing cognitive load in education. Liu et al. (2020) showed that multimedia learning systems can significantly reduce cognitive load by organizing information in a logical structure and adapting it to the learner. From a CLT perspective, AI helps reduce exogenous load by eliminating unnecessary elements from the learning process and providing step-by-step guidance to learners. At the same time, AI also helps increase germane load by supporting learners in focusing on building knowledge schemas rather than processing distracting elements. In addition, AI helps learners dynamically decompose complex knowledge units in Chinese, such as analyzing Chinese characters into radicals and structural components. This helps reduce intrinsic load by reducing the level of interaction between information elements, thereby improving cognitive processing efficiency.

The principles of multimedia learning also support the use of AI in language teaching. According to Mayer (2005), judiciously combining visual and auditory information reduces cognitive load and increases learning efficiency. Modern AI systems can integrate multiple information channels, thereby optimizing learners' cognitive processing. However, despite numerous studies on AI in education and CLT in foreign-language learning, there remains a lack of empirical research on how AI affects cognitive load in Chinese learning. This gap is particularly important because Chinese is a language with a complex cognitive structure and requires multidimensional information processing.

Therefore, this study was conducted to clarify the impact of AI on cognitive load and learning performance in the context of learning Chinese, thereby contributing to both CLT theory and the practice of designing AI-assisted learning systems.

2.2. Artificial Intelligence in Language Learning (CALL + AI)

Building upon the foundations of Computer-Assisted Language Learning (CALL), Artificial Intelligence in language education has flourished, with technology being used to expand learning environments beyond the traditional classroom (Beatty, 2013). CALL initially focused on structured practice exercises, but modern systems have shifted towards interactive, adaptive, and personalized learning based on learner data (Stockwell, 2012).

In the current context, Intelligent Tutoring Systems (ITS) are considered a significant advancement of AI in education, as they can simulate the role of a teacher by analyzing learning behavior and providing appropriate feedback (VanLehn, 2011). ITS can adjust the difficulty level of learning tasks based on learner performance, thereby maintaining an optimal challenge level without causing cognitive overload (VanLehn, 2011). This mechanism is particularly consistent with the principles of Cognitive Load Theory, which aim to reduce exogenous load and maintain germane load during the learning process (Sweller et al., 1998).

Besides Integrated Teaching Methods (ITS), the development of Large Language Models (LLMs) has opened up a new approach to language learning through AI chatbots. LLM-based chatbots can generate natural conversations, respond flexibly, and simulate real-life communication, thereby creating a highly interactive language practice environment (Kasneci et al., 2023). In foreign language learning, this provides learners with the opportunity for continuous practice without being limited by the time or space constraints of a traditional classroom (Kasneci et al., 2023).

Recent studies show that AI chatbots can serve as interaction partners, helping learners improve their language output and communication fluency (Godwin-Jones, 2023). Simultaneously, instant feedback from chatbots helps learners identify errors during interaction, thereby reducing the time spent processing incorrect information and limiting prolonged cognitive load (Godwin-Jones, 2023). According to CLT theory, this instantaneous feedback mechanism reduces extraneous load by eliminating the need for unnecessary self-inference about the correctness of linguistic input (Sweller, 1988).

Another development direction is adaptive learning platforms, in which the system uses learning data to tailor content, pace, and presentation style to each learner (Kulik & Fletcher, 2016). These systems can analyze learning performance in real time and automatically adjust task difficulty to optimize learning effectiveness (Kulik & Fletcher, 2016). This helps reduce information overload when learners have to access more knowledge than their working memory can process (Sweller et al., 2011).

In language learning, adaptive systems are particularly useful because learners often differ significantly in vocabulary, grammatical ability, and learning speed (Stockwell, 2012). Personalizing the learning path ensures that each learner only accesses information within their optimal cognitive domain, thereby limiting both underload and overload (Paas et al., 2003). This mechanism not only improves learning efficiency but also increases the learner's ability to self-regulate during the long-term learning process (Zimmerman, 2002).

AI technologies in CALL play a central role by optimizing information processing by offloading unnecessary cognitive load and enhancing directed learning (Kasneci et al., 2023). Through automated responses, content personalization, and simulated communication environments, AI helps learners focus more on constructing linguistic meaning rather than processing complex technical elements (Godwin-Jones, 2023). This

aligns with the core principle of CLT, which holds that learning efficiency depends on the judicious allocation of cognitive resources between information processing and knowledge schema construction (Sweller et al., 2011).

However, current research still primarily focuses on describing AI's potential for language learning, while empirical evidence on specific cognitive load-reduction mechanisms in individual linguistic contexts remains limited (Zawacki-Richter et al., 2019). Particularly in the field of Chinese language learning, there is still a lack of studies directly verifying the impact of chatbots, ITS, and adaptive systems on learners' cognitive load (Tan & Chan, 2018).

2.3. AI and learning Chinese characters in relation to cognitive load

Learning to write Chinese characters is considered one of the most complex linguistic tasks for learners due to the characteristics of its pictographic writing system and the structure of its many radicals (Shen, 2005). Unlike the alphabetic system, Chinese characters require learners to simultaneously process visual form, radical structure, stroke order, and semantic meaning, which creates a high level of interactivity among elements in working memory (Wong et al., 2011).

According to cognitive load theory, the more complex the knowledge component, the greater the intrinsic load, leading to the risk of cognitive overload during the learning process (Sweller et al., 2011). Research on learning Chinese characters indicates that learners often have difficulty encoding and memorizing characters because they must simultaneously process multiple sources of visual and phonetic information (Shen, 2005). The process of learning Chinese characters is not just about memorizing shapes but also involves building connections between form, sound, and meaning, which requires strong involvement of working memory (Wong et al., 2011). This makes Chinese characters a form with a high intrinsic cognitive load even when presented under optimal teaching conditions.

In addition to intrinsic workload, extrinsic workload in learning Chinese characters also significantly influences learning effectiveness. Studies on teaching design show that non-integrated information presentation, such as separating character shape, pronunciation, and meaning, can lead to a split-attention effect, increasing extraneous workload (Ayres & Sweller, 2014). In the context of learning Chinese characters, this occurs when learners have to constantly switch between multiple disparate sources of information to understand a character, leading to unnecessary consumption of cognitive resources (Chandler & Sweller, 1991). Empirical studies in the field of Chinese character learning show that inappropriate separation or integration of visual information can directly affect the ability to memorize characters (Wong et al., 2011).

When learners have to simultaneously process stroke structure and semantic interpretation that are not directly linked, learning efficiency decreases significantly due to increased exogenous load (Ayres & Sweller, 2014). This shows that the design of learning materials plays a decisive role in managing cognitive load during the learning of Chinese characters.

Intelligence (AI) is considered a tool that can reshape how learners approach Chinese characters by assisting with information decomposition, visualizing character structure, and providing adaptive feedback (Chen et al., 2020). AI-based learning systems can automatically analyze the structure of Chinese characters into radicals and smaller components, thereby reducing the level of interaction between information elements and reducing internal workload (Li et al., 2021). This mechanism is consistent with the CLT principle, which emphasizes reducing task complexity through segmentation and step-by-step guidance (worked examples) (Sweller et al., 2011).

Furthermore, AI can simultaneously integrate multiple forms of information, such as images, audio, and semantic descriptions, within a single learning environment, thereby minimizing the attention-scattering effect often seen in traditional materials (Chen et al., 2020). This integration helps learners process information more consistently, reducing external load and increasing the efficiency of working memory (Mayer, 2005). According to multimedia learning theory, synchronization between information channels optimizes the encoding and storage of information in long-term memory (Mayer, 2005).

Another important aspect is the AI's ability to personalize the complexity of Chinese characters according to the learner's capacity. Adaptive systems can adjust the speed of introducing new characters, the level of detail in structural analysis, and the amount of information displayed at each learning moment (Li et al., 2021). This helps ensure that learners are always operating within their optimal cognitive load, avoiding both overload and underload during the learning process (Paas et al., 2003).

However, some studies also warn that if AI provides too much simultaneous support, learners may become dependent on the system and reduce their level of deep cognitive processing, thereby affecting the formation of a sustainable knowledge schema (Kirschner et al., 2006). Therefore, designing AI systems to support learning Chinese characters requires a balance between cognitive support and the learner's self-processing requirements to maintain optimal germane load.

In summary, learning Chinese characters is a task with a high cognitive load due to the language's structural characteristics. At the same time, AI has significant potential to reduce both intrinsic and extrinsic

cognitive load through information decomposition, multimodal integration, and personalized learning. However, the true effectiveness of AI in optimizing cognitive load still needs further verification through controlled empirical studies in the context of learning Chinese as a foreign language.

2.4. AI and cognitive reduction in the process of learning Chinese

During the process of learning a foreign language, especially one with a complex writing system like Chinese, learners must simultaneously process multiple types of information, including character shapes, pronunciation, meaning, and usage rules in context. According to Cognitive Load Theory (CLT), when the number of elements to be processed exceeds working memory capacity, learning efficiency decreases due to cognitive overload (Sweller, 1988). Therefore, an important task of teaching design is to organize information in a way that helps learners reduce unnecessary cognitive activities and dedicate more resources to the formation of long-term knowledge (Sweller et al., 2011).

In this context, AI can be seen as a tool to support the design of learning environments, adjusting how learners receive and process information. Beyond simply providing content, modern AI systems can analyze the learning process, adjust the level of support, and provide feedback tailored to each learner's needs (Zawacki-Richter et al., 2019). These capabilities are directly related to the principles of CLT, particularly in reducing exogenous load and enhancing meaningful processing.

2.4.1 AI and information chunking in learning Chinese characters

One key mechanism AI uses to reduce cognitive load is its ability to help learners chunk information. In CLT, organizing many small units of information into meaningful structures reduces pressure on working memory and facilitates the formation of knowledge schemas in long-term memory (Sweller et al., 2011).

For Chinese, chunking plays a particularly important role because Chinese characters are not linear combinations of letters but consist of many structural components such as radicals, strokes, and semantic elements. New learners often have to memorize each character separately, leading to a high internal load due to the large level of interaction between elements (Shen, 2005).

Intelligent learning systems can support this process by breaking down Chinese characters into smaller units, such as radicals or structural components, helping learners shift from memorizing entire characters to recognizing meaningful structural patterns. This approach aligns with the principle of reducing cognitive burden by reorganizing learning information (Sweller et al., 2011).

Research on learning Chinese characters shows that learners memorize better when guided to identify the structure and relationships among character components rather than simply memorizing the character's shape mechanically (Shen, 2005). Therefore, AI-assisted analysis of Chinese character structure can help reduce the initial processing burden and allow learners to focus on building language knowledge.

2.4.2 AI and scaffolding: step-by-step support in the learning process

Besides chunking, providing step-by-step support (scaffolding) is an important feature of AI systems in education. Scaffolding refers to providing temporary support to help learners complete tasks they cannot yet perform independently (Wood et al., 1976).

In traditional learning environments, the level of support often depends on the teacher's time and observational abilities. However, AI systems can provide continuous feedback throughout the learning process, thereby creating a more flexible support environment (VanLehn, 2011).

In the context of learning Chinese, scaffolding can be demonstrated through guiding stroke order, correcting pronunciation errors, explaining character structure, or offering suggestions when learners encounter difficulties. Providing timely support helps learners avoid expending excessive cognitive resources trying to solve problems on their own (VanLehn, 2011).

According to CLT, step-by-step instruction can reduce external burden because learners do not have to process unnecessary information or experiment with too many incorrect options during the learning process (Sweller et al., 2011). At the same time, as support is gradually reduced based on learner capacity, AI can facilitate the transition from external support to independent self-processing.

2.4.3 AI and Exogenous Offload Reduction Through Information Design

Exogenous load often occurs when information is presented in a way that unnecessarily complicates learning. According to Chandler and Sweller (1991), combining multiple sources of information can significantly increase cognitive load, especially in highly complex tasks. In learning Chinese, this phenomenon can occur when learners have to simultaneously view Chinese characters, pinyin transliteration, Vietnamese meanings, and grammatical explanations in different locations. Constantly switching attention between information sources consumes working memory and reduces the ability to concentrate on the main content.

AI can help reduce exogenous overload by integrating information sources within the same learning environment. An AI system can present Chinese characters, pronunciation, meaning, and usage examples in a unified structure, helping learners process information more effectively. This perspective aligns with Mayer's (2005) multimedia learning theory, which emphasizes that a proper combination of visual and linguistic information can improve knowledge acquisition and limit cognitive overload.

2.4.4 AI and germane loading through knowledge building

Besides reducing unnecessary workload, AI can also promote germane loading – a type of cognitive load related to building and consolidating knowledge schemas (Paas et al., 2003). Unlike exogenous load, germane loading reflects cognitive efforts that are valuable for long-term learning. Through personalized feedback and adaptive training, AI can help learners focus on the important aspects of a learning task. For example, instead of simply memorizing a list of Chinese characters, learners can be guided to identify character formation patterns, the relationships between radicals and meaning, and changes in pronunciation across different contexts.

This process contributes to the formation of more stable cognitive schemas, helping learners process similar tasks more quickly in the future (Sweller et al., 2011). Therefore, the role of AI lies not only in making learning more convenient but also in restructuring the learner's cognitive processing. However, the use of AI needs to be carefully designed to avoid learners becoming overly dependent on external support. If the system provides too many suggestions or automatically completes important cognitive tasks, learners may reduce their level of participation in the process of constructing personal knowledge (Kirschner et al., 2006). Therefore, the effectiveness of AI in reducing cognitive burden depends not only on technology but also on pedagogical design principles.

2.5. Research gap

Although research on artificial intelligence (AI) in language education has grown rapidly in recent years, the relationship between AI and the underlying cognitive mechanisms of learning remains largely unclear. Most current research focuses on evaluating AI's ability to improve learner engagement, support communication, or personalize the learning process, while less research examines how AI affects learners' cognitive processing (Zawacki-Richter et al., 2019). In the field of Computer-Assisted Language Learning (CALL), AI research has primarily focused on practical benefits such as automated feedback, practice support, and enhanced language interaction (Godwin-Jones, 2023). However, the cognitive mechanisms explaining why and how AI can improve learning outcomes remain largely unproven. Specifically, whether AI truly reduces learners' cognitive burden or simply increases exposure to learning content is a question that requires further research.

From the perspective of Cognitive Load Theory (CLT), the effectiveness of a learning environment depends not only on the amount of information provided but also on how that information is organized and processed in working memory (Sweller, 1988). Although CLT has been widely applied to explain the effectiveness of teaching design methods, the combination of CLT and AI-based learning systems remains a new field, especially in the context of foreign language learning.

A key limitation of existing research is the tendency to view cognitive load as a whole concept, whereas CLT clearly distinguishes three components: intrinsic load, extraneous load, and germane load (Sweller et al., 1998). The failure to analyze each load separately makes it difficult to determine which aspect of the learning process AI is impacting. For example, AI might reduce extraneous load through information reorganization, but it needs to be verified whether it actually promotes germane load through knowledge construction.

This gap becomes even more apparent in the field of learning Chinese as a foreign language. Chinese has a writing system that differs from that of many alphabetic languages, requiring learners to simultaneously process the shapes of Chinese characters, their pronunciation, meaning, and radical structure (Shen, 2005). This characteristic creates a high intrinsic load, making the design of an effective learning environment a critical issue.

Although some studies have highlighted the roles of information design, visual aids, and learning strategies in improving the ability to memorize Chinese characters (Shen, 2005; Wong et al., 2011), there is still a lack of research examining how AI can affect cognitive load during the learning of Chinese characters. Specifically, there is not much empirical evidence on whether functions such as character structure analysis, instant feedback, step-by-step guidance, or content personalization help learners reduce cognitive load.

Furthermore, studies on AI in higher education also show that many current works focus solely on evaluating the effectiveness of technology use, while paying insufficient attention to the theoretical basis for changes in learners' learning processes (Zawacki-Richter et al., 2019). This creates a need to combine cognitive theories with AI research to build more in-depth explanatory models.

Therefore, the current study aims to fill this gap by integrating AI with Cognitive Load Theory in the context of learning Chinese. Specifically, the study focuses on analyzing whether an AI-supported learning environment can (1) reduce exogenous load through more efficient organization and presentation of information,

(2) assist learners in processing the intrinsic load of Chinese characters, and (3) promote germane load through meaningful knowledge construction.

Approaching AI from a cognitive load perspective not only helps evaluate the technology's effectiveness at the output level but also explains the underlying cognitive mechanisms of the learning process. This is a significant contribution to expanding CALL and CLT research in Chinese language teaching today.

2.6. Theoretical Framework

This study constructs a theoretical framework combining Cognitive Load Theory (CLT) and research on artificial intelligence in language learning (AI-supported language learning) to explore how learners experience the process of learning Chinese with AI support. Cognitive Load Theory, proposed by Sweller (1988), holds that human working memory has limited information-processing capacity, while long-term memory can store large amounts of knowledge through cognitive structures (schemas). Therefore, effective learning depends on the ability to organize information so that learners can use cognitive resources rationally.

According to Sweller et al. (1998), cognitive load comprises three main components: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. These three types of load do not exist independently but interact with each other during the learner's acquisition and processing of information. In the context of learning Chinese as a foreign language, intrinsic cognitive load is formed from the inherent complexity of the learning object. Unlike alphabet-based writing systems, Chinese characters require learners to simultaneously process the relationship between character shape, pronunciation, meaning, and radical structure (Shen, 2005). The high level of interaction between these components forces learners to mobilize many working memory resources during the initial acquisition phase.

Besides intrinsic workload, extrinsic workload arises when the way learning content is presented creates unnecessary processing requirements. Chandler and Sweller (1991) argued that when learners have to combine multiple sources of information presented in a disjointed manner, working memory is consumed by searching and integrating information rather than by knowledge formation. In learning Chinese characters, this phenomenon can occur when learners have to simultaneously process the character, pronunciation, meaning, and usage instructions, but these elements are not organized in a unified manner. From this perspective, AI can be seen as a factor capable of restructuring learners' information reception processes. AI systems in education can provide adaptive content, instant feedback, and personalized support based on the user's learning data (Zawacki-Richter et al., 2019). However, the educational value of AI lies not only in its ability to provide more information, but more importantly, in its ability to tailor how that information is presented and processed.

One important mechanism by which AI can influence cognitive load is information chunking. According to Cognitive Load Theory, organizing small pieces of information into meaningful units reduces pressure on working memory and supports the formation of cognitive schemas (Sweller et al., 2011). In learning Chinese characters, AI's analysis of characters into radicals, strokes, or structural components can help learners shift from memorizing complex forms to recognizing meaningful structures. Furthermore, AI can serve as stepwise cognitive support (scaffolding) in the learning process. The concept of scaffolding originated in the research of Wood, Bruner, and Ross (1976), which emphasized that learners can perform complex tasks more effectively when provided with appropriate support in the early stages. In an AI-powered learning environment, this support can manifest as hints, error correction, concept explanations, or adjustments to task difficulty.

Intelligent Tutoring Systems (ITS) have been shown to generate adaptive feedback that closely resembles personalized support in direct teaching (VanLehn, 2011). This characteristic is significant for Chinese language learners, as difficulties in recognizing Chinese characters or pronunciation often require immediate feedback at the time of error to prevent the formation of incorrect habits. However, in this study, AI was not considered an automatic cognitive load-reducing factor. Whether AI has a positive impact depends on its design and how learners use the tool. If AI provides too much information or completely replaces the learner's reasoning process, it can reduce the cognitive engagement necessary for knowledge construction (Kirschner et al., 2006).

Therefore, this study approaches AI from a balanced perspective that supports and maintains learners' cognitive functioning. The theoretical framework suggests that AI can influence the Chinese language learning experience through three main pathways:

- (1) AI helps reduce internal load by dividing and reorganizing the complexity of Chinese characters;
- (2) AI reduces exogenous load through the presentation of information that is structured, integrated, and relevant to learners' needs;
- (3) AI promotes germane loading by enabling learners to build knowledge connections and develop self-learning abilities.

Based on this theoretical framework, the current qualitative research explores learners' perceptions and experiences of AI's role in modulating cognitive load during Chinese learning. This approach aims to complement previous studies that primarily assessed the effectiveness of technology at the level of learning outcomes, but failed to clarify the cognitive mechanisms within the learning process.

2.7. Research Questions

Based on the theoretical framework above, the study proposes three questions:

RQ1: How does the cognitive load affect Chinese language learners when learning Chinese characters in an AI-assisted environment?

RQ2: Which AI functions are perceived by learners as capable of reducing cognitive burden during the process of learning Chinese characters?

RQ3: How does AI affect the self-learning and knowledge-building process of Chinese language learners?

III. Research Methodology

This study uses a qualitative approach to explore learners' experiences with AI in learning Chinese characters. Data was collected through semi-structured interviews with Chinese language learners who had experience using AI tools.

Data were analyzed using Thematic Analysis, following the guidelines of Braun and Clarke (2006). The analysis process included: data familiarization, coding, topic construction, topic testing, and topic interpretation. The topics were compared with the CLT framework to determine the role of AI in reducing exogenous load, supporting the processing of intrinsic load, and promoting germane load. Research reliability is ensured through transparent coding procedures, data verification, and detailed descriptions of the research context (Lincoln & Guba, 1985).

IV. Findings

Based on thematic analysis by Braun and Clarke (2006), data collected from 235 Chinese language students showed that AI was perceived by learners as a tool to support information processing, especially in learning Chinese characters. The main themes identified included: (1) AI assists in organizing and reducing the complexity of Chinese characters; (2) AI reduces cognitive burden due to information presentation; (3) AI provides step-by-step support in the learning process; and (4) AI promotes knowledge construction.

4.1. AI assists in segmenting information and handling the complexity of Chinese characters.

Analysis results show that many students find Chinese characters among the biggest challenges in learning Chinese, due to the need to memorize their shapes, pronunciations, and meanings simultaneously. AI helps learners break down Chinese characters into smaller components such as radicals, strokes, and character structure, thereby reducing the feeling of being overwhelmed when learning new characters.

This finding is consistent with Cognitive Load Theory, which states that organizing information into meaningful units reduces pressure on working memory and supports schema formation in long-term memory (Sweller et al., 1998; Sweller et al., 2011). Students believe that AI's explanations of the relationships among components in Chinese characters help learners understand the structure of Chinese characters. This realization suggests that AI can help reduce internal workload by assisting learners in processing the complex structure of Chinese writing.

4.2. AI reduces exogenous workload through learning information organization.

Another prominent topic is the role of AI in integrating multiple information sources within the same learning environment. Students reported that before using AI, they often had to constantly switch between Chinese characters, pinyin, Vietnamese meanings, and usage examples, which took significant time. According to Chandler and Sweller (1991), when learners must manually connect disparate information sources, working memory must devote more resources to searching and integrating information, leaving less time for learning.

In this study, students highly rated AI's ability to provide explanations and feedback within the same learning process. This suggests that AI can help reduce exogenous workload by redesigning how information is presented.

4.3. AI as a form of scaffolding in the self-learning process

Data shows that students use AI not only to find answers but also as a form of support in their self-learning. Functions such as pronunciation correction, grammar explanations, mnemonic suggestions, and instant feedback are considered factors that help learners maintain their learning. This finding is consistent with the concept of scaffolding, where learners can perform complex tasks more effectively when they receive appropriate support in the early stages (Wood et al., 1976). Studies on intelligent teaching systems also show that adaptive feedback can support learners in ways similar to individual instruction (VanLehn, 2011).

However, some students also found that over-reliance on AI could diminish their ability to reason independently. This aligns with the warning by Kirschner et al. (2006) that excessive assistance can limit the cognitive processing necessary for knowledge formation.

4.4. AI promotes germane loading through knowledge building.

Besides reducing difficulty, AI is also considered by students to help them develop a more systematic way of learning Chinese. Instead of just memorizing individual characters, learners begin to pay attention to the relationships between the structure of Chinese characters, their meanings, and their usage in context.

According to Paas et al. (2003), cognitive activities that contribute to organizing and linking new knowledge with existing knowledge are considered germane loading. In this study, AI's support in explaining letter structure, providing examples, and creating semantic links is considered a factor that promotes the construction of the learning schema.

Thus, the results show that the role of AI lies not only in reducing the amount of information learners have to process, but also in guiding how learners organize knowledge during the process of learning Chinese.

V. Discussion

This study explores how Chinese language learners experience AI's role in regulating cognitive load during Chinese character learning. The results show that AI is not only used as an information-providing tool but also plays a supporting role in the learners' processes of organizing, processing, and constructing knowledge. These findings expand the approach to AI in foreign language learning from a cognitive perspective, particularly within the context of Cognitive Load Theory (CLT).

5.1. AI and the process of reducing cognitive burden in learning Chinese characters.

A key finding of the study is that students perceive AI as a tool to help reduce the complexity of learning Chinese characters. For Chinese learners, the difficulty lies not only in memorizing characters but also in simultaneously associating their shapes, pronunciations, and meanings (Shen, 2005). Therefore, Chinese characters have a high intrinsic load because learners must process many interacting elements in working memory.

Research results show that functions such as radical analysis, character structure interpretation, and contextual examples help students move from memorizing discrete characters to recognizing meaningful structural patterns. This is consistent with CLT, which holds that organizing information into meaningful cognitive units reduces processing pressure and supports schema formation (Sweller et al., 1998).

However, the study does not suggest that AI automatically reduces all types of cognitive load. The effectiveness of AI depends on how the tool is designed and how learners interact with the system. If AI provides too much information at once, learners may still experience overload, especially in the early stages when their information processing abilities are limited.

5.2. AI as a mechanism for reducing exogenous workload in the learning environment.

The results also showed that students highly valued AI's ability to integrate multiple learning information sources into a unified environment. In learning Chinese, learners often have to process Chinese characters, pinyin, meanings, pronunciation, and usage simultaneously. If this information is presented separately, learners have to dedicate additional cognitive resources to searching for and linking information (Chandler & Sweller, 1991). From a CLT perspective, AI-assisted content organization can help reduce exogenous load, as learners do not need to expend excessive cognitive energy on operations that do not directly support learning goals. This finding is consistent with the view that the design of information presentation greatly influences the processing efficiency of working memory (Sweller et al., 2011).

The key takeaway is that AI's role isn't about providing more content, but about organizing it according to the learner's needs. This is the difference between using AI as a search engine and using AI as a cognitive support system.

5.3. AI, scaffolding, and the development of self-learning capabilities.

Another contribution of the research is clarifying the role of AI in the self-learning process of Chinese. Students found that immediate feedback, error explanations, and step-by-step guidance helped them maintain their learning process without relying entirely on direct teacher support. This finding relates to the concept of scaffolding, where temporary support helps learners perform tasks beyond their current capabilities and gradually develop independent competence (Wood et al., 1976). Studies on Intelligent Tutoring Systems also show that adaptive feedback can create a learning experience close to that of individual instruction (VanLehn, 2011).

However, the data also points to a problem that needs attention: AI can become over-relied on if learners use it to receive answers instead of engaging in the reasoning process. This aligns with the warning by Kirschner et al. (2006) that uncontrolled support can reduce learners' cognitive engagement. Therefore, AI in Chinese language teaching should be designed to support the thinking process, rather than replace learners' cognitive activities.

5.4. Theoretical Contribution: Extending CLT in the Context of AI-Supported CALL

This research contributes to the field of Computer-Assisted Language Learning (CALL) by approaching AI from a cognitive load perspective. Instead of simply evaluating AI based on satisfaction levels or learning outcomes, the study focuses on how AI affects learners' information-processing experiences.

The results show that AI can impact all three components of CLT:

- It supports handling internal load through the analysis and organization of the structure of Chinese characters;
- Reduce exogenous load through integrated information presentation;
- Promoting German load by supporting learners in building systematic knowledge.

This approach complements previous research on AI in education, which has primarily focused on personalization and automation (Zawacki-Richter et al., 2019), by emphasizing AI's cognitive role in the learning process.

VI. Conclusion

This study explores the role of artificial intelligence (AI) in supporting the learning of Chinese from a cognitive load theory (CLT) perspective. Based on data from 235 Chinese language learners, the results show that learners perceive AI as a tool to support information processing, especially in learning Chinese characters. This component often presents difficulties because it must simultaneously process character shape, pronunciation, and meaning. The findings suggest that AI can support learners through three main mechanisms. First, AI helps deconstruct the complexity of Chinese characters by analyzing character structure, providing explanations, and connecting components, thereby assisting learners in managing intrinsic load. Second, AI helps reduce extrinsic load by integrating information sources such as Chinese characters, pronunciation, meaning, and examples within a single learning environment. Third, AI has the potential to boost germane load by helping learners build knowledge connections and develop self-learning strategies.

The research also indicates that the role of AI depends not only on technological capabilities but also on how learners use the tool. AI can provide effective cognitive support by acting as a guide, providing feedback, and organizing information; however, passive use of AI can reduce the cognitive engagement necessary for the knowledge-building process.

This research contributes to expanding the application of Cognitive Load Theory in AI-assisted foreign language learning. While previous studies have primarily used CLT to evaluate material design and teaching methods, this research shows that AI can be considered a factor in regulating learners' cognitive load (Sweller et al., 2011).

In particular, the study emphasizes that AI not only increases access to information but can also influence how learners organize and process information in working memory.

For Chinese language teachers, AI should be integrated as a cognitive support tool rather than a replacement for teaching. Teachers can use AI to:

- Analyzing the structure of Chinese characters;
- Design adaptive training activities;
- Provide quick feedback;
- It helps learners identify errors on their own.

However, learning activities still need to include tasks that require learners to reason, memorize, and apply language to build long-term knowledge.

Developers of AI systems in language learning need to focus on cognitive design principles. Providing too much information or inappropriate feedback can increase exogenous load rather than reduce it. Therefore, AI systems should prioritize:

- Present the information step by step;
- Adjust the level of support according to the learner's abilities;
- It encourages learners to interpret and self-check their answers.

This approach aligns with the perspective of research on Intelligent Tutoring Systems, where the effectiveness of technology depends on the quality of cognitive support rather than the degree of automation alone (VanLehn, 2011).

This study has several limitations that need to be considered. First, the data were collected based on students' perceptions and experiences, so the results reflect learners' feelings about AI rather than directly measuring changes in cognitive load. Secondly, the study focuses on Chinese language learners within a specific educational context, so the possibility of generalizing to other learner groups or environments needs careful consideration. Third, the research primarily focuses on the experience of using AI, without analyzing differences among various types of AI tools. Further studies could combine qualitative and quantitative methods to examine the relationships among AI use, cognitive load, and learning outcomes. Furthermore, future research could expand

to include aspects such as the long-term impact of AI on memorization of Chinese characters, the development of self-learning skills, and the degree of learners' dependence on AI systems.

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