

The Role of Technology in Teaching and Learning Chinese Characters

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Chinese characters have been an obstacle preventing the development of Chinese proficiency for learners of Chinese whose native language does not have characters. A substantial literature review identified linguistic, pedagogical, and political factors as causes such difficulties. Tone changes represent different meanings of a word. Compound characters include the phonetic component radicals that do not always sound the same as the phonetic radicals. These unique linguistic features of the Chinese language add even more challenges for learning of Chinese as a foreign language (CFL). Technology integration has been found to facilitate the teaching and learning foreign languages in many efficient and effective ways. To overcome the difficulties of learning CFL, the authors of this paper present a technology enhanced character teaching model consisting of four stages—Radical awareness, enforcement of sound-meaning connections of characters, enforcement of sound-meaning-form connections of characters, and evaluation (REEE). This model was found to be effective in saving class time for interaction and in engaging students in the learning process. The authors suggest future studies are needed to further investigate the effectiveness of the REEE model of teaching and learning Chinese characters.

Keywords: Chinese character learning; radical instruction; multimedia design

INTRODUCTION

Information and communication technology applications have become an integral part of education. Foreign language education, as a fundamental discipline of education, has involved consistent search for and study of computer applications for language teaching and learning. From the traditional “drill-and-practice” type of computer-assisted language learning (CALL) in the 1960s and 1970s, to more interactive CALL in recent years, and mobile-assisted language learning (MALL) nowadays, language education has embraced

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more and more interactive programs, applications, and technological devices in both live and virtual environments to increase the variety of opportunities for learning foreign languages.

Technology has changed and enhanced foreign language education in many aspects. These changes can be seen in the avenues in which foreign languages are taught (in the traditional classrooms vs. online). More importantly, these changes can be seen in how foreign languages are taught with integrating technology, which has been found to facilitate teaching and learning foreign languages in many efficient and effective ways. This is particularly true about the teaching of Chinese characters.

Chinese characters are writing scripts that are considered extremely difficult language elements for CLF learners, especially for whose native language does not have Chinese characters or something similar. What has made Chinese characters difficult to teach and learn? How can technology help? This paper addresses these two questions through a substantial review of related literatures, beginning with identifying the difficulties that exist in teaching and learning Chinese characters, following with a discussion of the role that technology can play in teaching Chinese characters based on theoretical frameworks. Furthermore, this paper introduces a technology-enhanced character teaching model that the authors personally implemented in a Chinese classroom. Lastly, it mentions some popular websites and apps that can be used to help provide daily learning activities for teaching and learning Chinese characters, followed by suggestions for practical application in the classroom.

DIFFICULTIES EXISTING IN THE TEACHING AND LEARNING OF CHINESE CHARACTERS

The Chinese language is considered an extremely difficult language to learn for non-native speakers, such as American learners of Chinese. This assumption does not solely exist among Chinese language teachers and learners. Scientific research has found that Chinese speakers actively stimulate both left and right temporal lobes when communicating; whereas English speakers only stimulate the left temporal lobe when communicating (*Washington Observer Weekly*, July 23, 2003, as cited in Chen, 2005). This assumption is also partially reflected in a list of foreign languages, ranked by difficulty level, established by professional language training organizations, such as the Foreign Services Institute (FSI) of the Department of State and the Interagency Language Roundtable (ILR). According to this ranking, Chinese is considered to be one of the most critical, yet difficult languages for Americans to learn. For an educated English speaker, it normally takes 2200 class hours with a second year of in-country study to reach native-like proficiency; whereas other western European languages, such as French and Spanish, only need 575-600 class hours to reach the same proficiency level (Language Learning Difficulty, 2013).

What has made the Chinese language more difficult to learn than other languages? Chinese educators and researchers have determined the factors constituting its difficulty from linguistic, pedagogical, and language policy perspectives (Chen, 2005).

CHINESE LINGUISTIC FEATURES AND LEARNING OF CHINESE CHARACTERS

The linguistic perspective asserts that Chinese language is a tonal language and changes in tones have increased the difficulty of learning characters in terms of correct pronunciation and building the connection between the sound and meaning with characters and words. Chinese has four basic tones and variations of those tones and pitches. A change in any of these three elements may change speakers' emotional feelings or semantic meanings of the words in speech. Take the syllable qu for example, qū may mean area (

区), to expel (驱), or bent or to feel wronged (屈); qú may mean channel, gutter (渠) or a surname (瞿); qǔ may mean music (曲), to pick up (取), or to take a wife (娶); qù may mean to go (去) or fun and interesting (趣). A high pitch qù (去) in the sentence “你去吧” may indicate an angry “Go away,” but a soft pitch 去 may express “You may leave.” Even Chinese natives may have some difficulty articulating these sounds correctly. Therefore, distinguishing between the four tones and their variations is extremely difficult for native English speakers.

The unique formation of Chinese characters also increases the difficulty of learning Chinese language. Although second language acquisition theory proclaims that all languages are both systematic and arbitrary, Chinese characters are formed more systematically based on the manner in which characters were created or derived. Traditional classifications of Chinese characters include six categories (Zuo, 2005): pictographs (象形 xiàngxíng, i.e., 日, 月), [ideographic](#) (指事 zhǐshì, i.e., 上, 下), compound ideographs (会意 huìyì, i.e., 困, 囚), [phono-semantic](#) compounds (形声 xíngshēng, 江, 河), phonetic loan characters (假借, jiǎjiè, 北, 长) and derivative cognates (转注 zhuǎn zhù, 考, 老). Although statistics show that phono-semantic compound characters take up about 80% to 90% of the total number of Chinese characters, the characters in which the phonetic component containing exactly the same sound of the phonetic radicals only take up only 26.3% of the total phono-semantic compounding characters.

Due to the inconsistency of sound-meaning association, learning Chinese characters becomes even more challenging and sometimes intimidating for native English speakers. According to a survey on learning Chinese characters (Shi & Fang, 1998), even though 100% of students were aware of meaning components in characters, 77% of foreign students could not associate sound with a character when they were asked to read.

PEDAGOGICAL ISSUES IN TEACHING AND LEARNING CHINESE CHARACTERS

Existing studies have revealed two dominant issues in pedagogical approaches to teaching Chinese characters. These issues have resulted in more difficulties in learning Chinese characters. The first issue is the dilemma of sequence order when introducing the Chinese phonetic system of pinyin and Chinese characters. When teaching Chinese as a foreign language, it is common practice to teach pinyin first because it is believed that focusing on the phonetics without distracting from character orthography will build a solid foundation for spoken language, which will further help develop awareness of the language and skills for dealing with more challenging tasks, such as learning characters (Chen, 2005). Packard (1990) found that in comparison with students who were immediately introduced to Chinese characters in class, students who studied pinyin for three weeks before learning Chinese characters proved significantly better in phonetic discrimination, unfamiliar syllable transcription, and spoken Chinese. During the early stages of learning Chinese, making learning tasks less intimidating will help students become more comfortable with learning characters and may help lower the drop-out rate.

The pinyin-first teaching approach is derived from the “Phonetics Teaching and Whole Language Teaching” approach (Lam, 2011), which is very popular in teaching western European languages, in which phonetic forms associate with sounds and meanings. Chinese characters are the united formation of sound, form, and meaning. This special linguistic feature of Chinese determines that the language forms and meanings of a character should not be isolated in teaching. Some teachers believe Chinese character learning should be delayed until the third year of learning for CFL learners, so that their prior knowledge of Chinese language, now latent, can be used to assist in learning characters (Wang, 1998). However, research (Everson, 1988; Packard, 1990) has also

found that delayed introduction to Chinese characters can hinder language development as a whole. Consequently, students become more dependent on pinyin and more resistant in learning Chinese characters; thus, delaying the development of essential Chinese reading and writing skills. Luckily, despite difficulties in studying Chinese characters, additional research has shown over 96 % of students are genuinely very interested in learning them (Chang, 1998; Shi & Fang, 1998).

A survey of 914 students and 192 instructors found out that the majority of Chinese programs in the United States did not delay teaching characters. Most instructors and students believed that the best time point to introduce characters was near the beginning of the first semester (Ye, 2013). Studies (Wang, 2013; Zhang, 2005) have pointed out that typing *pinyin* with computers when American beginning learners of Chinese first learned *pinyin* allowed the learners to find out the surprising connections of the phonetic system and Chinese characters. This may arouse English speakers' awareness of orthographic rules and may promote learning motivations for learning characters. The result of early or delayed exposure to Chinese characters may be different when technology is integrated into instruction. Therefore, overemphasis on pinyin when teaching characters can potentially decrease students' natural interest and learning motivation, which can adversely affect learning results.

The second issue increasing difficulties in learning Chinese characters is the underemphasis of writing characters when teaching in the beginning stages of Chinese language learning. In a critical analysis of the various ways of teaching Chinese characters, Lam (2011) professed that although Chinese classes are different from each other in many ways, character-centered and meaning-centered approaches have often been adopted. Both of these two approaches emphasize character recognition and comprehension, but leave the writing of characters out of the learning process.

Character-Centered Approach. According to Lam (2011), Character-centered teaching developed from ancient times, when people chose the three classic texts to teach children. These texts were *Three Character Scripture* (三字经), *Hundred Family Names* (百家姓), and *A Thousand Characters* (千字文). These texts are rhythmic with a high density of characters to help children learn the characters first before reading. This method of learning separates learning to read from learning to write; therefore, learners can only read classic texts without being hindered by knowing how to write characters, a skill which requires more time to master.

Throughout history, a variety of methods focusing on teaching characters have been developed, yet the same ignorance regarding writing of Chinese characters remains in character-centered methods. Intensive learning of characters (集中识字) (Lam, 2011) is one approach that categorizes characters by radicals, which offer semantic or phonetic functions. For example, “江, 河, 湖, 海” can be categorized by their semantic radical 氵 (water). “工, 攻, 功” can be categorized by the phonetic radical 工. This approach was found to help learners recognize characters quickly, while associating the sounds and meanings of characters (Xu, 2014). However, in addition to the lack of writing practice, this approach has also been criticized for the following reasons: phonetic radicals are nice predictors of characters' pronunciations in low-frequency characters, while semantic and phonetic radicals are not reliable components in high-frequency characters. Only 26 % of phonetic radicals provide reliable cues for compound characters (Shen, 2007). Williams (2013) declared the radical method especially helpful for learners with intermediate high proficiency level whose character recognitions can be developed by semantic radicals prior to phonetic radicals, but Shen (2007) suggest not encouraging students to guess phonetic radicals for a new character, as it is necessary for students to know the role of phonetic radicals in a compound character. In short, regarding radical instruction, semantic radical

instruction is much more reliable for teaching Chinese characters than phonetic radical instruction.

Learning characters by their components or chunks (部件识字) means to analyze a relatively complex character and divide it into simple character components, which are not consistently associated with semantic or phonetic functions (Xu, 2014). For example, 韶 can be further divided into 立, 日, 刀, and 口. Although not all characters can be divided into more basic characters, learning characters by their components may help students to master more complex characters with ease, while concurrently reviewing simple characters. According to Shen (2007), students' ability to decompose compound characters can be developed at very early stages of learning Chinese characters (about three weeks after introducing Chinese characters). Unfortunately, research to see if writing the basic components of characters can help to learn and retain characters has not yet been conducted.

Meaning-Centered Approach. Contradictory to the character-centered approach, the extensive learning of characters (分散识字) stresses that they should be taught in a meaningful context from the very beginning. As Si (2001) suggested, "the characters should not be detached from the words, the words from the sentences, or the sentences from texts". This approach helps students to learn that some characters are used only in certain words (e.g., 哆嗦), difficult conjunctions (所以, 于是), or some polysemous words (e.g. 打在打网球, 打工, 打人, 打毛衣, 打交道, 打水, 打车, and 打酱油 etc.). By reading along with the text of a dialogue, students may learn the meaning of the new characters; furthermore, meaningful context helps students to recognize and use characters quickly and accurately.

It is obvious that both the character-centered and meaning-centered approaches can enhance learning Chinese characters in different ways. In order to best utilize the advantages of both approaches, some teachers have adopted a hybrid approach referred to as "texts of a family characters" (字族文), which uses meaningful texts with a focus on a family of characters with certain shared attributes. In order to emphasize basic characters and then expand upon their variations, poetic texts have been created (因字创文). By reading rhyming texts, in which many characters share common attributes, students can learn both meaning and target characters (创文识字).

The meaning-centered teaching approach methods emphasize teaching characters in meaningful contexts and help learners develop their reading skills. However, one issue of meaning-centered teaching approaches is that learners' understanding of characters may be incomplete or in an unorganized manner. Therefore, they may be easily confused by homophonous characters.

DIFFICULTIES CAUSED BY LANGUAGE POLICES

Chinese language policies published in 1958 in mainland China have changed or removed strokes and complicated elements of some characters. The historical significance of this change has helped Chinese people in mainland China achieve literacy very quickly. However, some simplified characters have lost ideographic and pictographic-phonetic mark symbols, along with the semantic representation of certain characters (Deng, 2009). Chinese scholars (Zou, 2005; Jia, 2001) have found that identifying the origin of character configurations helps students to recognize and write characters more accurately. When teaching characters by rationales (字理识字), teachers show their students how characters have been formed and changed from their original pictograph over time. However, some characters in modern simplified format may not completely connect with the original characters, such as love in the traditional format (愛), which explains only wholehearted (

心)love is real love, but in the simplified form of love(爱), the heart radical has been removed. In this case, the simplified 爱 lost the rich symbolic meaning of the original character 愛.

Current Chinese writing forms include simplified and traditional characters. Since 1958, simplified Chinese characters have been used in mainland China and Singapore, whereas traditional characters continue to be used in Hong Kong, Taiwan, and additional Chinese communities overseas. These two writing systems may be confusing to Chinese learners when they use Chinese characters in the real world because most learners just learn only one writing form, either simplified or traditional characters. Students who have mastered simplified characters may be very frustrated when they cannot read local Chinese community newspapers in the States, which are often written in the traditional form. Deng (2009) mentioned radical functions may be confusing in a compound character, when a radical is simplified or not simplified in different words, such as 拥(cuddle), 饗(cook). Teaching both simplified and traditional characters during class time is nearly impossible due to time limitations, increased cognitive load for students, and increased teaching load for teachers.

Overall, Chinese language features determine that characters are a unified configuration in which forms associate with semantic and phonetic components. Chinese language linguistic features, such as tones, pitches, stroke order, radicals, homophonous characters, simplified and traditional characters, etc., have made learning Chinese characters very difficult. Although Chinese teachers have creatively used both character-centered and meaning-centered approaches in teaching characters, during a limited class time, teachers cannot cover all aspects of all characters learned in each class.

How can the issues of teaching Chinese characters mentioned above be addressed? Integrating technology into the teaching and learning processes has become a very promising solution (Bourgerie, 2013; Chen, 2005; Liu, 2013; Xie, 1999, 2001). The remaining section of this paper addresses theoretical frameworks supporting technology integration in teaching Chinese characters, followed by a historical review of different technologies adopted in the Chinese classroom.

TECHNOLOGY SOLUTIONS TO CHALLENGE IN TEACHING AND LEARNING CHINESE CHARACTERS

Integrating technology in the classroom is not merely a good idea. Technology-based character teaching is strongly supported by learning theories, second language acquisition theories, and sociolinguistic theories. These theories have helped language educators understand the value and rationale of using technology in the Chinese classroom better and have guided teachers in designing curriculum and instructions that are both technologically and pedagogically appropriate.

THEORETICAL FRAMEWORKS SUPPORTING INTEGRATING TECHNOLOGY IN TEACHING AND LEARNING CHINESE CHARACTERS

Cognitive Theories. Learning is a cognitive process. Several cognitive theories can explain and guide technology integration into the Chinese classroom. The most fundamental theories are the information processing theory and the dual-coding theory.

The information processing theory is the primary foundation for learning foreign languages. This theory was presented in 1956 by American psychologist George A. Miller. This theory asserts that the mind receives the stimuli from the environment, processes them, stores them, locates them, outputs them, and then responds (Gredler, 2009). This information processing model has three major components: sensory memory, short-term

memory (working memory), and long-term memory. Sensory memory contains iconic memory and acoustic memory, which can be held longer than iconic memory. Sensory memory mirrors the information immediately received from one's senses into the brain. However, only less than 1% of sensory information passes on to short-term memory. During this stage, information is encoded, rehearsed, re-encoded, and then a very small amount of selected information is permanently stored in long-term memory, which contains the knowledge and information that affects our perception of the world. Therefore, sensory memory can be seen as the entrance to the world of knowledge. When teaching Chinese characters, providing more sensory stimuli through audio, visual, graphic, iconic, and animation formats will help learners to retain the visual images and sounds of Chinese characters.

Dual-Coding Theory. Dual-coding theory was developed in 1971 by Allan Paivio of the University of Western Ontario. This theory later becomes a foundation for multimedia language learning theories (Williams, 2013). Dual-coding theory states that when a person is encoding information, the encoding process involves both verbal and non-verbal (i.e. imagery) processes involving visual, auditory, tactual, and kinesthetic sensory modalities. The verbal system includes printed words, sounds of speech, Braille, and motor feedback from writing. The nonverbal system includes pictures or objects, environmental sounds, tactile objects, and motor feedback from haptic exploration of objects (Paivio & Begg, 1981, as cited in Williams, 2013). It is believed that when learners use both systems to encode information, they will learn and retain the information better than only using one system.

Second Language Acquisition (SLA) Theories. Among SLA theories, Gass's (1997) input and interaction theory serves as a solid foundation for educational practice for integrating technology into teaching and learning Chinese characters. Gass presented a second language acquisition model that specifies different stages starting from perceived input to comprehended input, intake, and interaction, to second language output.

Perceived input refers to the awareness that learners have for new information about the target language. At this stage, perceived input is not yet firmly established in learners' internalized knowledge. According to Gass (1997), input of the target language is the most important factor for learners of foreign languages. If input is lacking, language learners will not be able to produce a lot of quality "output." Comprehended input) emphasizes language exposure that is just beyond learners' current language level. It can be understood, analyzed and has the potential of being assimilated through the process of intake. Intake refers to internalized comprehensible input. Intake occurs only when learners are noticing the target language; otherwise, they will not intake the new information of the target language. For example, when correcting learners' errors, if learners do not notice their errors, they will repeat the same errors no matter how many times they are corrected.

Gass' (1997) interaction stage emphasizes negotiation that can help during breakdowns in communication. In a traditional language classroom, interaction involves the presence of teachers and students who are interlocutors of a conversation. However, in this digital age, where the internet and a variety of technological tools have been widely adopted in education, types of learning interactions have been reformed. The three essential components of learning interactions in curriculum and instruction consist of the learner, teacher, and content. Therefore, learner-content interaction, learner-instructor interaction, and learner-learner interaction have become the main forms of learning interactions (Moore, 1989). Relative emphasis on each of the components determines whether the teaching and learning approach is learner-centered, teacher-centered, or content-centered.

Being able to produce comprehensible output of quantity and quality is highly desired in learning foreign languages. Language learners need to be "pushed" to produce output.

They need a reason to produce output, and they need a topic on which to produce “output”. Moreover, the output needs to be comprehensible.

Carefully selected technology and thoughtfully designed learning applications can serve each stage of the information process when learning characters. As Williams (2013) stated, multimedia materials can provide visual presentations help make meaning clearer by illustrating relationships in multi-sensory ways that are not possible with words alone. Technology-based learning tools and resources may best satisfy students’ learning preferences. Comprehensible input alone does not guarantee learning. Because of individual differences among students, the same level of comprehensible input may not be appropriate for all learners. Technology can make learning more individualized and interactive so that each learner can produce more comprehensible output.

In addition, effective instruction requires consideration of learner’ unique characteristics. Nowadays, most learners are “digital natives” (Prensky, 2001). They have grown up with technology, living in a digital world, using computers, tablets, smart phones, videogames, video cameras, etc. Technologies are their toys and have become integral parts of their lives. Therefore, to engage learners of the 21st century in learning, more technology tools should be integrated into the classroom.

ROLE OF TECHNOLOGY IN TEACHING AND LEARNING CHINESE CHARACTERS

A few articles (Bai, 2003; Bourgerie, 2003; Chen 2005; Yao, 2009; Williams, 2013; Xie, 2001) have briefly reviewed how computer-based technology was initially used for teaching and learning Chinese characters. According to Yao (2009), computer technology has been used in the field of Chinese language instruction since the 1970s. In fact, the first few commercial Chinese language education programs were all specifically designed for learning of Chinese characters with the use of computers (Yao, 2009).

Recent relevant studies have discovered that multimedia and animations facilitate character recognition (Jin, 2006; Kou & Hooper, 2004). Because character recognition is the fundamental step to development of reading and writing skills, these research-based findings suggest more effective ways of integrating technology with character learning.

Many researchers have explored using multimedia technologies in learning Chinese characters. Multimedia in second language acquisition is formally defined as any technology that combines different media (audio, visual, graphic, and text) in one presentation format; however, with the advancement of technology, multimedia is now associated with networked computers and their media capabilities(Williams, 2013).

Kou and Hooper (2004) compared different approaches to learning Chinese characters using a computer-based tutorial designed to teach 30 Chinese characters to nonnative Chinese speakers. The target characters were divided equally between concrete words (人, 口, 树, 门, etc.) and abstract words (爱, 东, 飞, 说 etc.). In this study, ninety-two high-school students were randomly assigned to one of five treatment groups: translation, verbal mnemonics, visual mnemonics, dual coding mnemonics, or self-generated mnemonics. The post-test results on the same day showed that participants in the dual coding group scored the highest among all the groups, and those in the self-generated mnemonic groups demonstrated higher post-test performance than those in the visual coding, verbal coding, and translation groups; however, those who generated their own mnemonics spent more time on the task than any other group. Survey and qualitative data suggests that learners’ interpretations of Chinese characters were rooted in their cultural backgrounds and personal experiences.

The effectiveness of using multimedia enhancing character learning was also supported in Jin’s study (2006), discovering the effects of multimedia presentation, orthography, and processing experience on Chinese character recognition. In this study, one hundred twenty CFL learners of different language backgrounds (European, East Asian, and South Asian)

were asked to learn 36 Chinese characters displayed either on computer-based multimedia presentations focusing on radicals, character stroke sequences, or pinyin, or a traditional printout with pinyin and English translations. The results of an immediate recall task showed that computer-based multimedia helped CFL learners (regardless of their language backgrounds) effectively recognize characters than the traditional printout group. Within the same multimedia groups, radical presentation was performed best, followed by stroke presentation, and *pinyin*.

Animations as specific computer-based multimedia learning tools for character learning were thoroughly investigated in a recent study conducted by Lu, Hallman, and Black (2013). In this study, participants included 36 voluntary graduate and undergraduate students who had not previously studied Chinese prior the experiment. The participants were randomly assigned to one of three groups: (1) Traditional Learning group (TL), (2), Animation Learning Group (AL), and (3) Embodied Animation Learning group (EAL). All three groups were tasked to study 18 Chinese characters (7 pictographic, 5 indicatives, and 6 ideographs) by using different character learning programs created using Flash. The Flash programs shared three common features of characters: pronunciation, semantic meaning, and written form. However, each group was designed to be different: the TL group did not include a video in a static interface; the AL included a video that showed an animation of the character's etymological form changes of the learning program: The TL group EAL group included a video that showed an animation of the character's etymological form changes, as well as human bodily movements, actions, or gestures that depicted both the semantic meaning and written form of the character (Lu, Hallman, and Black, 2013, p.4). The participants were allowed 40 minutes to learn the 18 characters.

The results indicated that the EAL group outperformed the other two groups in the total recalled number of learned characters and in the overall post-test scores. The AL group outperformed the TL group and statistical significances and large effect sizes were found between the AL and EAL groups. The study also found practice effect to be a significant predictor of Chinese character learning outcomes. Given these positive results, this empirical study recommends the use of EA Chinese character learning for beginning learners of CFL.

Another role that technology plays in learning characters is helping to writing Chinese characters. Some researchers have explored the possibility of using modern technology, such as stroke sequence animation programs, as a tool for character learning (Jin, 2003, 2006; Zhu & Hong, 2005, 2012). A recent study compared the effectiveness of developing CFL learner's orthographic knowledge of reading and writing Chinese characters in different conditions (Xu, Zhang, Juan, & Perfetti, 2013). Participants in this study were thirty-six CFL learners of native English speakers, who had completed about 150 hours of Chinese instruction in their first year of Chinese study. They were randomly assigned to learn three sets of characters in three learning conditions: reading (the first condition for all the participants), reading with stroke sequence animation, and reading with writing the characters based on their pinyin and English translations. Three sets (with 20 characters in each set) of new characters that have identical or near identical components in both simplified and traditional format were selected as the learning materials, and the participants were required to spend 20 minutes learning each set before they were assessed.

The post-test and delayed post-test results showed that although all of the three learning conditions facilitated character learning in different ways, the combination of writing and stroke sequence animation conditions led to better form recognition. The animation program granted learners both reading and writing practice, while enhancing the acquisition of orthographic knowledge, including form, sound, and meaning. Therefore, findings of this study encourage the use of computer-assisted learning technologies within and beyond the classroom.

Digital tablets, one of the most advanced technologies today, have greatly contributed to character learning because they possess many features that can help face the challenges of learning Chinese characters. Tablets have multiple functions, including video, audio, camera, internet connection, file editing and saving, etc. These embedded features allow learners to access a variety of learning materials and learn Chinese characters at their own pace, according to their personal learning styles and preferences. In addition, tablets are highly interactive because of their multiple input methods—typing, handwriting, and voice input, and scanning. These multiple input methods have provided new ways for learners to associate sound and meaning with a character. In comparison to computers, tablets are more mobile; this feature provides learners with easy access to learning materials (Liu, 2012). Learners can immediately locate learning resources or tools for helping them learn Chinese.

In addition to the language learning functions that are embedded into tablets, many applications that can be downloaded online provide tools and resources for learning Chinese, especially for learning Chinese characters. Lin and Lian (2012) explored Chinese learning iPad apps and classified them into three categories: general apps, instructional apps, and other types of apps. General apps are for taking notes and basic file management, such as Evernote, iPad, Dropbox, and AudioNote Lite, etc. Instructional apps are for learning pinyin (e.g., Pinyin Chart, Pinyin Trainer, Tone Tutor, and iSayNihao), oral practice (Skype, Messenger, IMO.im, VoiceThread, Siri, iFlyDiction, and Dragon Diction), character learning (Pleco, DianHua Dictionary, Trainchinese: Dictionary & Flash Cards, and HanYu Chinese Dictionary), reading animated stories (Apple Tree), character recognition and writing (EZi Test Chinese, Chinese Writer, and Estroke), writing (StoryKit, StoryLines, GoodNotes), and self-learning apps (Hi, Nihao; Skitters). Other types of apps mainly refer to apps for class and grade management, such as Attendance. In recent few years, more and more iPad apps become available for teaching Chinese. Appendix lists some useful online resources and iPad apps that can be used to enhance the teaching of Chinese characters.

As mentioned above, Chinese can be a difficult language for native English speakers to learn because of its special Chinese linguistic features, pedagogical issues, and language policies. Technological tools have played a very important role in enhancing the learning of Chinese stroke sequences, synonyms, and traditional and simplified forms. With technology, one can easily connect all the elements of Chinese character together.

TECHNOLOGY ENHANCED INTEGRATED METHOD OF TEACHING AND LEARNING CHINESE CHARACTERS

Previous studies of Chinese character instruction have shown the importance of teaching radicals, origins of characters, and meaning representations of characters in context. However, due to the limited time for instruction during formal classroom settings, teaching all of these aspects of characters, in addition to other instructional activities for the development of the four proficiency skills, is very challenging and nearly impossible. A new way of teaching that help students obtain the fundamental knowledge of characters is desperately needed. The literature review in this paper has also shown the critical roles that technology tools can play to enhance teaching and learning of Chinese characters. Based on the findings of existing research and years of teaching experience teaching Chinese as a foreign language to American non-heritage students, the authors of this paper have developed a new instruction model aiming to use multimedia and mobile applications to enhance learning and teaching of Chinese characters.

This new character instruction model consists of four stages: Radical knowledge awareness, Enforcement of sound-meaning connection, Enforcement sound-meaning-form connection, and Evaluation (REEE). Graphic 1 below illustrates the model and its four repeated stages of learning new characters in each thematic lesson of the textbook that students use in their Chinese class.

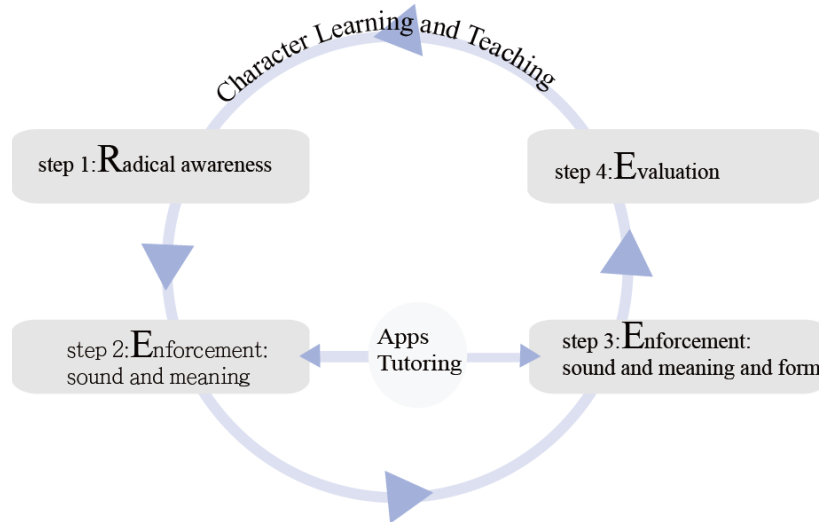


Figure 1. Character learning and teaching model REEE.

Stage 1 takes place before class. The instructors will create an animated vocabulary PowerPoint, which will display information of the character in the order of English translation with graphic, pinyin, character, and the dissected radicals and concrete words. Following the PPT design sequence, the instructors will create a video to explain the vocab PPT in Chinese at the students' Chinese proficiency level. Figure 2 illustrates the design of a vocabulary PowerPoint.

During the explanation, the instructor will provide some examples of sentences in which the character is used. The PPT videos will be assigned to students to watch before class. Students are required to record the vocabulary and identify radicals and concrete words when writing character sheets. This "flipped learning" style will engage students in the learning process and helped students develop their awareness of radical and character knowledge, while becoming familiar with the vocabulary before class.



Figure 2. Character PowerPoint design.

Stage 2 involves many instructional and learning activities to help build upon sound-meaning connections of characters. During this stage, the instructors first check on

students' preparation work for the class. Instructors will say aloud some words and phrases, and students need to write the pinyin and English meaning of what the instructor said. Then, more listening and speaking activities will be carried out in class to help students establish the connection between the sound and meaning of characters. After class, students are assigned to do more listening and speaking practices with tutors, as well as learn to write characters using some apps to strengthen sound-meaning connections. Meanwhile, students will also practice writing characters to connect their form with phonetic and semantic aspects of characters.

Stage 3 involves many instructional and learning activities to help build on sound-meaning-form connections of characters. During this stage, the instructors first check on students' preparation work for the class by dictation. The instructors will say aloud some words and phrases, and students need to write what they hear in characters, pinyin, and English translation. In addition, students need to dissect some characters into radicals and concrete words to demonstrate their knowledge of radicals and basic words. After the dictation, more listening, speaking, and reading activities will be carried out in class to help students strengthen the sound-meaning connections and further establish the sound-meaning-form connections of characters. The activities encourage students to understand and apply the vocabulary in meaningful context. Similar to Stage 2, after class, students are assigned to do listening, speaking, reading and writing practices with tutors, and use different apps to assist their learning.

Stage 4 occurs at the end of each lesson to evaluate learning and teaching. The evaluation includes different components, for example, dictation of sentences, identification of radicals and chunks, listening comprehension, talking about pictures, conversation with the instructor, and reading comprehension. The evaluation results will guide teaching and learning of Chinese characters in the next cycle.

The REEE model was implemented in first year and second year Chinese classes in the spring semester of 2014 in a southwestern university in the United States. Through the observation of students' performance in class activities and assessments, the instructors found that students were more interactive and participative during the learning process. The two stages of character learning focus on sound-meaning connection first and then move to sound-meaning-form connection. These break-down stages help students steadily develop a solid foundation of characters. Students were found to enjoy the learning process more, rather than being overwhelmed by explosive exposure of all aspects of information about characters in the class. Of course, these observations need to be verified with data collected in the future.

CONCLUSION

This literature review has looked into the difficulties of teaching and learning Chinese characters. To overcome this obstacle, many Chinese educators have developed a variety of instructional methods to help foreign students develop radical and character knowledge to build a foundation of further development of Chinese proficiency. Technology can facilitate character learning in many ways. Previous studies have found that computer and communication technologies, multimedia tools and animations, etc. have played critical roles in character recognition, stroke orders and sequences, and building associations between phonetic, semantic, and orthographic components of Chinese characters. More importantly, modern mobile technologies, such as handheld tablets, smart phones, and iPads/iPods, have allowed learners to study Chinese characters in a more personalized, interactive, and communicative way.

The REEE model of teaching and learning Chinese characters was presented by the authors as an integrated approach to enhance the teaching and learning of Chinese

characters. The presented REEE model of teaching Chinese characters saves valuable class time for students to practice, thus, helping to build on connections between sound, meaning, and form. In addition, the REEE model engages students in all stages of learning Chinese both in and out of the classroom. The REEE model was found to be very effective in the instructors' first year and second year Chinese classes. However, the effectiveness of learning and teaching Chinese characters with this model needs to be supported by both qualitative and quantitative data. Further research to evaluate the REEE model in Chinese learners of different cultural backgrounds and of different language proficiency levels needs to be conducted.

Technological potentials for enhancing the teaching and learning of Chinese characters are unlimited. However, Chinese educators need to understand that technology can never replace the role of real teachers in the classroom. Technology itself cannot make miracles. Thoughtful integration of technology into the curriculum, along with effective instruction involving the interaction between students and multifunctional technologies are two key factors that can greatly contribute to the successful learning of Chinese characters.

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APPENDIX

iPad Apps That Can Be Used to Enhance the Teaching of Chinese Characters.

Tool	Format	Developer	Fee	Main functions suggested applications
I Learn Chinese	App for iPhone and iPad	YOYASOFT LLC	Light (free) Full (\$4.99)	* stroke order , the Simplified and Traditional Chinese characters with picture origins and sound * Users can search with character's pinyin, Chinese writing, or the English meanings. * Character writing demonstrations and practice screens.
HeCharacter	Windows, Macs, iPads	Hezi.net	Free	* Best for learning basic radicals and character formation * Animations of character formation Self-learning assessment
Hanziface	iOs 4.3 or later in iPads, iTunes and iPhones	Taiwan Knowledge Bank Co., Ltd	Free (light version)	* unique paintings of Chinese characters * Chinese characters and phrases in traditional and simplified versions * English translation * Animation of Chinese characters origin * Stroke order demonstration and writing practice * True human voice pronunciation to each Chinese character and phrase
Yizijing	iOS 3.2 or above; iPads, iTunes and iPhones	Beijing Sinotype	Free	* use stories to learn Chinese characters; animations and translation in English
Jiayou Chinese	iOS 3.2 or above; iPads, iTunes and iPhones	LLC 2013 Pendula, LLC.	Free	* 500 foundational characters in animations * Each character comes with definition * Characters are all animated with proper stroke order

Traditional to Simplified Chinese Converter	iOS 5.1 or above; iPhone、iPad、iPod touch	FBM	Free	<ul style="list-style-type: none"> * Simplified and Traditional Chinese interchange * Simple and clear user interface * Send translated text with Messages or Email * Automatically copy the translated text to your clipboard * Works offline * Online dictionary. Can search words by pinyin or characters, stroke numbers, and radicals *stroke sequence animations; *audio *definitions
汉典	Website	Zdic.net	Free	
