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An Integrated Theoretical Framework for Deep Learning in Chinese Characters: Insights from Multimedia, Taxonomy, and Cognitive Semantics

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Abstract: This study proposes an integrated theoretical framework to support deep learning in Chinese character instruction by synthesizing three major theoretical perspectives: the Cognitive Theory of Multimedia Learning (CTML), Bloom's Taxonomy, and Cognitive Semantics. While Chinese character learning presents significant challenges due to its complex visual forms and semantic depth, multimedia technology offers promising but underutilized potential to support meaningful learning. Drawing on critical analysis of prior empirical and theoretical studies, the framework aligns CTML's design principles with Bloom's hierarchical cognitive objectives and the meaning construction mechanisms of Cognitive Semantics. The result is a comprehensive conceptual model designed to guide the development of multimedia-assisted modules that foster deep learning. This framework offers theoretical contributions to language learning and practical implications for instructional design, particularly in ideographic languages. Future empirical validation of this framework is recommended.

Keywords: deep learning; Chinese characters; cognitive theory of multimedia learning; bloom's taxonomy; cognitive semantics

1. Introduction

Chinese characters are the oldest and only writing system still in use in the world, which was developed for Chinese writing (Qiu, Watanabe, & Omura, 2021; Han et al., 2022). As the essential and fundamental element of literacy in China, Chinese characters serve as the foundation for reading and writing. Learning Chinese character is an important component of elementary school Chinese language education. According to the latest Compulsory Education Chinese Curriculum Standards (MOE, 2022), literacy is central to early education. It is an important teaching element and content throughout the entire stage of compulsory education.

However, the inherent characteristics of Chinese characters pose significant challenges for learners. Unlike alphabetic systems that provide a decoding mechanism through grapheme–phoneme correspondence, Chinese characters require the integration of visual form, semantic meaning, and often phonological components into a single unit (Yang, 2022). This unique structure causes deep cognitive challenges, demanding complex visual processing, form–meaning association, and contextual application (Nguyen & Dinh, 2024). As a result, learners frequently rely on rote memorization strategies, which are inefficient and prone to failure (Dai & Yang, 2022), thereby undermining their deep understanding and mastery of Chinese characters. Empirical evidence further



shows that 54.4% of errors in character shape and up to 50% of errors in composition are committed by lower-grade students (Lin, Lim, & Wu, 2022).

At the same time, the digital age has also promoted the widespread application of multimedia technology in education. In Chinese character learning, animation, video, interactive simulation, and audio are increasingly used to present content (Fu, 2018). This emphasizes that multimedia educational technology can improve students' learning interest and ability through rich, vivid, and intuitive presentation methods, and promote the depth and breadth of students' learning. However, there are still issues in using multimedia technology as teaching tools (Xie, 2019).

Many applications, while engaging, lack a solid theoretical foundation, whereas deep learning represents the very essence of this process. Deep learning is characterized by a profound understanding of new knowledge, connecting it with prior knowledge, engaging in critical analysis, and ultimately achieving conceptual understanding that can be transferred to new contexts (Winje & Løndal, 2020; National Research Council, 2012; American Institutes for Research, 2016). Unlike surface learning, deep learning avoids shallow, fragmented, and isolated classroom teaching (Lan, 2022). The researchers argue that deep learning of Chinese characters goes beyond mere recognition; it should encompass understanding the principles of character construction, grasping subtle semantic distinctions, and developing the ability to use characters flexibly and creatively.

Achieving this depth requires not only technology but also instructional framework guided by rigorous principles of human learning, information processing, and meaning construction. However, such frameworks in the learning of Chinese characters still lack depth, particularly in fostering higher-order cognitive thinking (Mthethwa-Kunene, Rugube, & Maphosa, 2022). Moreover, existing deep learning frameworks in education focus on algorithmic and system-level design—such as emotion-aware Intelligent Teaching Systems (Yang, 2025), Natural Language Processing models (Chen, 2025), and Latent Dirichlet Integrated Deep Learning (LDiDL) (Li & Mohamad, 2023)—primarily serving functions like performance prediction, automated assessment, and personalized content delivery in (mostly English) language learning, offering limited guidance for the unique cognitive, linguistic, and cultural demands of logographic script learning. This gap is especially evident in the primary-level context, where learners require structured support to develop deep understanding.

Therefore, the main purpose of this study is to fill this gap. We aim to develop a comprehensive and integrated theoretical framework for native Chinese using learners in primary education, which is able to guide and promote deep learning of Chinese characters. This framework does not propose specific tools or software; rather, it serves as a conceptual model that synthesizes multiple theories. By integrating the Cognitive Theory of Multimedia Learning (CTML), Bloom's Taxonomy, and Cognitive Semantics, the framework provides a coherent blueprint for designing interventions that address the challenges of Chinese character learning using multimedia technology while fostering deep learning. Thus, the research questions of this study are: (1) What are the key theoretical components that contribute to the deep learning of Chinese characters, as identified through CTML, Bloom's Taxonomy, and Cognitive Semantics? (2) How can these theoretical components be formulated into an integrated framework that guides the design of a multimedia-assisted learning module for fostering deep learning in Chinese character education?

2. Review of Literature and Related Theories

2.1. Deep Learning in Educational Contexts

Deep learning refers to learners' ability to engage meaningfully with academic content by constructing, transferring, and applying knowledge in novel situations in light of prior cognitive structures and experiences (Hermida, 2014; Marton & Säljö, 1976). In contrast, surface learning is characterized by a dispassionate approach where the learner is not concerned with understanding, and the information acquired is usually lost after examinations (Hermida, 2014; Marton & Säljö, 1976). Deep learning has contemporary significance and characteristics, as it is referred to as a "21st-century competencies" (Yulu & bin Masran, 2023). It is also a deep-level learning method that can improve students' advanced thinking ability to solve practical and complex problems (Yulu & bin Masran, 2023).

Specifically in the context of language learning, deep learning has been operationalized through a variety of pedagogical strategies aimed at promoting higher-order thinking, learner autonomy, and meaningful knowledge construction. For example, Delgado-Crespo et al. (2020) explored deep learning in EFL instruction by integrating scaffolded thinking routines, cooperative learning, educational technologies, reflective practices, and project-based learning. These approaches supported learner engagement in large, diverse classrooms and facilitated metacognitive development. In the case of Chinese characters, deep learning emphasizes the integration of sound, form, and meaning, which are inseparable components of character understanding. Instructional strategies that focus on the semantic structure of characters and the principles of character formation have been shown to foster

deeper literacy and cognitive restructuring (Guo & Guo, 2021; Chen, 2023). Students are encouraged to independently observe, analyze, and abstract language patterns, thereby internalizing character rules through concept-driven categorization.

In this study, deep learning serves both as a design principle and as a learning outcome. It guides the development of instructional materials that aim to engage learners cognitively and semantically and it serves as a criterion for evaluating how learners process, apply, and extend knowledge of Chinese characters.

2.2. Cognitive Theory of Multimedia Learning

The CTML provides a solid foundation for explaining how multimedia supports deep learning. According to Mayer (2009), information supplied in both text and visuals will result in deeper learning than information presented only in text. It includes three basic assumptions: (1) processing visual and audio information is performed through two separate channels, this is also known as the multimedia principle; (2) each channel has a limited capacity to process information (that means human beings can only effectively process information in limited amounts, therefore they attempt to comprehend it by constructing mental representations of the information sources); and (3) the last one is referring to active learning that is accomplished by accessing relevant information, filtering, selecting and organizing the information via mental structures, and integrating information based on existing knowledge.

These principles highlight the significance of cognitive load management and dual-channel processing in multimedia-based learning. By optimizing cognitive load, instructional design can enhance learners' ability to process and retain complex information, thereby fostering deeper understanding (NRC, 2012). Research further supports these implications: multimedia instruction has been shown to improve information retention, problem-solving skills, and critical thinking abilities (Putra, Nurdin & Fathimah, 2024). Collectively, these findings reinforce the role of multimedia as a powerful tool to promote deep learning through active engagement and meaningful information integration.

The application of the CTML to Chinese language education has shown significant benefits. Studies have shown that the redundancy principle, which typically advises against presenting the same information in multiple formats, needs modification for language learning. Specifically, combining animation, narration, and on-screen text has been found to enhance learning efficiency in technical Chinese courses (She et al., 2009a). Integrating multimedia elements such as sounds, pictures, videos, and Flash animations into e-learning systems for technical Chinese has been shown to optimize learning efficiency. This approach aligns with the principles of CTML, which emphasize the use of dual channels (visual and auditory) for processing information (She et al., 2009b). What's more, the use of interactive courseware based on CTML principles has been effective in improving students' writing performance and satisfaction in learning Chinese characters. This approach supports active processing by allowing students to engage with the material through various multimedia elements (Tin et al., 2018). Students generally perceive multimedia-assisted learning materials positively, indicating high acceptance and satisfaction with the integration of multimedia elements in their learning process (Tin et al., 2018).

However, there are some shortcomings of multimedia technology in teaching. Multimedia presentations often generate clutter and insufficient display space, leading to increased cognitive load, which can hinder learning efficiency (Cheng, Lu, & Yang, 2015). The hypertext structure, multitasking, and unnecessary information can disturb the learning process, contributing to cognitive overload (Aidi, 2009). Many students fail to process multimedia materials in ways that foster deeper understanding because deficits in self-regulation and monitoring prevent them from applying the cognitive processes necessary for meaningful learning, leading instead to superficial engagement (Scheiter et al., 2017).

It is vital to ensure that multimedia technology supports deep understanding rather than just superficial engagement. Segmenting information, removing nonessential content, and signaling essential information, using multi-display systems to present focused and uncluttered content can reduce cognitive load and enhance learning effectiveness (Cheng, Lu, & Yang, 2015). Following established multimedia design principles and ensuring that multimedia materials are designed to foster meaningful learning rather than rote memorization is crucial. This involves focusing on appropriate cognitive activities during learning (Mayer, 2014b).

2.3. Bloom's Taxonomy: Structuring Deep Learning Objectives

Bloom's taxonomy, first introduced in 1956, classified cognitive learning into six hierarchical levels—Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation—providing a framework for observing and categorizing student learning behaviors (Bloom et al., 1956; Athanassiou, McNett, & Harvey, 2003). In 2001, the taxonomy was revised to shift from noun-based to verb-based categories and to better reflect cognitive

development as a dynamic process (Anderson & Krathwohl, 2001; Armstrong, 2010). The revised version identifies six levels of cognitive processes: Remember, Understand, Apply, Analyse, Evaluate, and Create, progressing from lower-order to higher-order thinking.

At the foundational level, Remember involves recalling information from semantic memory, such as facts, methods, or structures. The next stage, Understand, goes beyond rote memory by requiring learners to grasp the meaning of material. Apply emphasizes the transfer of knowledge to new situations, enabling learners to use rules, concepts, and problem-solving strategies with minimal guidance. Moving into higher-order processes, Analyse requires breaking down material into components, recognizing underlying structures, and becoming aware of one's own thinking processes. Evaluate entails making judgments based on specific criteria, fostering critical reflection, and openness to alternative perspectives. At the highest level, Create requires learners to generate original ideas, design solutions, and synthesize elements into new, coherent structures. Together, these levels illustrate the progression from surface to deep learning, moving from basic recall to complex reasoning and innovation. The Figure 1 shows the six levels of Bloom's Taxonomy.

This taxonomy has been closely linked to the distinction between surface and deep learning. While some scholars contend that only Analyse, Evaluate, and Create represent deep learning (Li, 2010), others argue that Apply also entails meaningful engagement, as it requires the transfer of knowledge to new contexts and the demonstration of problem-solving abilities (Prismana et al., 2018). This debate underscores that deep and surface learning are not discrete categories but exist along a continuum of increasingly complex cognitive processes. Consistent with this perspective, the present study defines deep learning as encompassing the last four levels—Apply, Analyse, Evaluate, and Create—since these stages involve critical analysis, evaluation, and innovation, demanding learners to connect, adapt, and extend knowledge in novel contexts.

Recent studies have demonstrated the adaptability of Bloom's Taxonomy across diverse instructional contexts. In blended learning, it has been used to structure both online and face-to-face components effectively (Zhang, 2016). In digital settings, Bloom's levels have been mapped onto tools such as search engines, multimedia, and online discussions (Hu, Xiao, & Chen, 2023). Within outcome-based education, the taxonomy supports the development of higher-order thinking (Ravichandran & Virgin, 2024). Moreover, in teacher education, it provides novice teachers with a framework for designing structured and student-oriented lessons (Nurmatova & Altun, 2023). These findings highlight Bloom's flexibility and its relevance for Chinese character learning, particularly in promoting deep learning objectives.



Figure 1. Bloom's Taxonomy (2001).

2.4. Cognitive Semantics: Meaning Construction

Cognitive semantics emphasizes that language and cognition are inseparable, with meaning understood as subjective, situated, and dynamic. Rather than a direct link between linguistic forms and the external world, meaning construction occurs through the cognitive system, which integrates perception, reasoning, memory, attention, emotion, and cultural structures (Talmy, 2000). This perspective highlights that linguistic meaning is rooted in conceptual metaphors, schemas, and cultural experience, making language not merely a symbolic system but also a reflection of human cognition and social practice (Kövecses, 2012).

Applying Cognitive Semantics in teaching Chinese characters involves focusing on the semantic radicals of pictographic and ideographic characters as cognitive clues and etymological stories. Pictographic and ideographic

characters are fundamental in Chinese writing, where characters combine sound, form, and meaning. This unique structure requires learners to understand the etymology and semantics represented by the shapes of characters (Wang et al., 2024). Radical awareness is crucial in learning Chinese characters. Radicals provide semantic and phonetic clues that help in understanding and remembering characters. Studies show that learners' ability to identify and apply semantic radicals improves with grade level, indicating a shift from phonetic to semantic learning strategies (Tong, Tong, & McBride, 2017). Repeated exposure to radicals during training enhances understanding and pronunciation of characters, although it may sometimes hinder the exact meaning retention due to confusion among similar radicals (Takashima & Verhoeven, 2019). Moreover, cultural context and etymological stories are essential in teaching Chinese characters. Understanding the cultural beliefs and historical context behind characters can help learners form a deeper connection and better semantic networks (Xi, Chow, & Xia, 2023).

2.5. Synthesis and Critical Reflection

Despite their individual strengths, the three theoretical strands each exhibit inherent limitations that underscore the need for an integrated framework. CTML provides strong guidance on managing cognitive load but offers little explanation for how learners construct the cultural and semantic meanings central to Chinese characters. Bloom's Taxonomy effectively structures cognitive processes yet does not address how these processes interact with the conceptual and cultural knowledge embedded in logographic script learning. Cognitive Semantics, while illuminating meaning construction through conceptual and cultural schemas, lacks operational guidance for instructional sequencing and cognitive load management. Taken together, these limitations suggest that no single theory sufficiently accounts for the cognitive, pedagogical, and cultural complexities of Chinese character learning, thereby justifying the development of a synthesized framework that leverages their complementary strengths.

3. Method

The method employed in this study was a critical analysis of the literature, involving systematic reading, comparison, and evaluation of relevant theories and principles to identify those most suitable for constructing a comprehensive framework for deep learning in Chinese character education. This process drew on authoritative theoretical works and peer-reviewed studies across educational psychology, multimedia learning, and Chinese linguistics, with attention to their explanatory power, internal coherence, and applicability to the context of Chinese character learning.

The selection of theories was inductive and rationale-driven, emphasizing their fit to research objectives and their complementary value in conceptualizing deep learning (Angeles et al., 2014). During the analysis, the core assumptions, key constructs, and pedagogical implications of each candidate theory were compared to determine their relevance and potential contribution to the framework.

Three theoretical strands were ultimately chosen. The CTML was selected for its explanatory power in understanding cognitive processing and for providing empirically tested design principles to reduce cognitive load and enhance information integration. Bloom's Revised Taxonomy was incorporated to offer a hierarchical structure for categorizing learning objectives, enabling the operationalization of deep learning as a progression from applying knowledge to analysing, evaluating, and creating. Cognitive Semantics was integrated for its emphasis on meaning construction and cultural grounding, which are essential in the unique morphology, semantics, and etymology of Chinese characters.

By combining these three perspectives, the study ensures that the proposed framework is not only conceptually coherent but also practically oriented, offering a balanced integration of technology, cognition, and semantic understanding in the design of Chinese character education.

4. Results—An Integrated Theoretical Framework

The results of the critical analysis identified three core theoretical strands that form the basis of the proposed framework: the CTML, Bloom's Taxonomy, and Cognitive Semantics. Each theory offers unique contributions that, when brought together, provide a comprehensive perspective on how students acquire, process, and apply knowledge in Chinese character education with the assistance of multimedia technology. These theories were critically examined in terms of their main principles, focus, application contexts, user levels, and relevance to the present study. The results of this analysis are summarized in following tables in this section.

4.1. CTML

The analysis of the CTML highlights its value in guiding the design of multimedia instructional materials through principles that regulate cognitive load and optimize learning processes. As shown in Table 1, empirical studies have applied CTML principles such as the Redundancy principle, the Coherence and Signaling principles, Spatial and Temporal Contiguity, the Modality principle, and the Dual-Channels assumption across contexts, including Chinese language learning and English as a foreign language (EFL). These applications demonstrate that CTML provides effective guidelines for structuring multimedia environments in higher education and school settings.

Building on these findings, the CTML also provides twelve empirically grounded multimedia design principles that can be systematically applied to instructional design (Mayer, 2009). They can be grouped into three categories: reducing extraneous processing, managing essential processing, and fostering generative processing (Rudolph, 2017; Mayer, 2009). These principles are highly relevant to the design of the multimedia-assisted deep learning module for Chinese characters, ensuring that multimedia elements are structured to optimize learning, enhance comprehension, and minimize cognitive overload. Among Mayer's multimedia design principles, eleven were selected for their relevance to the cognitive, motivational, and structural goals of the proposed module. These principles were categorized into three functional clusters to support cognitive load reduction, structured learning progression, and learner engagement, as shown in Table 2.

Table 1. Critical Analysis of CTML.

No.	Author (Year)	Main Principle	Application Context	User Level	Relevance to Current Study
1.	She et al. (2009a)	Redundancy principle	Used for multimedia technical foreign-language learning, Chinese learning	Higher Education, schools	Suitable for studying principles of multimedia design, Chinese language learning
2.	Jiang, Renandya, & Zhang (2017)	Coherence Principle, Signalling Principle, Spatial and Temporal Contiguity Principles	Multimedia courseware for teaching English as a foreign language (EFL)	Higher Education	Suitable for studying principles of multimedia design, language learning
3.	Liu, Jang, & Roy-Campbell, (2018)	Modality Principle	multimedia technic for teaching English as a foreign language (EFL)	Higher Education	Suitable for studying principles of multimedia design, language learning
4.	She et al., (2009a)	Dual Channels Assumption	Design of an e-learning system for technical Chinese courses	Higher Education, schools	Suitable for studying principles of multimedia design, Chinese language learning

Table 2. Categories and Functions of CTML Principles in Module Design.

Category	Included Principles	Function	Emphasis in this study
Reducing extraneous processing	Coherence, Signaling, Redundancy, Spatial contiguity, Temporal contiguity	Minimize irrelevant information and direct attention to key features	Emphasize the perceptual processing stage, by highlighting key information and reducing interference, to improve learners' focus and memory of the form and meaning of Chinese characters.
Managing essential processing	Segmenting, Pre-training, Modality	Control information flow and support learner-paced understanding	Emphasis on learning process design, through segmentation, pre-training, and appropriate channel matching, to help learners gradually build the form, sound, and meaning representation of Chinese characters
Fostering generative processing	Personalization, Voice	Encourage active engagement, meaningful integration, and learner motivation	Emphasizes the intrinsic motivation and generative processing of deep learning, and promotes learners' active integration, transfer, and creative application through personalized expression and authentic voice.

Note: Multimedia principle is the foundation of all principles.

The findings confirm that CTML is a relevant and transferable framework for this study because it offers empirically supported design principles that reduce extraneous processing, enhance essential processing, and foster generative learning. By applying these principles, the current study is able to construct multimedia-assisted modules that facilitate the integration of visual, auditory, and semantic components in Chinese character learning, thereby directly addressing challenges of cognitive overload and superficial memorization.

Taken together, these patterns indicate that CTML is consistently used to manage cognitive load in language learning, particularly through signaling, contiguity, and modality-based design, which justifies its selection as the cognitive-processing backbone of the proposed framework.

4.2. Bloom's Taxonomy

The analysis of Bloom's Taxonomy highlights its value as a framework for structuring cognitive learning objectives and supporting the progression from lower-order to higher-order thinking. As shown in Table 3, empirical studies demonstrate its application across diverse instructional contexts. Bloom's Taxonomy has been applied in blended Chinese courses to balance online memorization and analysis with face-to-face creative practice (Zhang, 2016), adapted to digital contexts through the use of online tools aligned with cognitive levels (Hu, Xiao, & Chen, 2023), incorporated into outcome-based education to foster higher-order thinking (Ravichandran & Virgin, 2024), and used in teacher education to help novice teachers design structured, student-oriented lessons (Nurmatova & Altun, 2023).

Table 3. Critical Analysis of Bloom's Taxonomy.

No.	Author (Year)	Main Principles/ Key Tenets	Application Context	User Level	Relevance to Current Study
1.	Zhang (2016)	used to structure blended learning: FTF for application/creative practice, online for memorization, analysis, and cultural comprehension.	Blended Chinese course for engineering students	Higher Education (non-Chinese majors)	Suitable for structuring both online and offline activities, designing Chinese character modules.
2.	Hu, Xiao, & Chen (2023)	Digital Bloom's Taxonomy integrates digital tools with cognitive levels; tools matched to goals (search engines, media, discussions).	Online Chinese language education	Schools and Higher Education	Highlights the potential of digital tools with Bloom's Taxonomy; relevant to multimedia-assisted design.
3.	Ravichandran & Virgin (2024)	Outcome-Based Education (OBE) applies Bloom's Taxonomy to enhance cognitive and analytical skills.	English literature education, adaptable to Chinese language	Higher Education	Demonstrates how Bloom's Taxonomy promotes higher-order thinking (analyze, evaluate, create), aligning with deep learning objectives.
4.	Nurmatova & Altun (2023)	Bloom's Taxonomy integrated into instructional frameworks helps novice teachers design structured, student-oriented lessons.	EFL context for novice teachers	Teacher Education	Provides guidance for lesson design in Chinese instruction; supports module development and teacher training focus.

Taken together, these findings confirm that Bloom's Taxonomy is highly relevant to the present study, as it not only provides a systematic method for formulating and evaluating instructional objectives but also serves as a practical scaffold for structuring blended, digital, and outcome-based instruction. Across the reviewed studies, Bloom's framework consistently supports the design of learning activities that promote higher-order thinking—particularly analysis, evaluation, and creation—thereby justifying its use in this study to operationalise deep learning as a progression from applying knowledge to engaging in more complex cognitive processes in Chinese character education.

4.3. Cognitive Semantics

Cognitive Semantics, in turn, highlights the inseparability of language and cognition. The analysis of Cognitive Semantics underscores its importance in explaining meaning construction in Chinese language learning. As shown in Table 4, studies demonstrate its application in various contexts. For example, idioms can be better understood through conceptual metaphors and metonymies, suggesting more effective ways of organizing lexicographic entries (Li, 2019). Cognitive linguistic approaches have also informed teaching strategies, with lesson plans showing effectiveness in explaining linguistic phenomena in L2 classrooms (Wu, Huang, & Polley, 2024). Concept-based instruction supported by SCOPA visual schemas has been applied to polysemous verb compounds, enabling systematic understanding of complex structures (Zhang, 2024). Moreover, research on classifiers highlights how semantic networks reflect human categorization processes and clarify conceptual relations between nouns and classifiers (Jiang, 2017).

Table 4. Critical Analysis of Cognitive Semantics.

No.	Author (Year)	Main Principles/ Key Tenets	Application Context	User Level	Relevance to Current Study
1.	Li (2019)	Cognitive semantics explains idioms through conceptual metaphors and metonymies; idioms can be organized by conceptual mechanisms rather than alphabetical order	Chinese lexicography and idiom learning	L2 Chinese learners	Demonstrates how cognitive semantics reveals deeper meaning structures, supporting cultural and semantic aspects of the framework.
2.	Wu, Huang, & Polley (2024)	Cognitive linguistics (CL) provides analytical tools and teaching strategies; sample lesson plans show effectiveness in explaining linguistic phenomena	L2 Chinese teaching and classroom instruction	Teachers and learners	Offers practical teaching methods grounded in CL, aligning with the study's focus on meaning construction.
3.	Zhang (2024)	Concept-Based Instruction (CBI) with SCOPA visual schemas helps learners master polysemous verb compounds systematically	Teaching verb compounds in L2 Chinese	Higher-level L2 learners	Supports systematic understanding of complex linguistic structures, reinforcing the cognitive dimension of deep learning.
4.	Jiang (2017)	Classifiers reflect human categorization processes; semantic networks clarify conceptual relations between nouns and classifiers	Vocabulary and classifier teaching in Chinese	L2 learners	Highlights conceptual categorization in Chinese, relevant to cognitive semantics in the framework.

These findings indicate that Cognitive Semantics is highly relevant to this study, as it not only provides theoretical support for meaning construction in Chinese characters but also strengthens the cognitive dimensions of the proposed framework, thereby providing the semantic–cultural dimension that is essential for deep learning of Chinese characters within the proposed framework.

4.4. The Integrated Theoretical Framework

Taken together, the three theoretical strands complement one another in addressing the key dimensions of Chinese character learning. Figure 2 presents the integrated framework, which unifies information flow, learning hierarchies, and meaning construction into a coherent process. Based on CTML, multimedia elements (images, animations, texts, etc.) first enter the perception stage and then undergo cognitive processing to reduce extraneous load, manage essential information, and promote generative processing. The processed input subsequently contributes in two ways:

- (1) Meaning construction—drawing on Cognitive Semantics, learners form cultural schemata and strengthen semantic networks of Chinese characters through multimedia-supported representations;
- (2) Learning hierarchies—multimedia-supported tasks guide students' progression from applying to analysing, evaluating, and creating, following the structure of Bloom's Taxonomy.

These two pathways ultimately converge in Chinese character education to achieve deep learning, which encompasses cognitive outcomes such as academic achievement, problem-solving skills, and critical thinking—outcomes that Bloom's Taxonomy also helps to assess. The framework clarifies how the three theories work together to support deep learning rather than functioning independently.

For example, when teaching the character “棚 (stable)”, the framework would guide design decisions at multiple levels. From a CTML perspective, the lesson would use segmentation, signaling, and contiguity to present the character's components step by step, highlighting the semantic radical and its relation to meaning. Bloom's Taxonomy would be used to move students from remembering the form and pronunciation to applying the character in new words, analyzing its structure, and creating short sentences or stories using “棚 (stable)”. Cognitive Semantics would inform the use of character etymology and cultural stories, helping learners link the visual form to embodied and cultural experiences (e.g., the image of a stable), thereby enriching their semantic network and supporting deep learning.

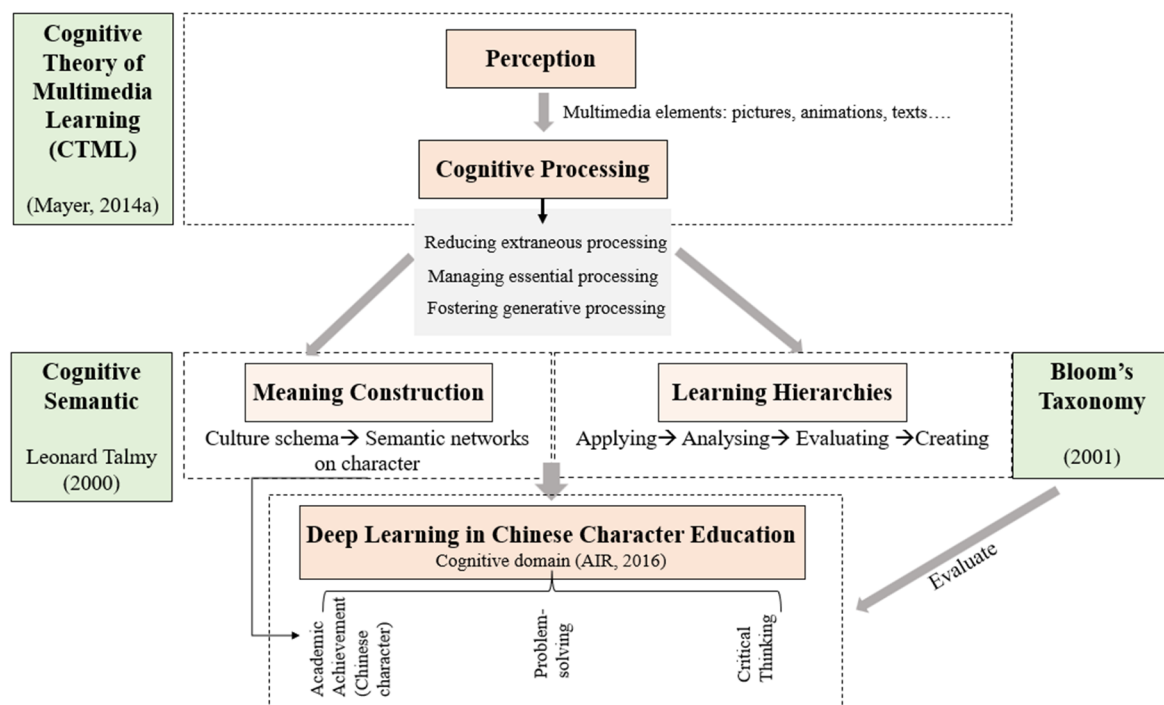


Figure 2. The Integrated Theoretical Framework.

5. Discussion

5.1. Interpreting the Integrated Framework in Light of Deep Learning

The integrated theoretical framework proposed in this study addresses deep learning as a multi-dimensional cognitive process that involves perception, semantic construction, and higher-order thinking. By aligning the design principles of the CTML (Mayer, 2009, 2014a), Bloom's taxonomy (Anderson & Krathwohl, 2001), and Cognitive Semantics (Talmy, 2000), the framework offers a comprehensive strategy for promoting meaningful engagement with Chinese characters.

CTML contributes by regulating cognitive load through empirically supported design principles that optimize the use of visual and auditory elements (Mayer, 2009, 2014a). This supports learners in processing complex visual forms, such as Chinese characters, while maintaining attention and reducing unnecessary distractions (Jiang, Renandya, & Zhang, 2017; She et al., 2009a). Bloom's taxonomy provides a cognitive roadmap that guides learners from basic understanding to the application, analysis, evaluation, and creation of knowledge, aligning with the intrinsic demands of deep learning (Anderson & Krathwohl, 2001). Cognitive Semantics, in turn, provides the semantic grounding necessary for learners to interpret the meaning of Chinese characters in context, thereby enabling meaningful knowledge construction beyond surface-level recognition (Talmy, 2000; Li, 2019). Together, these three perspectives situate deep learning not merely as an abstract outcome but as a process embedded in instructional design, learning goals, and semantic understanding.

5.2. Theoretical Implications of the Triadic Integration

The integration of CTML, Bloom's taxonomy, and Cognitive Semantics represents a novel theoretical contribution to language and literacy education. While prior research has applied these theories individually in language learning (Li, 2019; Wu, Huang, & Polley, 2024; Jiang et al., 2017), their combination into a unified framework tailored to the challenges of Chinese character acquisition is both timely and innovative. This study advances the field by demonstrating that none of these theories, when used in isolation, is sufficient to explain the multi-layered cognitive and semantic processes involved in learning logographic writing systems.

This triadic integration addresses existing theoretical gaps by acknowledging that effective learning is not solely dependent on instructional input or assessment design but also on how learners actively construct meaning from linguistic symbols. Specifically, Chinese characters, as logographic and culturally embedded units, require an instructional approach that balances design efficiency (CTML), cognitive sequencing (Bloom), and semantic complexity (Cognitive Semantics). This framework advances current understanding by demonstrating how these theories can work synergistically to support learning in ideographic language contexts.

The theoretical innovation of this framework lies in its ability to articulate how perceptual processing, cognitive progression, and semantic–cultural interpretation interact dynamically to produce deep learning in Chinese character education. In doing so, it offers a more holistic understanding of deep learning in ideographic language contexts and illustrates how multimedia-based instruction can be aligned with cognitive and semantic principles in a systematic and theoretically coherent manner.

5.3. Practical Implications for Instructional Design

Beyond theoretical value, the proposed framework provides practical guidance for the design of a multimedia-assisted deep learning module in language education. Educators and instructional designers can use CTML principles to reduce cognitive overload and enhance learner focus, especially in visually dense content such as Chinese characters. Bloom’s taxonomy offers a structure for designing learning tasks that progressively engage higher-order thinking skills, ensuring learners move beyond memorization to apply, analyze, and create with the learned content (Zaidi et al., 2018).

Moreover, the application of Cognitive Semantics enables learners to construct culturally and contextually rich interpretations of characters, fostering semantic awareness and improving long-term retention. When applied together, these insights allow for the creation of learning environments that are not only technologically enhanced but also cognitively and semantically grounded, making them more effective in cultivating deep learning outcomes.

Furthermore, the framework can inform teacher training programs, emphasizing pedagogical content knowledge that integrates multimedia design skills, learning theory, and semantic analysis. In digital environments, the framework can be applied to the design of adaptive platforms that adjust content complexity, modality, and semantic depth based on learner profiles, thereby supporting differentiated instruction in both L1 and L2 contexts. It may also guide collaborative material development, where educators co-design digital booklets and multimedia modules that are theoretically informed and pedagogically sound.

To support future empirical research, the framework suggests several concrete methodological pathways. Experimental or quasi-experimental designs may be used to compare framework-informed instruction with traditional approaches, with outcome variables including academic achievement, semantic understanding, cognitive load, motivation, and higher-order thinking. Mixed-methods approaches could further capture process-level data such as eye-tracking, think-aloud protocols, or log-data from digital platforms to examine how learners interact with multimedia and semantic cues. These methodologies would provide robust evidence regarding the framework’s effectiveness and its mechanisms of impact.

The framework also holds potential for application in multilingual and multicultural settings, where learners encounter Chinese characters as a second or foreign language. Its emphasis on semantic motivation and cultural grounding may support learners with diverse linguistic backgrounds; however, adaptation may be required for learners whose prior literacy experiences are primarily alphabetic. Future studies could therefore investigate the framework’s cross-cultural applicability, identifying which components transfer well and which require contextual modification.

6. Conclusions

This study proposed an integrated theoretical framework to support deep learning in Chinese character instruction, drawing insights from the CTML, Bloom’s taxonomy, and Cognitive Semantics. Each theoretical strand contributed uniquely to the design of a multimedia-assisted deep learning module: CTML offered empirically grounded design principles to regulate cognitive load and enhance multimodal instruction; Bloom’s taxonomy provided a hierarchical structure to scaffold higher-order thinking; and Cognitive Semantics emphasized the contextual and conceptual grounding of meaning, which is essential for interpreting logographic characters.

Through a critical synthesis of existing literature, the study demonstrated that the integration of these three perspectives offers a comprehensive and coherent approach to designing learning environments that foster both conceptual understanding and knowledge transfer. The proposed framework addresses key challenges in Chinese character learning—such as superficial memorization, semantic ambiguity, and cognitive overload—by aligning instructional design with cognitive processes and meaning construction.

The framework contributes theoretically by bridging distinct but complementary bodies of literature that are often applied in isolation. Practically, it offers educators and instructional designers a concrete model for developing effective learning materials that promote sustained cognitive engagement and deep learning outcomes. While the framework has not yet been empirically tested, it lays the groundwork for future studies seeking to evaluate the effectiveness of multimedia-assisted instructional models in complex language learning contexts.

Ultimately, this study underscores the value of interdisciplinary theoretical integration in educational design, particularly for ideographic and semantically rich languages such as Chinese. By combining principles of multimedia learning, cognitive development, and semantic processing, the framework paves the way for more effective and cognitively aligned language instruction.

7. Limitations and Future Research

Despite its theoretical and practical contributions, this study still has some limitations. As a conceptual paper, the proposed framework has yet to be empirically tested in real-world instructional settings. While existing literature supports the theoretical coherence and relevance of each integrated component, future research should proceed in staged validation. For instance, expert evaluation through structured review or Delphi method can be used to assess the framework's clarity, completeness, and practical relevance. Future studies also could use this framework to design and develop a multimedia assisted deep learning module, and implement the module in classroom settings and evaluate its usability and effectiveness on students' learning outcomes using quantitative and qualitative measures. Additionally, research could explore how different learner profiles—such as age, proficiency level, or cognitive style—interact with specific components of the framework. Such investigations would not only provide empirical support for the current model but also inform its refinement and broader application across educational contexts.

Based on expert feedback, pilot classroom implementations can be conducted to use the framework in designing a multimedia-assisted deep learning module and to examine its outcomes effectiveness and usability in practice.

Author Contributions

Y.-L.J.: Conceptualization, Methodology, Writing—original draft, Literature Review, Formal analysis, Module design, Writing—review & editing. B.-W.S.: Investigation, Literature support, Writing—original draft, Data curation. N.M.H.B.N.R.: Supervision, Conceptualization, Writing—review & editing, Theoretical guidance. M.N.M.: Supervision, Methodology, Writing—review & editing, Project administration. Q.-F.Z.: Writing—review & editing, Visualization. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Not applicable. This study is a theoretical paper that develops an integrated conceptual framework based on critical analysis and synthesis of existing literature and does not involve human participants, animals, or primary data collection.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

No new data were created or analyzed in this study. This article presents a conceptual framework developed through the critical synthesis and integration of existing literature; therefore, data sharing is not applicable.

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Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

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