THE EFFECTS OF A CUSTOM-DESIGNED ANIMATION PROGRAM ON LEARNING CHINESE CHARACTERS

by

Lin Shi
A Dissertation
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DEDICATION

This is dedicated to my loving husband Dave, my son Henry, and my parents.

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ABSTRACT

THE EFFECTS OF A CUSTOM-DESIGNED ANIMATION PROGRAM ON LEARNING CHINESE CHARACTERS

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As the economic growth of China increasingly affects the global economy, the interest in learning the Chinese language in U.S. schools has been growing rapidly. For adult learners who are non-native Chinese and who are beginning learners of Chinese as a foreign language (CFL), one of the difficult tasks is to produce Chinese characters correctly. Although it is important to write Chinese characters with the correct stroke sequence, most CFL learners in U. S. higher education institutions do not have the knowledge of the basic strokes in Chinese characters. With the advances of computer technology, computer animation has been used to support learning in education. However, few research studies have investigated the effects of computer animation on the content of language learning. Therefore, the purpose of this study is to evaluate the effects of a custom-designed computer animation program on learning Chinese characters by beginning learners of Chinese as Foreign Language (CFL) in a higher education setting. This study used a matched comparison quasi-experimental design to explore the

effects of the customized computer program within two groups of students. The treatment groups were two classes of CHIN 110 course taught by instructor A and the control groups were two classes of CHIN 110 course taught by instructor B. A demographic questionnaire, a posttest, and a pre and post attitude Surveys were given to students to measure the effects of the custom-designed computer program. A one-way ANOVA was performed to compare the posttest scores and test completion time between control group and treatment group. The results showed there was a significant difference in test scores between the control group and the treatment group, and there was no significant difference on test completion time between the control group and the treatment group, The Chi-Square tests were conducted to compare the attitudes toward learning Chinese characters between control and treatment group. The results showed no significant difference on attitudes toward learning Chinese characters between control and treatment group. Additionally, the results of supplementary attitude questionnaire showed the treatment group had a positive view of the program. The findings of this study can help Chinese language teachers to understand how computer animation can affect Chinese characters learning and will encourage adoption of the computer animation program in the teaching of their courses.

CHAPTER 1 INTRODUCTION

In the past two decades, China as the world’s most populous nation has been growing rapidly. Its tremendous economic growth has had a great impact on the global economy. Between 1978 and 2002, China's annual GDP growth reached 9.4%, three times the world's average, and from 2001 to 2004 China accounted for one third of global economic growth (Asia Society, 2012).

China’s economic growth has created new opportunities and challenges for U.S. businesses. According to the U.S. Census Bureau (2007), China has become the second-biggest trading partner of the United States with total sales at $386.7 billion in 2007 between the two countries. For American manufacturers and corporations, China is an immense market for American goods and services.

The growing business between the United States and China has provided many new job opportunities for people who can speak Chinese. Government agencies, such as the Central Intelligence Agency (CIA), the U.S. State Department, and the Federal Bureau of Investigation (FBI), are recruiting employees who can teach or speak the Chinese language. Embassy Beijing and the five consulates general in China house one of the largest U.S. diplomatic presences in the world. More than 30 U.S. Government agencies maintain offices and personnel in China; the total staff exceeds 2,000 employees. Consulates General Guangzhou and Shanghai are as large as many mid-sized embassies, each with more than 250 employees (U.S. State Department, 2010). Additional staff increases are expected as the United States–Chinese relationship continues to expand (U.S. State Department, 2010). International corporations are looking for people who can speak Chinese as well. When searching the job website Monster.com with “Chinese” as a key word on a single search, around 520 job positions, such as Chinese language teacher, interpreters, import-export coordinator, engineer, etc., are listed (Monster.com, March 15, 2012).

Besides the importance for business needs, the Chinese language is the most widely spoken language in the world, extending beyond the People’s Republic of China and Taiwan to Indonesia, Thailand, Malaysia, Singapore, Brunei, the Philippines, and Mongolia. In the United States, the Asian and Pacific Islander population is projected to grow 213 percent, from 10.7 million to 33.4 million in the next 50 years, a substantial demographic shift. Their share of the nation’s population will double, from 3.8% to 8 % (Asia Society, 2012).

Given all these trends, the interest in learning the Chinese language in U.S. schools has been growing rapidly among American youth. By searching the database of the University of Minnesota Center for Advanced Research on Language Acquisition, there are 762 programs in U.S. universities and colleges that offer Chinese (Less Commonly Taught Languages, March 28, 2012). The Modern Language Association (2004) conducted a survey of foreign language enrollments in United States institutions of higher education. This survey reported that national enrollment of Chinese language has increased 20%, from 28,456 in 1998 to 34,153 in 2002 (Welles, 2004). A recent survey also conducted by Modern Language Association in 2007 reported that the national enrollment in Chinese language has significantly increased 51.0% from 34,153 in 2002 to 51,582 in 2006. Between 2002 and 2006, Chinese language was the sixth most commonly taught foreign language in U.S. higher education, following Spanish (822,985), French (206,426), German (94,264), Italian (78,368), and Japanese (66,605), but ahead of Russian (24,845) and Arabic (23,974) (Furman, Goldberg, & Lusin, 2007). A College Board survey reported that 2,400 schools expressed interest in offering the Advanced Placement (AP) Course and Examination in Chinese (Mandarin) Language and Culture (Asia Society, 2005). With more and more American students enrolled to study Chinese as a foreign language (CFL), Chinese language teachers have been facing various challenges in teaching these learners because unlike English, Chinese uses characters instead of letters to form words and sounds.

Background of the Problem

For adult learners who are non-native Chinese and who are beginning learners of Chinese as a foreign language (CFL), one of the difficult tasks is to produce Chinese characters correctly. Although the learners have the opportunity to learn and write Chinese characters with the teacher together in the classroom, they are still unable to write the Chinese characters in correct stroke sequence afterwards. This phenomenon has been recognized by CFL teachers and researchers. For example, X. Li (1996) observed that the high dropout rate in Chinese language learning has much to do with its writing components known as characters. In an empirical study, Ke (1996) compared production tasks and recognition tasks for CFL learners and found that CFL learners tend to perform significantly worse in production tasks than in recognition ones. Yin (2003) conducted a survey to investigate what the most difficult task is for CFL learners in learning Chinese characters and found that 66% of students thought that remembering the way characters are written is the most difficult task. However, this most difficult part of learning Chinese is essential to CFL learners, because to be literate in Chinese, one has to master at least 3,500 Chinese characters that are used most often (Norman, 1996).

For hundreds of years, the learning of the basic strokes and the correct sequence rules for the execution of strokes has been regarded by Chinese people as an essential component in the learning of Chinese character handwriting (Law, Ki, Chung, Ko, & Lam, 1998). Chinese children are always taught the proper stroke sequence for producing the characters based on some calligraphic rules when they begin to learn to write in Chinese. For example, in an empirical study, Law et al. (1998) found that the children were taught to write characters in a particular way by their teachers, pre-school teachers, or parents and 90% of the children responded that the sequence in which a character is written is important. Although most of them were not able to pinpoint a reason, some of them asserted that the correct stroke sequence would make writing easier to remember and that it would be easy to make mistakes in the writing if the correct sequence is not followed (Law et al., 1998).

In fact, previous CFL research studies showed the knowledge of Chinese character strokes and writing Chinese characters in correct stoke sequence can always assist Chinese learning. Laychuk (1983) stated that given the complexity of Chinese orthography, teaching CFL learners the etymological explanations of Chinese character forms can enhance Chinese characters memorization and retention. Nagy et al. (2002) found that morphological awareness instruction increased subjects' performance on tasks that emphasize character-level knowledge in both first- and fourth grade students. The results of an experimental study conducted by Packard et al. (2006) showed that raising children's awareness of the morphemic and orthographic structure of Chinese words would lead to beneficial results in their learning to write Chinese. J. H. Li and Li (2006) also stated that writing Chinese characters with correct sequence would affect the mastery of the pronunciation and the meaning of Chinese character. Law et al. (1998) found that teaching proper stroke sequence of Chinese characters can help children write Chinese characters quickly and accurately, and the stroke counting and deconstruction of a Chinese character are necessary for beginning learners to look it up in a dictionary if its pronunciation is unknown in advance.

The Problem

Although it is important to write Chinese characters with the correct stroke sequence, most CFL learners in U. S. higher education institutions do not have the knowledge of the basic strokes in Chinese characters (Yin, 2003). Ma (2006) observed "the most interesting and challenging aspect of studying Chinese is writing Chinese characters. Unfortunately, the learning of Chinese characters only receives marginal attention in a typical classroom" (p. 1). Ma further pointed out that CFL learners' struggles with Chinese characters are at least partially due to the lack of systematic introduction of Chinese characters morphology in textbooks and the time pressure of a CFL classroom. S. C. Wang (1998) observed that CFL learners feel that learning and producing Chinese characters is painful and CFL teachers acknowledge that students are struggling with Chinese characters. However, eighty percent of CFL learners would like to study the characters by themselves and CFL teachers also believe that studying and memorizing the characters should be an individual activity. S. C. Wang further argued that CFL learners' experience of learning Chinese characters should not be so lonely and frustrating, but she failed to advise how to solve the problem in the time limit of a Chinese language class.

Significance of the Problem

Chinese words are constructed with three levels of orthographic structure: Character, radical, and stroke. A Chinese character is a two-dimensional logograph (Law, et al., 1998) and it is composed of strokes, radicals/parts and may be other Chinese characters. For example, the Chinese character for "family/home", 家, is composed of ten strokes, and the Chinese character for "mother", 妈, is composed of two radicals. One can just write or copy the character as if drawing a diagram without paying attention to the stroke sequence as long as the final product looks the same. However, Chinese character writing rules mandate that characters be written in a particular sequence.

As we can see, a Chinese character such as 家 is not easy to produce in correct stroke sequence without seeing how it is written in stroke sequence. The best way for students to learn how to write Chinese characters is to learn from the teacher in the classroom. However, the lack of class time for CFL teachers to teach writing Chinese characters and the belief of both CFL teachers and CFL learners that studying Chinese characters should be an individual task after class makes it is hard to teach and learn writing Chinese characters in the classroom. Therefore, a potential and practical solution to this problem would be to provide supplementary instructional materials that facilitate CFL beginning learners in writing Chinese characters in the correct stroke sequence outside the classroom.

Computer animation could serve as supplementary instructional material. According to Bétrancourt (2005), computer animation provides a visualization of dynamic phenomenon, when it is not easily observable in real space and time scale (e.g., plate tectonics), when the real phenomenon is practically impossible to realize in a learning situation (e.g., too costly), or when it is not inherently visual (e.g., expansion of writing over time). Also, the computer animation program can be posted online or stored in a local computer that learners can access when they need the instructions. These advantages of computer animation can meet the needs of CFL learners when they study Chinese characters after class.

Although computer animation has been used and evaluated to support learning in education for a long time, few research studies have investigated the effects of computer animation on the content of language learning, particularly for Chinese language. For example, Lam et al. (2001) stated that although a lot of work has been done in developing technologically-supported microworlds for learners to explore structural explanations behind natural and formal phenomena in the area of science and mathematics, there has been comparatively less work of this kind in the area of language learning and even less in the domain of learning Chinese characters.

A limited number of empirical studies have been conducted and have found that Computer Assisted Language Learning (CALL) programs can benefit Chinese characters learning. Lam et al. (2001) designed and developed several Computer Assisted Language Learning programs including the Rhymes program, the Interactive Exercises on Character Origin program, the Stroke Sequence program, and the Character Knowledge Base program, to enhance the learning of Chinese characters. In classroom experiments, all the developed software and material were given to the teachers for their use. The results of the classroom experiment have shown evidence of the feasibility and the need for integrating the software with an affective and contextual way of teaching Chinese characters. However, the researchers did not test the effects of those CALL programs, particularly the Stroke Sequence program, on the performance of student's Chinese characters learning. Another research study conducted by Zhu and Hong (2005) examined the effects of voiced-pronunciation and stroke sequence animation in Chinese multimedia flashcards on production of characters by beginners of Chinese as a foreign language. Zhu and Hong found the group that viewed characters displayed with voice and stroke animation performed significantly worse, and the group with voice only scored much better than the rest of the experimental groups. However, this study did not verify the effects of stroke sequence animation on learners' production of Chinese characters in correct stroke sequence. According to Zhu and Hong, further investigations of the effects of stroke sequence animation are needed, such as whether the stroke sequence animation can assist learner's mastery of proper stroke sequences.

In summary, previous research studies of Chinese character learning show the need to investigate the effects of computer animation on learner's learning Chinese characters. Therefore, the significance of this study lies in its inquiry into whether a custom-designed animation program that teaches how to write Chinese characters with correct stroke sequence can facilitate and improve CFL learner to learning Chinese characters.

Purpose of the Study

The purpose of this study is to evaluate the effects of a custom-designed animation program on learning Chinese characters by beginning learners of Chinese as Foreign Language (CFL) in a higher education setting. The findings of this study can help Chinese language teachers to understand how computer animation can affect Chinese character learning and can encourage adoption of the computer animation program designed and developed in this study in the teaching of their courses.

Research Questions

The research questions are as follows:

(1) Does the custom-designed computer animation program affect the accuracy of the production of Chinese character by beginning CFL learners in a higher education setting?

(2) Does the custom-designed computer animation program affect the speed of the production of Chinese characters by those beginning CFL learners in a higher education setting?

(3) Does the custom-designed computer animation program affect attitudes toward learning Chinese characters by those beginning CFL learners in a higher education setting?

Definition of Terms

Table 1

Definition of Terms

Computer Assisted Language Learning (CALL)	A form of computer-based accelerated learning which carries two important features: bidirectional learning and individualized learning. It is not a method. CALL materials are tools for learning. The focus of CALL is learning, and not teaching. CALL materials are used in teaching to facilitate the language learning process. It is a student-centered accelerated learning material, which promotes self-paced accelerated learning.
Chinese as Foreign Language (CFL)	Particular programs and curricula offered to students who do not speak or write Chinese as the primary language.
Computer Animation	Any application which generates a series of frames, so that each frame appears as an alteration of the previous one, and where the sequence of frames is determined either by the designer or the user.
Kai Shu	A modern script that came into existence more than a thousand years ago, distinguishes eight basic strokes.
PinYin (Chinese: 拼音)	A system of romanization for the Chinese language, where *pin* means "spell" and *yin* means "sound". It can refer to several transcription systems for Chinese. One of the several transcriptions is Hanyu Pinyin, what most people mean when referring to pinyin that is the official romanization system in the People's Republic of China and official in the Republic of China since Jan, 1st, 2009.

CHAPTER 2 LITERATURE REVIEW

The purpose of this study is to evaluate the effects of a custom-designed animation program on learning Chinese characters by beginning learners of Chinese as Foreign Language (CFL) in a higher education setting. To review existing knowledge in the field, this chapter is divided into three sections. The first section presents the various learning theories developed within animation, outlines the theoretical framework for the present study, and discusses previous research studies on computer animation. The second section discusses Chinese character learning and the prior research studies relevant to Chinese character learning. The third section describes the computer animation technologies and their integration and uses within Chinese character learning.

Animation and Information Processing Theories

Technological advances make it possible to present computer-based and web-based multimedia instruction that includes motion images, voice, data, text, graphics, and still images (Moore, Burton, & Myers, 2003). One important advancement is animation, in which images are exhibited in motion. According to Bétrancourt and Tversky (2000), computer animation is any application which generates a series of frames, so that each frame appears as an alteration of the previous one, and where the sequence of frames is determined either by the designer or the user. F. Dwyer and Dwyer (2006) stated that visuals and visuals in motion (animation), when properly designed and positioned, can provide both motivation- and attention-related components in the instructional environment.

Information processing theory. The general theoretical support for visuals and visuals in motion (animation) comes from information processing learning theories. Imagery, the visualization of knowledge in continuous dimensions, has been shown to play an important role in working memory because of the compact nature of spatial information (E. D. Gagne, 1985).

The early information processing theories (Atkinson & Shiffrin, 1968; Klatzky, 1980) described the human brain as similar to a computer, while human learning has been likened to a computer's information processing function. The memory system has three main storage structures: (a) sensory register, which gathers stimuli in the memory system; (b) short-term memory (STM), which serves as temporary storage; and (c) long-term memory (LTM), which permanently stores information. In the sensory register, only a part of the information is transferred into STM. Information is selected through a process known as selective perception (Gagne & Driscoll, 1988). Short-term memory can only hold five to nine chunks of information (Miller, 1956). Information in STM might be encoded and stored into LTM, but not all information in LTM may be retrieved. Retrieval is more likely when appropriate cues are provided in the encoding process (Driscoll, 2005). Reiber, Boyce, and Assad (1990) asserted that animation helped decrease the time necessary to retrieve information from long-term memory and then subsequently reconstruct it in short-term memory. Reiber (1990) further explained that animation facilitates the reconstruction process during retrieval by encouraging organization and suggested that animation can have one of three functions in instruction: (a) attention-gaining, (b) presentation, and (c) practice.

Dual coding theory. Paivio’s (1971, 1986) Dual Coding Theory (DCT) further explained two separate information processing subsystems in human cognition: A visual system that processes visual knowledge and a verbal system for processing verbal knowledge. Although each system is considered to be able to function independently, it is hypothesized that they are interconnected so that a concept represented in a visual format could be translated into its verbal counterpart and vice versa (Klatzky, 1980; Paivio & Csapo, 1973).

Dual Coding Theory assumes associative and referential/associations/networks within and between the verbal and nonverbal systems which code mental representations (see Figure 1) (Clark & Paivio, 1991). Associative networks within the verbal and nonverbal/imaginational representations are basic mental structures, and activations of these representations are fundamental mental processes (Paivio, 1971, 1986; Paivio & Begg, 1981; Clark & Paivio, 1987). Referential connections between two systems join corresponding verbal and imaginational codes and potentially allow such operations as imaging to words and naming to pictures (Clark & Paivio, 1991).

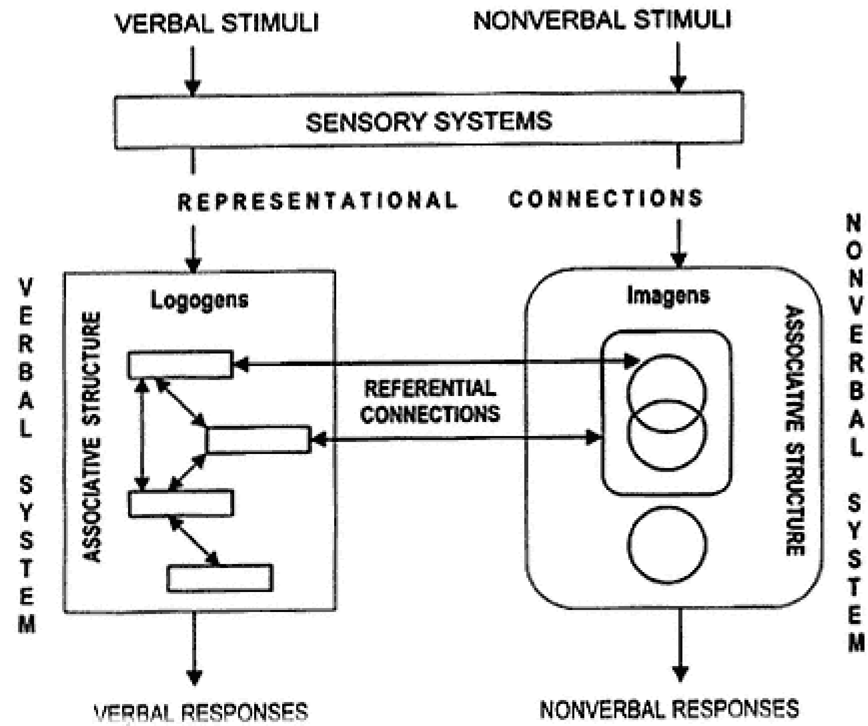


Figure 1. Dual coding theory. Adapted from "Dual Coding Theory and Education," by J. M. Clark and A. Paivio, 1991, *Educational Psychology Review*, *3*(3), p.152. Copyright 1991 by the American Psychological Association.

According to Dual Coding Theory, imagery processes can facilitate the memorization of learning materials because of "elaborative" and /or "integrative" procedures (Clark & Paivio, 1991). Elaborative processing refers to the additive effects of generating imagery coding from verbal coding (Paivio, 1975; Paivio & Lambert, 1981), and integrative processing refers to the "reintegration" phenomenon of recalling an entire representation via partial cues (Begg, 1973; Bower, 1970; Paivio, 1969). The chances to retrieve information are doubled when information is coded both visually and verbally. This prediction has been used to explain the superiority of pictures to words in recall

(Kobayashi, 1986; Paivio, 1991; Paivio & Csapo, 1973; Rieber, 1996). Animation, due to its unique dynamic qualities, is more likely to be dually coded "deeper" and "harder" into the long-term memory than are static graphics (Lin, 2001, p. 20).

A model of animation, dual-coding, and information processing. Gagne and Driscoll (1988) developed a basic model of learning and memory based on modern information-processing theories. This model was adjusted to present how animation should work as an aid to both dual-coding and information processing (see Figure 2). People process visual and verbal information from the environment concurrently. Animation is more likely to be coded as both visual and verbal knowledge because of its dynamic qualities (Lin, 2001). Animation as an attention-gaining strategy helps in capturing attention and ensuring selective perception, while animation as an elaboration strategy not only helps to ensure selective perception but also facilitates encoding and retrieval processes by connecting information and providing alternative retrieval pathways (R. M. Gagne, 1985).

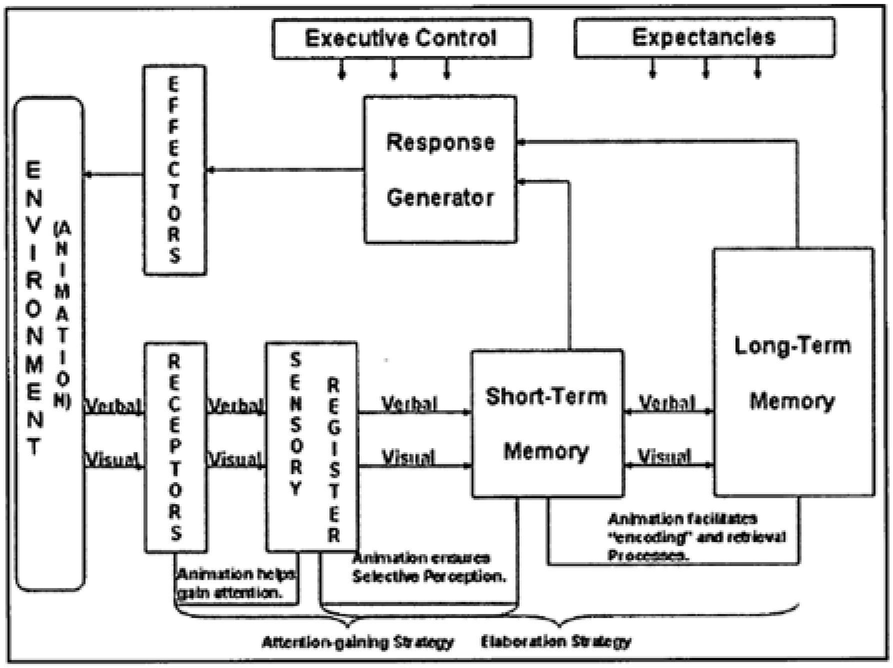


Figure 2. A model of animation, dual-coding and information processing. Adapted from *Essentials of learning for instruction* (2nd ed.) (p. 13), by R. M. Gagne and M. P. Driscoll, 1988, Englewood Cliffs, NJ: Prentice-Hall. Copyright 1988 by Prentice Hall, Inc.

Prior Research Studies on Animation and Computer Animation

Based on the Information Processing theories and Dual Coding theory stated above, the use of animation should advance information acquisition. However, prior research studies on animation in computer based instruction have led to mixed results.

Anglin, Vaez, and Cunningham (2003) reviewed the results from 42 studies conducted between 1949 and 2000 that included at least one animation treatment. These research studies on animation covered various content areas and used a variety of methods to test different learning outcomes. The authors found that 21 of 45 studies revealed significant effects of animation, while 24 of 45 studies had insignificant differences. Some studies reported significant effects for the animation treatment under certain circumstances (Blankenship & Dansereau, 2000; Catrambone & Seay, 2002), while others reported insignificant effects for the animation treatment (Chanlin, 2001a, 2001b; Koroghlanian & Klein, 2000; Lowe, 2003).

Sanger, Phelps, and Fienhold (2000) investigated the animation effect on learning chemical processes and found that students who viewed animation predicted chemical processes more correctly and recognized them better. Brewer, Harvey, and Semmler (2004) examined whether mock-jurors' comprehension of judicial self-defense instructions improved when an audio-visual instructional format involving computer animations and a flow chart was used. In a mock-juror paradigm, 90 law students (experts) and 90 legally untrained adults (novices) were randomly allocated to one of three instructional conditions (audio, audio-elaborated, audio-visual). Dependent measures of self-defense comprehension included verdict delivery, multiple-choice (recognition), paraphrasing (recall) and novel scenarios (transfer). Law students performed better on self-defense comprehension tests than novices in the audio-only conditions. The audio-visual format significantly enhanced novices' comprehension, with their comprehension scores matching those of law students.

F. Dwyer and Dwyer (2006) conducted five independent research studies that used systematically designed content, four individual criterion measures assessing different kinds of learning outcomes, and a variety of animation and animation enhancement strategies with 781 subjects. The results showed significant implications for the use of computer animation in facilitating knowledge acquisition. Mayer, Deleeuw, and Ayres (2007) examined and compared the effects between narrated animation and the annotated illustrations on college students' understanding a physical system. The finding showed the students performed similarly with narrated animation and the annotated illustrations.

Bétrancourt and Tversky (2000) reviewed the studies that have animation and static visuals and found the results are inconsistent and failed to support the assumption of general superiority over static visuals. Animation may impose greater cognitive processing demands than static visuals because information is frequently transient if critical objects and their relations disappear during animation (Hasler, Kersten, & Sweller, 2007). In other words, learners have to integrate the new information with their prior knowledge in long-term memory and with the information shown in earlier scenes of animation when watching transient animation.

Interactivity Principle and Prior Research Studies on Computer Animation

Bétrancourt (2005) stated there are two main explanations related to the way humans perceive and conceive of dynamic information that may account for the failure of animation to be beneficial to learning. First, human perceptual equipment is not very efficacious regarding processing of temporally changing animation. Second, even when actual motion is smooth and continuous, people may conceive of it as composed of discrete steps. Furthermore, Bétrancourt pointed out that interactivity may overcome these perceptual and conceptual obstacles. According to Bétrancourt, interactivity is the capability of controlling the frames over the pace of animation. Learners in control of the pace of the animation not only find the material more enjoyable but also perform better on tests of deep learning than learners who have no control over the animation. With the advanced computer animation technology, learners have the opportunity to control the pace and direction of computer animation with simple interaction. For example, learners can pause-play, rewind, forward, step by step, and direct access to the desired frame of computer animation.

This gain has been found even when control was minimal such as deciding when to run the next sequence. Mayer and Chandler (2001) conducted two experiments with college students. In Experiment 1, students who were allowed to control the pace of the narrated animation before a second presentation of the same material at normal speed performed better on transfer, but not on retention tests compared with students who received the same two presentations in the reverse order. In Experiment 2, students who were allowed to control the pace of the narrated animation across both presentations performed better on transfer, but not on retention tests compared with students who received the same two presentations at normal speed without any control. These results suggest that incorporating a modest amount of interactivity using theory-based multimedia design can promote deeper learning.

Rebetez, Sangin, Bétrancourt, and Dillenbourg (2004) found that a continuous (but learner-controllable) computer animation led to better comprehension performance than a succession of static snapshots for instructional materials explaining geological and astronomic phenomena when learners were in pairs. Hasler et al. (2007) conducted a study to investigate the influence of learner-controlled pacing in educational animation on instructional efficiency. Three versions of an audio-visual computer animation and a narration-only presentation were used to teach primary school students the determinants of day and night. The animations were system-paced using a continuous animation, learner-paced using discrete segments or learner paced using “stop” or “play” buttons. The two learner-paced groups showed higher test performance with relatively lower cognitive load compared to the two system-paced groups, despite the fact that the “stop” and “play” buttons were rarely used. The researchers further concluded that Learner Control, either in the form of pre-defined segments or by allowing the learners to pause the animation at any time, should be integrated in educational animation in order to improve instructional efficiency.

Paas, Gerven, and Wouters (2007) used cognitive load theory to investigate whether computer animation about the cardiovascular system can become a more effective educational tool by designing it with sensitivity to the capacity limitations of working memory. Two interactive instructional conditions, which required learners either to construct or reconstruct the sequence of key frames, were compared to a non-interactive condition. The hypothesis is the interactive activities would lead to more efficient transfer performance. The results confirmed the hypothesis, indicating the interactive conditions required less mental effort to attain the same performance as the non-interactive condition.

Cohen and Hegarty (2007) also conducted a study in which the participants were required to perform a novel spatial inference task. While performing the task, participants could interactively control two computer visualizations (animations) of the object. There were large individual differences in how frequently participants used the computer visualizations, which were related to spatial ability. Use of the interactive visualizations was highly predictive of performance on the cross-section task and mediated the correlation between spatial ability and performance. These findings suggest that interactive computer visualizations can aid performance on spatial inference tasks, but that they do so only for a subset of individuals who can discover how to best use the additional information that they provide.

According to Bétrancourt (2005), control can overcome perceptual limitations, because the presence of pauses in the animation enables learners to process the continuous flow of information without perceptual and conceptual overload. New information can be processed and integrated progressively in the mental model (Mayer & Chandler, 2001). In addition, learners who have complete control over the pace and direction of the animation can monitor the cognitive resources (e.g., attention and processing) they allocate to each part of the animation.

Summary of Theories and Previous Research Studies

Information Processing Theory, Dual Coding Theory, and Interactivity Principle give the proposed study a theoretical framework. The Information Processing Theory suggests that using animation can help decrease the time necessary to retrieve information from long-term memory and then subsequently reconstruct it in short-term memory. The Dual Coding Theory approach is found to be beneficial to facilitating the mental process of information. However, given the perceptual and conceptual obstacles for learners to process information from animation, the Interactivity Principle suggests using learner control over the pace and direction of animation to overcome the information processing obstacles. Numerous research studies have been conducted to prove the effectiveness of computer animation on improving students' learning. Based on the Information Processing Theory, Dual Coding Theory, and Interactivity Principle, the custom-designed computer animation program for Chinese Character Learning was designed and developed in this present study in order to facilitate CFL student' learning Chinese characters. The CFL students were able to control the pace and direction of learning the Chinese characters when using the computer animation program.

Chinese Character Learning

Chinese language has more complex orthographic systems than alphabetic languages. Chinese words are constructed with three levels of orthographic structure: Character, radical, and stroke. A Chinese word can be formed with one, two, or more characters, but two-character words compose 74% of the total corpus of commonly used words according to the Modern Chinese Frequency Dictionary (1986). Generally speaking, radicals are the meaningful components of characters (Shen & Ke, 2007). An integral character contains one radical (see Figure 3), a compound character contains two or more radicals (see Figure 4). According to the Dictionary of Chinese Character Information (1988), about 96% of commonly used characters are compound characters. Radicals that compose compound characters can be identified by two categories based on their orthographic functions: Phonetic radicals and semantic radicals. A phonetic radical indicates the pronunciation of a compound character and is usually located on the right side of a character; a semantic radical indicates the meaning and is usually located on the left side of a character. As seen in Figure 4, for example, the compound character has the “sun” semantic radical on the left side and the phonetic radical “qing” on the right, and so the character is pronounced “qing” (following the phonetic radical) and means “clear or sunny” (as implied by the “sun” semantic radical).

An integral character
日
Character pronunciation is ri Character meaning is sun

Figure 3. Integral character.

A compound character
晴
Character pronunciation is qing Character meaning is sunny, cloudless sky Phonetic radical pronunciation is qing Semantic radical meaning is sun

Figure 4. Compound character.

Strokes are the building blocks for radicals and they are the basic units of the Chinese writing system. There are as many as thirty-two strokes (Modern Chinese Dictionary, 1988) within one Chinese character, with the mean number being about eight strokes per character.

Basic strokes and stroke sequence rules. A stroke is a short straight or curved segment, or a combination of two segments connected by an angle, written in a single movement, as shown in Figure 3. The modern script, Kai Shu, which came into existence more than a thousand years ago, distinguishes eight basic strokes.

It is generally accepted that there is a finite number of stroke forms that comprise the tens of thousands of Chinese characters; however, there is no consensus on the number of such stroke forms (Law, et. al., 1998). Searching through the Chinese calligraphy handbooks, dictionaries and other publications, the number of the stroke forms varies from 22 stroke forms (Wen, 1964) to 41 stroke forms (Wang & Xu, 1993). The differences come from the different categorization schemes. Some schemes view all the various stroke forms as variants of the eight basic stroke types and build the categorization around them (Sun, 1980; Wang & Xu, 1993). Some schemes do not use any categorization scheme and just comprise a list of stroke forms (Fei, Huang, & Zhang, 1992; D. S. Li, 1993). In this research study, the list provided by Fei et al. (1992), shown in Table 2, is used as a reference as it provides the frequency statistics for the stroke forms as found in the published set of 6196 most commonly used Chinese characters in print (Ministry of Culture and the Committee for Revolutionizing Chinese Characters, 1965).

Table 2

Basic Stroke Forms, Name of Stroke Forms and Frequency of Appearance in Chinese Characters

	Stroke form	Stroke name	Example character	Frequency
1	一	横	十	18143
2	丨	竖	中	11585
3	丿	撇	八	10454
4	丶	点	主	8929
5	㇕	横折	口	4362
6	㇏	捺	人	1945
7	㇀	提	地	1887
8	㇆	横折钩	刀	1491
9	亅	竖 钩	小	1031
10	㇇	横撇	又	898
11	㇖	横钩	买	823
12	㇟	竖弯钩	儿	776
13	㇜	撇折	幺	720
14	㇙	竖提	民	567
15	㇗	竖折	山	526
16	㇛	撇点	女	248
17	㇉	竖折折	马	247
18	㇂	斜 钩	我	174
19	㇌	横撇弯	队	155
20	㇊	横折提	记	150
21	㇁	弯钩	家	130
22	㇈	横折弯钩	九	110
23	㇄	竖弯	四	67
24	㇍	横折弯	朵	41
25	㇎	横折折折	乃	34
26	⺄	横斜钩	飞	34
27	㇋	横折折撇	及	30
28	ㄣ	竖折撇	专	6
29	㇞	竖折折	鼎	2
30	㇅	横折折	凹	1
31	㇎	横折折折	凸	1

Note. Stroke forms 1, 2, 3, 4, 6, & 7 are also basic stroke types and are referred to as simple stroke forms while all other stroke forms are composite stroke forms. Adapted from "Children's Stroke Sequence Errors in Writing Chinese Characters" by N. Law, W.W. Ki, A. L. S. Chung, P.Y. Ko, & H. C. Lam, In C. K. Leong and K. Tamaoka. (Eds.) *Cognitive Processing of the Chinese and the Japanese Languages (*p 116). Copyright 1998 by Kluwer Academic Publishers.

Each of the basic stroke forms not only defines the shape of stroke, but also defines the direction along which the stroke should be written (Law et. al., 1998). Knowledge of these basic stroke forms is an important part of the knowledge base required for learning Chinese handwriting as these are the only allowable strokes for the proper construction of characters.

Besides the knowledge of these basic stroke forms, the writing process must follow some standard stroke sequence rules. The standard stroke writing order of the Chinese character is specified in some Chinese dictionaries. Xu (1983) presents a popular set of stroke sequence rules (see Table 3).

Table 3

Major Stroke Sequence Rules for Kai Shu

1.	Write from top to bottom (i.e. writing from the topmost stroke downwards), e.g. in 三, the sequence is 一，二，三.
2.	Write horizontal strokes before the vertical ones, e.g. in 十, the sequence is 一，十. However, if a horizontal stroke form the base of the structure, that horizontal stroke should be written last, e.g. in character 土, the sequence is 一, 十, 土.
3.	Write the leftward downward slant (pie, 撇) before the rightward downward slant (na, 捺), e.g. in 人, the sequence is 丿，人.
4.	Finish writing the left component before the right one., e.g. in 明, the sequence is 日，明.
5.	Finish the middle component before writing the strokes on either side, e.g. in 山, the sequence is 丨，𠃊 and 山.
6.	Where there is an enclosure structure, first set up the outside, then complete the inside, and then finally complete the last horizontal stroke to close the rectangular structure, e.g. in 回, the sequence is 冂，冋 and 回.

Note. Adapted from "Children's Stroke Sequence Errors in Writing Chinese Characters" by N. Law, W.W. Ki, A. L. S. Chung, P.Y. Ko, & H. C. Lam, In C. K. Leong and K. Tamaoka. (Eds.) *Cognitive Processing of the Chinese and the Japanese Languages (*p 117). Copyright 1998 by Kluwer Academic Publishers.

Traditional writing instruction in China. Writing instruction in the traditional Chinese classroom generally does not take full advantage of the systematic information inherent in Chinese character orthography (Packard et al., 2006). The traditional instruction of writing Chinese characters relies on memorization, generally accomplished by having children copy characters until they have internalized their production as a motor skill. In an empirical study, Law et al. (1998) found that the children reported they were taught to write characters in a particular way by their teachers, pre-school teachers, or parents. Typically, the Chinese teachers present the students how each character is written stroke by stroke on the blackboard and then students produce a repetitive copying task on worksheets in classroom. For example, when learning Chinese character “土”, firstly the teacher writes “一” on blackboard, secondly “十”, and finally “土”; students write the character on their worksheets stroke by stroke following the teacher’s writing procedure. Although teachers sometimes draw attention to the more common semantic radicals that will enable children to, for example, look up characters in the dictionary, for the most part the students are not given explicit instruction on how the characters may be analyzed into semantic and phonetic radicals, and so generally receive little explicit instruction on orthographic structure (Wu, Li, & Anderson, 1999).

Prior Research Studies on Chinese Character Learning

With the growing demand for Chinese language programs in higher education, a number of research studies on Chinese character learning have been conducted. Some of them focused on CFL learners’ Chinese character learning strategies; others evaluated the effects of the knowledge of radicals and stroke sequences on Chinese character recognition.

Ke (1998a) observed CFL learners’ Chinese characters learning strategies and found that “more non-heritage learners considered practicing character writing more effective than reading a character text for character learning” (p. 102) and “more non-heritage learners considered associating new character with characters they are already familiar with in terms of graphic structure to be more effective than associating them with sounds” (p. 102). In addition, although CFL learners identified that the learning and using of knowledge on graphic structure and character component in Chinese character learning is valuable, most of them still simply memorize a Chinese character as a whole by writing it repeatedly. Ke further explained that since CFL beginning learners have only mastered a few Chinese characters, they are limited in their ability to use Chinese character dissembling strategy when memorizing the character.

Yin (2003) conducted a survey to investigate the most difficult task for CFL learners in learning Chinese characters and found that 66% of students thought that remembering the way characters are written is the most difficult task. Yin also found that the strategy used most often to memorize Chinese characters is to write them repetitively. Although writing Chinese characters over and over again is the popular way that CFL learners usually use to learn Chinese characters, it has been found to be less efficient than mnemonic methods that are designed to improve memory through the use of personal encoding techniques or mental images that are external to the material being learned (Levin, 1993; McDaniel & Einstein, 1986).

The “semantic analysis method” used in S. Li’s (1997) research study links the Chinese character’s form to its meaning. This information is utilized as mnemonics in the study. S. Li found that mnemonic groups taught with the semantic analysis method performed much better in both recognition and production of Chinese characters than the group using the rote memory method. Additionally, S. Li concluded that the semantic analysis method of teaching Chinese characters worked well for Chinese character production, especially when one considers its similarities to the semantic analysis method.

W. Li (2004) conducted a research study of the Grapheme Combination Method (GCM), which emphasizes “Graphemes” and “Combinations” as teaching and learning procedures. A grapheme is the smallest unit that can be seen as a basic unit in a Chinese character. The combinations mean that each complex character is constructed by using different graphemes according to certain rules. The GCM departs from the traditional rote method (TRM) of teaching Chinese characters by providing the learner a few basic graphemes along with rules on how to construct complex characters. Associating the new character with previously learned characters avoids learning each new character entirely from scratch. By doing so, the GCM enables the learner to fully utilize his/her cognitive thinking skills and independent learning strategies developed previously. In addition, the GCM makes the learning take place in a fun, interesting and motivating atmosphere. Finally, the GCM provides a unique way of learning Chinese characters that is similar to the way in which English speakers learn English words. To a large extent, GCM allows Western adult learners to transfer their previous knowledge and academic skills that they have already developed in learning their first language. The results showed that the group treated with the Grapheme Combination Method was superior in Chinese reading tests. W. Li also stated that complex Chinese characters are usually constructed with several simple but meaningful graphemes and learners can understand the target Chinese characters better, review previously learned characters with common graphemes, and build up new characters in similar schema by learning the graphemes and their combination rule.

In the area of morphological processing of Chinese characters, numerous studies have been carried out over the past several decades in search of answers to whether or not submorphemic (radical) information is involved in word recognition. A study conducted by Taft and Chung (1999) investigated if knowledge of the internal radical structure of Chinese compound characters helped beginning learners to memorize those characters. All participants were presented with 24 compound characters, each containing a semantic radical. Each character was presented three times together with its meaning in English. The participants were then presented with all the characters again without their meaning, and the participants were asked to write out the appropriate meaning for each character. The participants were divided into four groups. Group 1, 2, and 3 were told the semantic radicals and were presented with the character list before the test; Group 4 was presented with the character list. The results showed that the participants in Groups 1, 2, and 3 used their radical knowledge to recall the meanings of the characters. Group 2, which was provided with radical knowledge right at the first presentation of the characters, performed best within 4 groups.

Shen (2000) examined the role of radical knowledge and its relation to both character recognition and character production among college learners of Chinese. The participant either had completed first-year Chinese or had completed second-year Chinese. The participants were asked to complete a radical knowledge test and two radical knowledge application tests. The results showed that students with good radical knowledge performed significantly better in both tasks than did students with poor radical knowledge.

Shen and Ke (2007) also conducted a study to investigate developmental trends in acquiring knowledge of radicals, radical perception skills, and skills in applying knowledge of radicals among nonnative adult learners of Chinese across learning levels.

The study also examined the relationship between the acquisition of radical knowledge and the development of radical perception and radical knowledge application skills, as well as how the development of radical knowledge application skills is associated with Chinese word acquisition. The results of this study suggest that radical knowledge, radical perception skills, and radical knowledge application skills do not develop synchronously across learning levels, but rather that each of them shows a unique developmental trend. A linear trend exists between the development of radical knowledge and the application of this knowledge; a moderate positive association is observed between the development of radical knowledge application skills and Chinese word acquisition. In short, by examining learning and using radical knowledge across four learning levels, the study provides a picture of a developmental continuum of radical awareness across instructional levels among adult nonnative learners of Chinese. All these studies provide positive evidence that learners' radical knowledge affects character learning.

The importance of learning the stroke sequence of Chinese characters has been evaluated in the literature. Huang (1986) studied visual integration processes in the recognition of fragmented Chinese characters. Huang presented the participants with sequences of fragments (strokes or combination ions of stokes) of characters, with the task of mentally assembling them together to get the whole character. The results showed the task of the participants was highly facilitated when the serial order of presentation of the fragments was consistent with the writing order of the strokes. Similarly, Ji and Luo (1989) found some facilitation in the integration of the fragments of characters when the sequence of presentation of the different fragments was consistent with the appropriate stroke sequence.

In an experimental study, Flores d'Arcais (1994) tested the hypothesis that stroke writing order has been coded in memory as an essential component of the orthographic knowledge of a character, and that this specific motor schema is used as a cue in lexical retrieval. In the first experiment, fragments of Chinese characters consisting of "early" or of "late" strokes, namely strokes which are written first or last during writing, were pre-exposed to target characters to be named as fast as possible. The results showed that "early" strokes were better retrieval cues for character names than "late" strokes. In the second experiment, participants were asked to make same-different judgments about two characters which had in common either "early" or "late" strokes. Different characters having same "early" stokes were more frequently incorrectly judged than characters having "late" strokes. Flores D'Arcais further concluded that the process of learning to read and write, which is characterized by a long routine of repeatedly tracing the strokes of each character in a rigorously standard order, does affect the memory representations; and the motor sequence required and used for writing a character seems to have been internalized as a code which is likely to be activated during word recognition and which can be a useful retrieval cue for the memory representation of that character.

Law et al. (1998) investigated the how far young children can master the correct stroke sequences in writing and the common kinds of errors children made. The researchers found that stroke production errors contributed seriously to children's poor overall performance in stroke sequencing in the writing of Chinese characters. Based on the results of their study, the researchers proposed that there are a number of important reasons for teaching the proper writing of the basic stroke forms. Firstly, stroke reversals occur in directions that prove to be difficult to draw and thus would lead to poorer and slower handwriting for right-handed scribes. Secondly, since the number of strokes in a character is commonly used as an indexing key in Chinese dictionaries, the inability to identify the correct stroke forms would lead to difficulties in using dictionaries. The observed frequent use of broken strokes is also another cause for concern. Third, if children mistake the simple stroke forms to be the only legal stroke forms, then many of the composite or angled strokes would be broken up into disjointed line segments. This would probably make the reproduction memory task more difficult. Lastly, characters which look similar, but are composed of different basic stroke forms are not considered as the same character. For example, 士 and 土 and (please note the difference in the central vertical stroke) would be considered as different characters (Law et al., 1998).

CFL learners self-reported that producing Chinese characters is the most difficult task when learning Chinese characters (Yin, 2003).

> According to N. Ching and Ching (1975), manipulations of strokes is the primary factor when generating factors that distinguish one Chinese character from other, since similar but slightly different strokes (e.g., "犬 versus 尤"), number of strokes (e.g., "一 versus 二"), position of strokes (e.g., "犬 and 太", length of strokes(e.g., "目 versus 且"), etc., all directly contribute to distinguishing Chinese characters from one another. In addition, the position of components is another

important factor for distinguishing compound Chinese character (e.g., "杏 versus 呆"). (p. 22)

Therefore, N. Ching and Ching argued that CFL beginning learners need to form good habits and be instructed as thoroughly as possible by CFL teachers, including issues of strokes production (legibility, position, size, and length) and spacing (especially for compound Chinese characters). Similarly, Mickel (1980) stated that by helping students in their first year of study to learn a solid foundation of Chinese character origin, script types, and component analysis etc. and by helping them to better understand the logic underlying the Chinese writing system (origin, basic strokes and stroke order, radical and phonetic component rules, etc.), CFL beginning learners can overcome their anxieties about Chinese character learning which benefit their studies. In fact, Yin (2004) offered a course to teach adult CFL beginning students the basic Chinese character, radicals and stroke sequence with 15 lessons in one semester. At the end of the semester, he compared test scores of the recognition of Chinese character radicals and of the application of Chinese character radicals between the students who took the Chinese character course and students who only took the regular Chinese beginning course. The results indicated that the students taking the Chinese character course performed better in the test than the students only taking the regular Chinese beginning course. Based on the results, he further concluded that the Chinese character course is beneficial for the CFL students learning Chinese characters.

The existing research studies on Chinese character learning show the necessity and importance of teaching CFL beginning learners the radicals and stroke sequence for learning Chinese characters. However, in practice, most CFL learners self-reported they do not know radicals and stroke sequence, and this indicates that learning radical and stroke sequence is not given attention by CFL teachers (Yin, 2003).

Summary of Previous Studies on Chinese Character Learning

Prior research studies on learning Chinese characters have shown the importance of the knowledge of radicals and stroke sequence for CFL learners to memorize and recognize Chinese characters. Since the knowledge of radicals can link a new character to related characters which share a radical learners have already memorized, teaching CFL learners the knowledge of radicals of target Chinese characters has proven to bring more efficient learning than learning without such knowledge. Learning basic strokes and correct stroke sequence of Chinese characters is believed to assist CFL learners in memorizing characters. However, this kind of knowledge is not given enough attention by CFL teachers, and most CFL learners memorize Chinese characters by writing them repetitively. Thus, further investigation on how to use stroke sequence instruction to improve Chinese character learning is needed.

Prior Studies on Learning Chinese Characters using Computer Multimedia

With the advances in computer technologies, computer multimedia has rapidly been incorporated into various educational fields including teaching Chinese as a Foreign Language. Early attempts at using computer multimedia for teaching CFL started in the late 1980s and 1990s (Zhu, 2005). Ng and Wu (1990) stressed the benefits of teaching stroke sequence of Chinese characters and discussed a “modified keyboard for Chinese character entry”, which could be used to enter Chinese characters into a computer by strokes and proper stroke sequence. Ng and Wu argued that this kind of keyboarding might help CFL learners better understand the structure of Chinese characters so as to assist the learning of characters.

Currently, various computer technologies have been used to develop educational programs for learning Chinese language. For example, A professor, Yong Zhao, at Michigan State University created a free online video game called Zon/New Chengo to help students learn Chinese (Read, 2008). The multi-player game allows users to choose Mandarin phrases to converse with other characters in the game about exchanging money, buying breakfast, and other activities visitors to China would experience (Zhao, 2008). Another example is an online learning community, ChinesePod.com, which was founded in 2005 by Ken Carroll, Hank Horkoff and Steve Williams. ChinesePod.com provides a daily language course podcast and accompanying website that offers lessons in Standard Mandarin Chinese. Its primary goal is to teach spoken Mandarin to its listeners.

X. Li (1996) developed a computerized teaching program, HyperCharacters, and conducted a pilot study with college students. HyperCharacters program uses images, graphic symbols, sounds and animated presentation to produce an integrated learning environment for CFL learners. It allows a student to analyze and comprehend the components of the characters by both graphic and verbal texts enhanced by voice. HyperCharacters also allows students to control the learning process. As a pilot study, the program covers about one-third of the basic components used to form Chinese characters. The program has proven its value through experimental study and via the researcher's observations of and interviews with students. The results showed that students who used the HyperCharacters program had a better grasp of the radicals than the students who only attended the lecture. Although there was no significant difference between the test scores immediately after using the program and scores of a delayed test a month later, longer term retention of the radicals are necessary for students seeking to master written Chinese. In addition, interviews with the students provided more detailed and concrete feedback on HyperCharacters. The interviewees stated that the principles of the formation of the characters, the etymology section and the visualized description of the characters helped them learn this writing system in an understanding manner instead of by rote memory. As one student said in X. Li's study, "with the program it is easier to remember the characters because it tells you how they were formed and developed" (p. 88). In addition, although the use of HyperCharacters did not affect the students' attitude toward computer assisted instruction in learning the Chinese language, statistically, the frequency of students' voluntarily returning to use the program shows that they were interested in Computer Assisted Instruction (CAI). In terms of implementation, results showed that students prefer user-controlled learning over instructor-driven classroom presentation. Students who control their own learning explore knowledge voluntarily and tend to have more self-confidence—a vital component of successful learning. Some students suggested that the instructor should incorporate programs like HyperCharacters into his or her curriculum, but not necessarily use it during classes. In this way the instructor can serve as a facilitator to encourage students to ask good questions and help them find out answers.

Lam, et al. (2001) designed and developed CALL software based on a pedagogic method that helps young students to develop the higher order skills to analyze and categorize Chinese characters by using components. The CALL software includes rhymes, interactive exercises on character origin, stroke sequence, a Character Component, a morphological Component and a Chinese Character Knowledge Base. The software had been tried out on a limited scale in three primary schools (about 4 teaching sessions per school); the associated classroom teaching strategies were also investigated. In the experiment, all the software and materials were given to the teachers for their use. They could choose any part they liked to try and designed their own lesson plans. The result of the classroom experiment showed supportive evidence on the feasibility and the need of integrating the software with an affective and contextual way of teaching Chinese characters.

Zhu and Hong (2005) conducted an experimental study to examine the effects of digital voiced pronunciation and stroke sequence animation on Chinese character memorization. One hundred college students of elementary Chinese participating in the study were required to memorize Chinese characters displayed on four different types of computer-based multimedia flashcards. The results indicated that the group of students who viewed Chinese characters displayed with voice and stroke sequence animation performed significantly worse, while the group of students who viewed the character displayed with voice only scored better than the rest of experimental groups.

Jin (2006) conducted an empirical study to investigate the multimedia effects on CFL learners from three different orthographic backgrounds. All subjects performed a recall task immediately after viewing 36 Chinese characters displayed either on a computer or a printout with various types of presentations, focusing on word formation rules (radicals), character stroke sequences, and pronunciation. The results showed that participants who worked with the radical presentation performed best, and the performance of those who worked with stroke sequence presentation was better than those working with pronunciation presentation.

The research studies conducted above all used multimedia to support teaching Chinese characters. Zhang (1999) and J. Q. Wang (1999) stated that when computer technologies have been used widely in our daily life to handle tedious and time-consuming tasks, it is logical that they also can be used by our students to face the challenges in memorizing Chinese characters as advocated by some teachers. However, Yin (2003) conducted a survey and found that 76% of the 193 participated students have never used a computer to help with memorization of Chinese characters. In addition, 16% of the students seldom use a computer to assist with memorization of Chinese characters. Thus, a total of 92% of the students failed to take advantage of the computer technologies in learning Chinese characters. Yin (2006) further speculated that there are two reasons for the majority of the students not choosing to use computers to help with memorization of Chinese characters. First, there is no computer software on learning Chinese characters available to the majority of the students learning Chinese as foreign language. Second, Chinese instructors do not know what computer software on learning Chinese characters is available and consequently, they cannot recommend any to students. Yin also emphasized that it is important to think about and find out under what circumstances the majority of students would utilize computers to help with memorization tasks if instructors promoted the use of computers. Therefore, Yin started a study within a 3-year college-level Chinese language program and reported the findings of the study, in which students used computer flashcard software to learn Chinese characters. Beginning in the 1998-99 academic year, the college-level CFL students were encouraged to use the computer flashcard software, Chinese Character Tutor, which was installed in the language computer lab. In the 1999-2000 academic year, the students were guided on how to use the flashcard software. In the 2000-01 academic year, the students had their own flashcard software to use and were required to complete assignments with the flashcard software. The findings showed the percentage of positive attitudes towards learning Chinese characters had changed from 50% before they used Chinese flashcard software to 90% after they used the software. In addition, the students had increased the number of Chinese characters they were able to recognize, and the retention rate had increased from 30% to more than 50% year over year. Yin further concluded that to keep the retention rate high, providing the students with right tool—a good computerized flashcard program—is a crucial first step, and that setting up the standards are required to reach by using the computer program is a reassuring second step.

Summary of Research on Learning Chinese Characters with Computer Multimedia

As computer multimedia technologies become widely used in education, more and more computer multimedia have been developed and used for teaching and learning Chinese characters for CFL learners. The literature has shown evidence of the feasibility of and the need for integrating the software with an effective and contextual way of teaching Chinese characters. In addition, the interest of students using computer multimedia in learning Chinese has gradually increased. However, as Yin (2006) pointed out, it is important to think about and find out under what circumstances a majority of students would utilize computers to help in memorizing Chinese characters. In other words, it is important to find out if multimedia technology, including computer animation, digital audio, or podcasting, will support Chinese language learning in a particular situation, such as learning Chinese characters, learning spoken Chinese, or learning Chinese grammar.

A New Approach to Learning Chinese Characters

Based on the literature review, it is apparent that teaching radicals, basic strokes and correct stroke sequence of Chinese character to CFL learners is able to assist CFL learners in memorizing characters. However, this kind of knowledge is not given enough attention by CFL teachers, and the strategy that most CFL learners use to memorize Chinese characters is writing Chinese characters over and over again. This strategy has been found to be less efficient than mnemonic methods that are designed to improve memory through the use of personal encoding techniques or mental images that are external to the material being learned.

The literature also shows that many computer multimedia programs that were designed and developed with the strategies including radical explanations, mnemonics, embedded audio pronunciations, and stroke sequence animation, have been used to teach Chinese characters, and that student interest in using computer multimedia programs to learn Chinese has gradually increased. However, it is not clear if the computer multimedia technology built specifically to address the stroke sequence will improve learning Chinese characters of beginning CFL learners in a high education setting. Therefore, the present study focuses on developing a custom-designed animation program on the examination of individual and interactive learning effects of stroke sequence animation on CFL adult learners' Chinese characters learning will benefit CFL education.

CHAPTER 3 METHODOLOGY

This chapter describes the research methodology used to investigate the effects of a custom-designed animation program on learning Chinese characters by CFL beginning learners in a higher education setting. The following sections include overview, setting of the study, participants, instrumentation, data collection procedures, and data analysis methods.

Software Development Phase

The development of the custom-designed computer animation program was the first phase of this study in 2009. Based on the theories of Information Processing and Dual Coding, as well as Interactivity, the user requirements, the specifications describing what features/functions must be in the software, were constructed for the animation of Chinese character stroke sequence, the pronunciation of the Chinese character stroke, and the learner control buttons of playing, pausing, continuing the animation. The researcher designed and developed a working prototype of the customized computer program using Adobe Flash and Captivate software. Using audio and visual flash animation, the prototype presented the stroke sequence of the Chinese characters in the text book of the course, CHIN 110. In Figure 5 and Figure 6, the animation with stroke sequence along with pronunciations of the strokes was presented to the students in the computer program. Additionally, the students could use the buttons, “Play”, “Pause”, and “Continue”, to control their learning pace. The program was developed in collaboration with the class instructor and students in the fall 2009, and then pilot tested in the spring of 2010. In order to meet student and instructor needs and expectations, the researcher modified the prototype by adding the PinYin and English of the Chinese Character to the animation program (See Figure 7). After the modifications, the revised prototype was posted on the website hosted by the university in fall 2010 and the CHIN 110 students began to use the program during fall semester 2010.

Figure 5. Animation of a Chinese character with the control buttons.

Figure 6. Continuing animation of a Chinese character with the control buttons.

Figure 7. PinYin and English added to the animation program.

Research Design

The research questions were (1) Does the custom-designed computer animation program affect the accuracy of the production of Chinese character by beginning CFL learners in a higher education setting; (2) Does the custom-designed computer animation program affect the speed of the production of Chinese characters by those beginning CFL learners in a higher education setting; (3) Does the custom-designed computer animation program affect attitudes toward learning Chinese characters by those beginning CFL learners in a higher education setting. In response to these three research questions, a posttest was used to evaluate the accuracy and speed of the production of Chinese character by beginning CFL learners, and an attitude survey was used to assess the attitudes toward learning Chinese characters by those beginning CFL learners. Creswell (2009) stated that quantitative research is a means for testing objective theories by examine the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures (Creswell, 2009). Based on the research questions of this study, the quantitative research method was used to evaluate the test and survey data. Also, because the participants who enrolled the Chinese classes were not randomly assigned to the treatment group or control group, this study used a quasi-experimental design. Quasi-experimental designs are experiments, to some degree, but they lack the critical element of random assignment to groups (Suter, 2006). According to Suter, quasi-experimental research design is a research design that incorporates a quasi-independent variable (an independent variable manipulation without random assignment). This research study used a matched comparison quasi-experimental design to explore the effects of the customized computer program. The matched comparison group design involved one group that receives a treatment and another group, usually chosen because of its similarity with the treatment group that functions as a baseline comparison group.

The treatment groups were two intact classes of students who voluntarily enrolled CHIN 110 courses taught by instructor A in two semesters and the control groups were two classes of CHIN 110 course taught by instructor B in two semesters at the same university. A questionnaire was given to students to collect each participant's demographic and background information. A posttest to assess performance was given to participating students in both the treatment group and the control group after the treatment group used the customized computer program. There was no pretest of Chinese language knowledge for either group because the Chinese language introduction course (CHIN 110: Elementary Chinese) was offered only to students with little previous Chinese language knowledge, so it can be assumed that the two groups entered their courses with equally minimal knowledge of Chinese. A pre and post Attitude Survey was given to the treatment group to measure the effects of the customized computer program on students' attitudes. The following table shows the design of the study.

Table 4

Classroom Experiment

Semesters	Instructor A class	Instructor A class	Instructor B class
Fall 2009	Software development phase		
Spring 2010		Pilot testing phase	
Fall 2010		Treatment group	Control group
Spring 2011		Treatment group	Control group

Setting of Study

This study was carried out as part of a Chinese language introduction course (CHIN 110: Elementary Chinese) offered by the modern and classical languages department at George Mason University. This course was chosen because it included Chinese character learning for beginning CFL learners and the course instructors were willing to use the custom-designed computer animation program to assist teaching Chinese characters.

The course focused on developing the four basic skills in language and culture necessary to communicate orally and in writing with native Mandarin Chinese speakers. It included practice in writing Chinese characters using essential vocabulary and elementary grammar for oral and written communication, exploring aspects of Chinese culture and society, and comparing the Chinese language and culture with the language(s) and culture(s) of the students. In addition, authentic text or audiovisual materials were used to enhance development of communicative competence (see Appendix A CHIN110 syllabus).

The course content included lectures on Chinese pronunciation, Chinese characters, Chinese vocabulary, dialogues and sentence patterns. The content was delivered through face-to-face class lectures. For the purposes of this study, the course had also included Chinese characters delivered with a customized computer program that could assist students learning Chinese characters independently after class.

The sampling approach in this study was convenience sampling. Heiman (1995) asserted that convenience sampling selected subjects who were conveniently available.

Convenience sampling was appropriate for this study because the purpose of this study was to evaluate the effects of a custom-designed animation program on learning Chinese characters by beginning learners of Chinese as Foreign Language (CFL) in a higher education setting. Thus, the researcher chose the sample for this specific purpose. The target sample needed to be adult students who were learning Chinese characters as beginning CFL learners. The students enrolled the Elementary Chinese course (CHIN 110) met the requirements of the target sample for this study.

Participants

CHIN 110 had three sections in fall 2010 and two sections in spring 2011, with each section having more than 15 students enrolled. The present study employed four course sections, two of which were in fall 2010 and two in spring 2011. Instructor A and instructor B were native Chinese. The students in the classes of Instructor A were in the treatment group and the students in the classes of Instructor B were in the control group.

In fall 2010 and spring 2011, there were a total of 71 students enrolled in CHIN 110, 37 of which were in class of instructor A and 34 of which were in class of instructor B. There were a total of 56 students participating in this study, 25 of which were in the control groups and 31 in the treatment groups (see Table 5). 15 students did not participant the study. Due to the relatively small sample sizes, for analytical purposes, the two treatment groups were combined into a single treatment group and the two control groups into a single control group.

Table 5

Participant Numbers in This Study

	Fall 2010	Spring 2011	Total
Control Group	12	13	25
Treatment Group	12	19	31
Total	24	31	56

The demographic and background data on the subjects' mother tongue, prior Chinese learning experience, and home computer availability was collected from all 56 participants and analyzed by SPSS. As shown in Table 6, the majority (67.9 %) of participants were native speakers of English. For prior Chinese learning experience, 80.4 % of participants reported they had never tried to learn Chinese. All participants (100%) had computer at home.

Table 6

Participant Characteristics

		Frequency	Percent	Valid Percent	Cumulative Percent
Mother Tongue	Chinese	3	5.4	5.4	5.4
	Other Asian	11	19.6	19.6	25.0
	English	38	67.9	67.9	92.9
	All Other	4	7.1	7.1	100.0
	Total	56	100.0	100.0	
Prior Chinese Experience	Yes	11	19.6	19.6	19.6
	No	45	80.4	80.4	100.0
	Total	56	100.0	100.0	
Computer at Home	Yes	56	100.0	100.0	100.0

Instrumentation

Three instruments, a demographic questionnaire (see Appendix B), an attitude instrument including a pre instruction attitudes questionnaire, a post instruction attitudes questionnaire, and a post instruction attitudes supplementary questionnaire for the experimental group (see Appendices B, C and D) and a posttest (see Appendix E), were used to measure the treatment effects in this study. McMillan and Schumacher (2001) asserted that a general rule of advice in conducting research was to choose an instrument that had established the reliability and validity the researcher needs. Therefore, this study adapted one existing attitude instrument with established validity and reliability. In addition, based on the Chinese course text book, the researcher developed a posttest to examine the student's performance of learning Chinese characters strokes after the participants in treatment used the customized Chinese character learning program. The type of data produced by these instruments is discussed below.

Attitude instrument. The attitude instrument was originally designed and developed by X. Li (1996). X. Li's instrument was developed specifically for the evaluation of the computer assisted instruction program, HyperCharacters. HyperCharacters uses images, graphic symbols, sounds and animated presentation to produce an integrated computer assisted learning environment. It allows a student to analyze and comprehend the components of the Chinese characters by both graphic and verbal texts enhanced by voice. HyperCharacters also allows students to control the learning process. In this study, the customized computer program developed by the researcher only used text, graphic, and the animated presentation to focus on teaching the students how to write Chinese characters with correct stoke sequence. Because X. Li's attitude instrument is the only instrument to focus on using computer assisted instructional program to learn Chinese characters, it was appropriate to adopt X. Li's attitude instrument for this study that investigates the participant's attitude towards the custom-designed computer animation program, with slight modifications. The pre instruction attitudes questionnaire also included a few questions designed and developed by the researcher to collect each participant's demographic and background information. These three attitude questionnaires were paper based surveys and asked the participants closed-end questions.

Posttest. After using the custom-designed computer animation program to learn the Chinese stroke sequence, a posttest (Appendix D) containing a total of 15 questions was used to test the participants' accuracy and speed of the stroke sequence production. The 15 Chinese characters used in 15 questions were picked by Instructor A and researcher, in order to evaluate the subjects' writing skills. There were three types of questions in the test. The first type of question asked the participants to select the correct stroke sequence for each of the five Chinese characters. The second type of question asked the participants to identify the total number of strokes for the five Chinese characters. The third type of question required participants to write down the stoke sequence of the five Chinese character. Each correctly answered question was counted as one point. Since there were 15 questions, the possible range for the test was 0 to 15 points. The researcher along with the Instructor of CIN110 picked the 15 words from the all the words showed in custom developed computer program and designed the posttest. Instructor A reviewed the posttest for its validity in the pilot testing phase and approved the final version of the posttest. The questionnaires, posttest and the participant consent form were approved by George Mason University Human Subjects Review Board on June 28th, 2010.

Procedures

Before each semester started, the researcher contacted instructor A of the treatment group and instructor B of the control group to arrange the data collection process according to their class schedules. Based on the schedule and the purpose of this present research study, the researcher paid two visits to the Chinese classrooms in each semester. At the beginning of the semester, the researcher went to the Chinese classes and explained this research study to the students. The consent form was distributed to the students at the visit. The students who signed the consent form and agreed to participate in the study took the demographic survey and the pre instruction attitude survey. After learning PinYin, the treatment group was required by instructor A to use the custom-designed computer animation program after class at home to facilitate their learning of Chinese character stroke sequence. The server on which the program was hosted tracked frequency of student usage of the program throughout the semesters. Towards the end of the semester, week 12, the researcher visited the Chinese classes and distributed the posttest and surveys to both treatment groups and control groups. The treatment groups were required to take the posttest, the post attitude survey and a post instruction attitude supplementary questionnaire. As part of the post instruction attitude supplementary questionnaires, the participants in the treatment groups reported how many times they used the custom-designed computer animation program. The control groups were also asked to take the same posttest and the attitude survey at the same period of time. The researcher recorded the completion time of the posttest for each participant on the test site. The following figure 8 summarizes the procedure based on the schedule of the Chinese course section in fall semester 2010 and spring semester 2011.

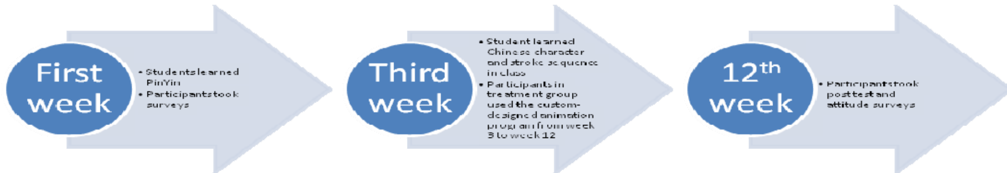


Figure 8. Procedure.

Data Analysis Methods

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software. Based on the research questions and the type of collected data, one-way Analysis of Variance (ANOVA) and Chi-Square testing were used to analyze the data.

According to Tabachnick & Fidell (2001), analysis of variance is used to compare two or more means to see if there are any reliable differences among them. Pallant (2007) states that one-way ANOVA involves one independent variable (called a “factor”) that has a number of different levels. These levels correspond to the different groups or conditions. In this present study, one-way ANOVA was used to compare the mean scores on student’s performance of the posttest between treatment group and control group.

The Chi-Square test for independence is used to determine whether two categorical variables are related and it compares the frequency of cases found in the various categories of one variable across the different categories of another variable

(Pallant, 2007). As the participants' attitude was measured on nominal (categorical) scales in this study, the Chi-Square test was conducted to compare the attitude towards learning Chinese character for control group and treatment group.

In addition, there was ordinal (ranked) data collected from a supplementary attitude questionnaire. The questionnaire was given to the treatment group to collect the subjects' evaluation of the custom-designed computer animation program. The questionnaire included 10 questions measured on a 5-point scale and the scale points from 1 for Strongly Agree to 5 for Strongly Disagree. Reliability of the scales was calculated with the Cronbach alpha coefficient .891, which is well above the ideal of .7 (Pallant, 2007). Normally the scale points are range from 1/Strongly Disagree to 5/ Strongly Agree. The variables of scale questions were also reversed to recoded variables with the scale points from "5 for Strongly Agree to 1 for Strongly Disagree" in SPSS.

Checking for outliers. The posttest scores, posttest completion time and times used program by treatment group were checked for outliers using SPSS. The posttest scores and posttest completion time have no outliers (see Figures 9 and 10). There are 3 outliers, ID 40, 29 and 42, for the times used program by treatment group (see Figure 11).

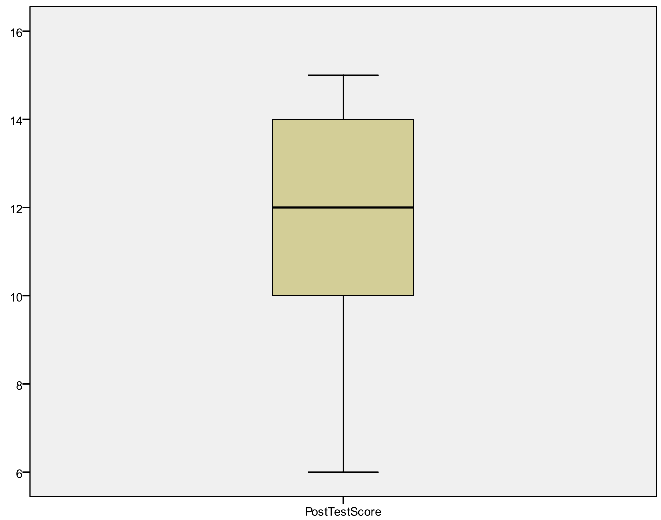


Figure 9. Boxplot for posttest scores.

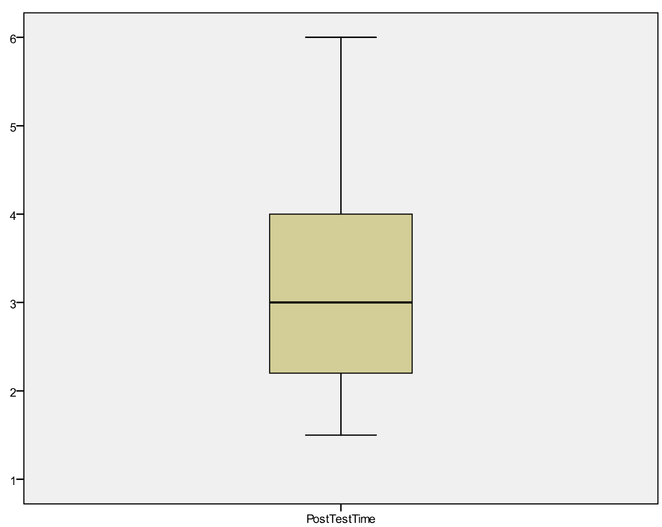


Figure 10. Boxplot for posttest completion time.

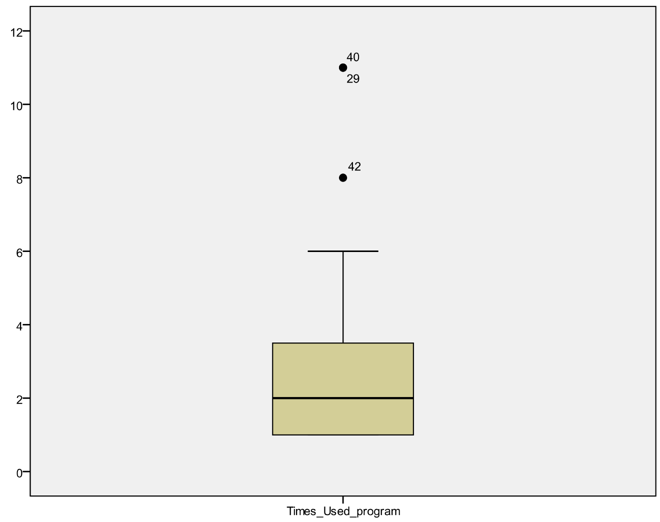


Figure 11. Boxplot for times used program by treatment group participants.

Assessing normality. At the 12th week of Chinese class, the treatment groups and control groups took the posttest to examine their accuracy of production of Chinese character. The posttest score and the posttest completion times for each participant were collected. Kolmogorov-Smirnov testing was conducted to assess normality of the scores and completion times. The Sig.value (.001) of the posttest score and Sig.value (.001) of the posttest completion time suggest violation of the assumption of normality for posttest scores and posttest completion time (see Table 7). The means, medians, standard deviations, skewness and kurtosis for the posttest score and the posttest completion time are shown in Table 8. The negative skewness value (-.668) indicates a clustering of posttest scores at the high end that could be seen in Figure 12. The positive skewness value (.708) of posttest time indicates that most subjects took a short time to finish the test and the shape of the distribution for posttest time can be seen in Figure 13.

Table 7

Test of Normality for Posttest Scores and Posttest Time

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Posttest Score	.163	56	.001	.910	56	.001
Posttest Time	.166	56	.001	.928	56	.002

a. Lilliefors Significance Correction

Table 8

Posttest Scores and Test Completion Time of All Participants

	N	Mean	Median	Std. Deviation	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
Posttest score	56	11.54	12.00	2.56	-.668	.319	-.607	.628
Posttest time	56	3.11	3.00	1.06	.708	.319	.440	.628

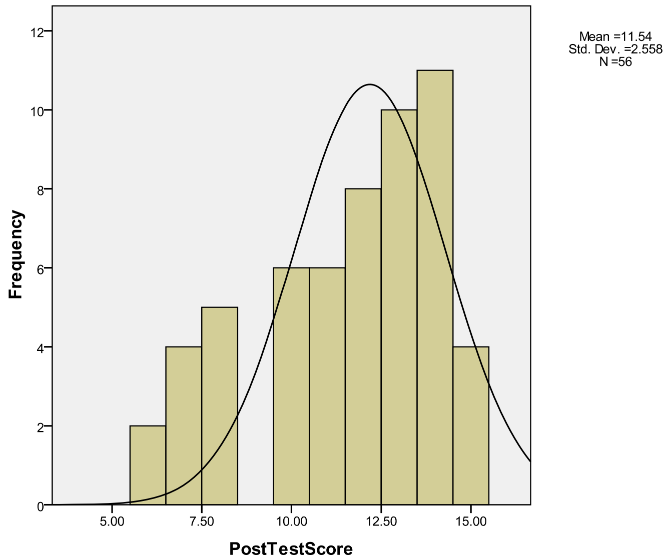


Figure 12. Histogram of posttest scores.

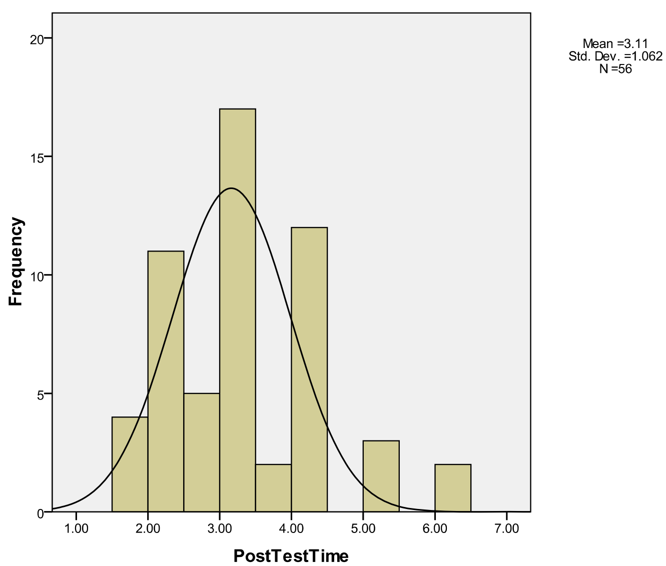


Figure 13 . Histogram of posttest time.

Since the sample size (n=31) of the combined treatment groups and the sample size (n=25) of the combined control groups are not equal, the Levene's test was conducted to determine the equality of variances. The variances of posttest scores for two groups are the same (p =.629) and the variances of posttest time for two groups are also the same (p =.758), which satisfy the ANOVA assumption of equal variances.

Transforming variables. The test results of normality indicate the posttest score and posttest time are not normally distributed. Pallant (2007) stated the alternative when having a non-normal distribution was to “transform” the variables. This “transform” involved mathematically modifying the scores using various formulas until the distribution looked more normal (Pallant, 2007). Transformation is undertaken because the distribution is skewed and the mean is not a good indicator of central tendency of the scores in the distribution (Tabachnick & Fidell, 2001). Tabachnick and Fidell (2001) also presented the syntax (formula) for transforming variables in SPSS based on the type of skewness. In this present study, the posttest score is negatively skewed and the posttest time is positively skewed. Based on the syntax, the posttest score is transformed with “reflect and logarithm” and posttest time is transformed with “square root”. Accordingly, the transformation formula of posttest score is “LG10 (K - PostTestScores), K= large possible value + 1” and the transformation formula of posttest completion time is “SQRT (PostTestTime)”. The skewness and kurtosis values for transformed posttest score and transformed posttest time are improved to close to zero (see Table 9). The shapes of the distribution for transformed posttest score and transformed posttest time are improved and can be seen in Figures 14 and 15. With the transformed posttest scores and transformed posttest time, one-way ANOVA can be used to evaluate the difference on test performance of the treatment group and the control group.

Table 9

Skewness and Kurtosis Values for Transformed Test Score and Test Time

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
Posttest score	-.34	.31	-.51	.62
Posttest time	.28	.31	.19	.62

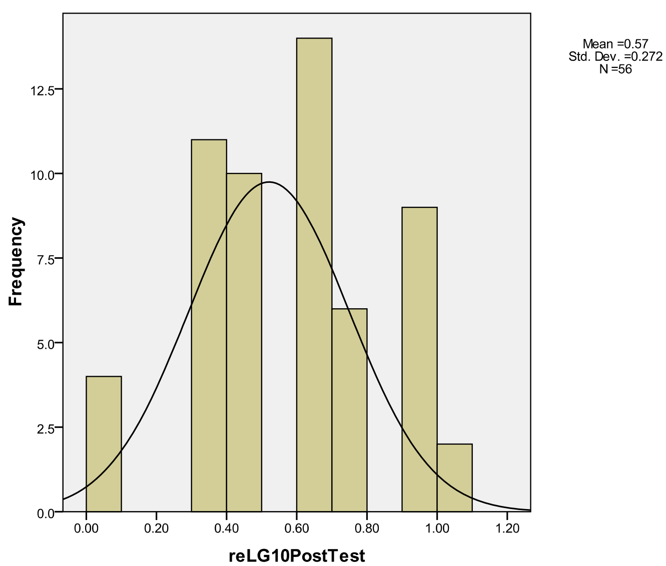


Figure 14. Histogram for transformed posttest score.

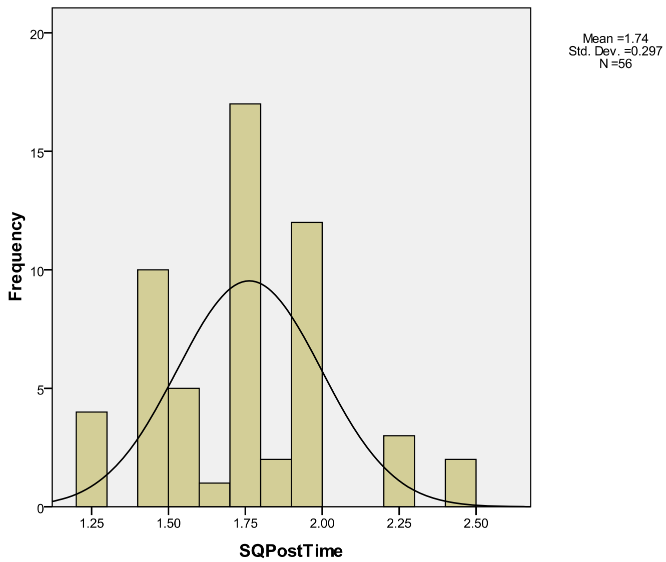


Figure 15. Histogram for transformed posttest time.

CHAPTER 4 FINDINGS

This chapter presents the results of the Analysis of Variance (ANOVA) and the Chi-Square testing conducted to investigate the effects of a custom-designed animation program on learning Chinese characters by CFL beginning learners in a higher education setting. In addition, the results for students' evaluation of the custom-designed computer animation program are presented.

Effect of the Software on Test Scores

To address the first research question, "Does the custom-designed computer animation program affect the accuracy of the production of Chinese character by beginning CFL learners in a higher education setting?" a one-way analysis of variance (ANOVA) was conducted to compare the transformed variable of posttest scores for the treatment group and the control group. Table 10 shows the Means and Std. Deviation for control group and treatment group. There was a significant difference in posttest scores for the control group (M =.49, SD =.03) versus the treatment group (M =.64, SD =.23), $F(1,55) = 4.24$, p =.044, indicating that the treatment group outperformed the control group on the posttest conducted in class. (see Table 11).

Table 10

The Means and Standard Deviations for Test Score of Treatment Group and Control Group

				95% CI	
	N	Mean	SD	Lower Bound	Upper Bound
Control	25	.49	.30	.36	.62
Treatment	31	.64	.23	.55	.72
Total	56	.57	.27	.50	.65

Table 11

One-way ANOVA for Test Score between Treatment Group and Control Group

	df	Mean Square	F	Sig.
Between Groups	1	.30	4.24	.044
Within Groups	54	.07		
Total	55			

Effect of the Software on Test Completion Time

To answer the second research question, “Does the custom-designed computer animation program affect the speed of the production of Chinese characters by those beginning CFL learners in a higher education setting?” the researcher collected the test time in minutes that each subject used to finish the posttest. The means and standard deviations for the test completion time used by control group and treatment group are presented in Table 12 and displayed in mm.ss format. A one-way analysis of variance (ANOVA) was also used to compare the posttest completion time between control group and treatment group. The result showed there was no significant difference, $F(1,55) = 1.55$, $p = .219$, between the test completion time used by control group (M =.1.69, SD =.31) and the test time used by treatment group (M =1.78, SD =.28) (see Table 13).

Table 12

The Means and Standard Deviations for Test Completion Time by Control Group and Treatment Group

				95% CI	
	N	Mean	SD	Lower Bound	Upper Bound
Control	25	1.69	.31	1.56	1.82
Treatment	31	1.78	.28	1.68	1.89
Total	56	1.74	.30	1.66	1.82

Table 13

One-way ANOVA for Test Completion Time between Treatment Group and Control Group

	df	Mean Square	F	Sig.
Between Groups	1	.14	1.55	.219
Within Groups	54	.09		
Total	55			

Effect of the Software on Attitudes toward Learning Chinese Characters

In order to address the third research question, “Does the custom-designed computer animation program affect attitudes toward learning Chinese characters by those beginning CFL learners in a higher education setting?” the treatment group and the control group responded to the pre and post attitude surveys toward Chinese characters learning. Pallant (2007) stated the Chi-Square test for independence was used to determine whether two categorical variables were related and it compared the frequency of cases found in the various categories of one variable across the different categories of another variable. As the participants' attitude was measured on nominal (categorical) scales with multiple choices questions in this study, the Chi-Square tests were conducted to compare the attitude toward learning Chinese character between control group and treatment group.

Pre treatment attitude surveys. The attitude survey asked the subjects about: (1) what they thought about Chinese characters over-all, (2) how easy or difficult to learn Chinese characters, and (3) how confident they felt about learning the Chinese character writing system. The frequency of the responses from the control group and the treatment group are listed in Tables 14, 15 and 16.

As shown in Table 14, 69.6% of participants in both groups thought Chinese characters were meaningful and interesting. Table 15 shows that 72% of participants in the control group versus 77.4% of participants in the treatment group thought that Chinese characters could be mastered, which indicates that the majority of participants in both groups thought that Chinese characters could be mastered. As shown in Table 16, 44.6% of all participants thought they could succeed if they try hard, 23.2% of all participants were positive and could master it, and 23.2% of all participants thought they could learn it. Thus, the majority of participants in both groups thought they could succeed and master Chinese characters.

The Chi-Square tests were conducted to compare the attitude toward learning Chinese character between control group and treatment group. The results of the Chi-Square tests are presented in Table 17. For all three questions, the Chi-Square test revealed that there was no statistically significant difference between the control group and the treatment group.

Table 14

Responses of Question "What they thought about Chinese character over all" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Meaningful & interesting	13	52.0	26	83.9	39	69.6
Like other foreign writing system	3	12.0	1	3.2	4	7.1
Meaningless lines & dots	2	8.0	0	.0	2	3.6
Something I don't know	7	28.0	4	12.9	11	19.6

Table 15

Responses of Question "How easy or difficult to learn Chinese character" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Difficult to learn	6	24.0	5	16.1	11	19.6
Can be mastered	18	72.0	24	77.4	42	75.0
Something I have no idea	1	4.0	2	6.5	3	5.4

Table 16

Responses of Question "How confident they felt to learn Chinese character writing system" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Positive I can master it	4	16.0	9	29.0	13	23.2
I can learn it	4	16.0	9	29.0	13	23.2
I can succeed if try hard	13	52.0	12	38.7	25	44.6
I am not sure how I feel	4	16.0	1	3.2	5	8.9

Table 17

Chi-Square Test for Pre Attitude Survey for Control Group and Treatment Group

	Value	df	Asymp. Sig. (2-sided)
Chinese character over all	7.59	3	.05
Is it easy or difficult	0.64	2	.72
Confidence to learn Chinese character writing system	5.10	3	.16

Post treatment attitude surveys. The post treatment attitude survey asked the participants the same three questions as the questions in the pretreatment survey. The frequency of responses from the control group and treatment group for post attitude questions 1, 2 and 3 is listed in Tables 18, 19 and 20.

As shown in Table 18, 84.0% of participants in the control group versus 93.5% of participants in the treatment group thought Chinese characters were meaningful and interesting, which indicates that a majority of all participants thought Chinese characters were meaningful and interesting. Table 19 shows 84.0% of participants in the control group versus 80.6% of participants in the treatment group thought that Chinese characters could be mastered, which again indicates that a majority of all participants thought that Chinese characters could be mastered. As shown in Table 20, 100% of participants in both groups thought they could master and learn it.

The Chi-Square tests were performed to compare the attitudes for the control group versus the treatment group after the treatment group used the custom-designed computer animation program throughout the semester. There was no significant difference between the control group and the treatment group on each of the attitude questions (see Table 21). The pre attitude survey and post attitude surveys within treatment group were also compared to assess any changes of participants' attitude. The Chi-Square test results showed no significant difference between the pre and the post attitude surveys of treatment group on each of the attitude questions (see Table 22).

Table 18

Responses of Post Question "What they thought about Chinese character over all" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Meaningful & interesting	21	84.0	29	93.5	50	89.3
Like other foreign writing system	3	12.0	1	3.2	4	7.1
Something I don't know	1	4.0	1	3.2	2	3.6

Table 19

Responses of Post Question "How easy or difficult to learn Chinese character" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Difficult to learn	4	16.0	6	19.4	10	17.9
Can be mastered	21	84.0	25	80.6	46	82.1

Table 20

Responses of Post Question "How confidence they felt to learn Chinese character writing system" Crosstab

	Control		Treatment		Both groups	
	Count	Percentage	Count	Percentage	Count	Percentage
Positive I can master it	5	20.0	10	32.3	15	26.8
I can learn it	6	24.0	7	22.6	13	23.2
I can succeed if try hard	14	56.0	14	45.2	28	50.0

Table 21

Chi-Square Tests of Post Attitude Survey for Control Group and Treatment Group

	Value	df	Asymp. Sig. (2-sided)
Chinese character over all	1.65	2	.43
Is it easy or difficult	.00[a]	1	1.00
Confidence to learn Chinese character writing system	1.11	2	.57

Table 22

Chi-Square Test of Pre and Post Attitude Survey for Treatment Group

	Value	df	Asymp. Sig. (2-sided)
Chinese character over all	1.96	2	.37
Is it easy or difficult	2.11	2	.34
Confidence to learn Chinese character writing system	1.45	2	.69

Satisfaction of Treatment Group with the Software

A supplementary attitude questionnaire was given to the treatment group to assess satisfaction with the custom-designed computer animation program. The questionnaire included 10 questions measured on a 5-point Likert scale from “5” for Strongly Agree to “1” for Strongly Disagree. The mean scores and standard deviations for the 10 scale questions are reported in Table 23. Results indicate that 3 out of 10 items had mean scores above 4.0, indicating high satisfaction with those three attributes by subjects in the treatment group and 7 out of 10 items had mean scores between 3.1 and 3.9, indicating satisfaction with those attributes. The three highly scored attributes included “helpful practice exercise of the program”, “easy to learn to use this program” and “satisfaction of the materials used in the program”. It meant that students were satisfied with the practice, presentation and the content of the computer program. The mean for “arouses my interest in exploring modern instructional technology” was 3.12. However the standard deviation of this attribute was very high, 1.08. This meant that there was a large difference of opinions about this attribute among the treatment group. This indicated the participants in the treatment group might be coming from widely differing starting points in terms of interest in technology. No attribute earned a mean score of less than 3.0.

The treatment group also reported how many times they used the custom-designed computer animation program throughout the semester. As shown in table 24, 32.3 % of the subjects in treatment group used the custom-designed computer animation program once, 29 % of them used the program twice, 12.9 % of them used the program three times, 3.2 % of them used the program four times, 9.7 % of them used the program five times, 3.2% of them used the program six times, 3.2 % of them used the program eight times, and 6.5 % of them used the program eleven times. The two participants who used the program eleven times had higher scores (13 points of full score 15points) on the posttest accordingly. The mean number of times the program was used by the treatment group is 3.06.

Table 23

The Mean Scores and Standard Deviations of the Supplementary Attitude Questionnaire for Treatment Group

	Mean	SD
The computer program makes Chinese characters easier to learn and more interesting	3.80	.70
The practice exercise is very helpful	4.03	.75
It is easy to learn to use this program	4.19	.90
The materials used in the program were satisfactory	4.00	.73
This program helped me a lot in understanding and remembering the Chinese characters	3.70	.78
This program arouses my interest in Chinese characters	3.58	.67
This program maintains my motivation in learning the characters	3.67	.65
This program reduces the time needed to learn the radicals	3.80	.98
This program provides experiences not otherwise available	3.80	.79
This program arouses my interest in exploring modern instructional technology	3.12	1.08

Table 24

The Times that Treatment Group Used the Custom-designed Computer Animation Program

	Number of Times used program by Treatment group	Frequency	Valid Percent
	1	10	32.3
	2	9	29.0
	3	4	12.9
	4	1	3.2
	5	3	9.7
	6	1	3.2
	8	1	3.2
	11	2	6.5
Total		31	100.0
Mean		3.06	

Summary

The purpose of this research study was to evaluate the effects of a custom-designed animation program on learning Chinese characters by beginning learners. A one-way ANOVA was performed to compare the posttest scores and test completion time between control group and treatment group. The results showed there was a significant difference in test scores between the control group and the treatment group, indicating the custom-designed computer animation program did affect test scores of the production of Chinese character by the participants. However, the ANOVA analysis result did not show significant difference on test completion time between the control group and the treatment group, which indicates that the computer animation program did not affect the test completion time of the production of Chinese characters by participants. The Chi-Square tests were conducted to compare the attitudes toward learning Chinese characters between control and treatment group. The results showed no significant difference on attitudes between control and treatment group, indicating that the computer animation program did not affect the attitude of participants toward learning Chinese characters.

Additionally, a supplementary attitude questionnaire was given to the treatment group to evaluate satisfaction with the custom-designed computer animation program. The results showed the treatment group had a positive view of the program. Lastly, the mean score of usage of the software by the treatment group was about 3 times.

CHAPTER 5 DISCUSSION

The purpose of this research study was to evaluate the effects of a custom-designed animation program on learning Chinese characters by beginning learners. To achieve this, this study used a matched comparison quasi-experimental design to assess the effects of the customized computer program on the accuracy, speed of and attitudes toward the production of Chinese character of beginning CFL learners in a higher education setting. A one-way ANOVA was performed to compare the posttest scores and test completion time between control group and treatment group. The Chi-Square tests were conducted to compare the attitudes toward learning Chinese characters between control and treatment group.

The results of the one-way ANOVA showed there was a significant difference in posttest scores between the control group and the treatment group, indicating the custom-designed computer animation program did affect test scores of the production of Chinese character by the participants. However, the ANOVA analysis did not show significant difference on test completion time between the control group and the treatment group, which indicates that the computer animation program did not affect the speed of production of Chinese characters by CFL learners. The results of Chi-Square tests showed no significant difference on attitudes between control and treatment group, indicating that the computer animation program did not affect the attitude of participants toward learning Chinese characters. A supplementary attitude questionnaire was also given to the treatment group to evaluate satisfaction with the custom-designed computer animation program. The results showed the treatment group had a positive view of the program. Lastly, the mean score of usage of the software by the treatment group was about 3 times.

The conclusion of this study is drawn and discussed based on the results of the data analysis. Additionally, the results of this study have both theoretical and practical implications.

The Effect of the Program on Accuracy of Production of Chinese Characters

The first research question focused on the effect of the computer animation program on the accuracy of production of Chinese characters by CFL learners. It was expected that participants in treatment group, who used the computer animation program would have significantly higher accuracy scores than participants in the control group, who did not use the computer animation program. The results from the ANOVA indicated that the participants in the treatment group scored significantly higher than the participants in the control group.

The custom-designed computer animation program in this study was a learner controlled animation program, which was developed based on Gagne and Driscoll's (1988) model of learning and memory and Betancourt's (2005) interactivity principle. Gagne and Driscoll's model of learning and memory was based on information processing theories (Atkinson & Shiffrin, 1968; Klatzky, 1980) and Dual Coding theory (Paivio, 1971, 1986). The model was adjusted to present how animation should work as an aid to both dual coding and information processing. The result for the first research question was consistent with the information processing theory that suggests that using animation can help decrease the time necessary to retrieve information from long-term memory and then subsequently reconstruct it in short-term memory, and with Dual Coding Theory that suggests imagery processes can facilitate the memorization of learning materials because of “elaborative” and /or “integrative” procedures (Clark & Paivio, 1991). In the current study, the computer animation program affected undergraduate students’ learning, which is consistent with Su’s (2008) study that suggested that application of computer multimedia would facilitate undergraduate students to acquire basic scientific knowledge and improve their performance.

Also, the result of this study supports Betancourt’s (2005) interactivity principle that suggests learners’ control over the pace and direction of animation can overcome the information processing obstacles. It is also consistent with Wang, Vaughn & Liu ‘s (2011) study that examined the impact of animation interactivity on novices’ learning of introductory statistics and which showed that the increase of animation interactivity did enhance student achievement on the intermediate level learning.

Furthermore, the result of the current study is consistent with the findings of several prior studies on learning Chinese characters using computer multimedia technology. For example, the significant difference result between the treatment group, who used computer animation program and the control group, who did not use computer animation program agreed with Jin’s (2006) study that showed the participants who worked with computer multimedia presentation to learn Chinese characters performed significantly better than those only working with paper presentation to learn Chinese characters.

The result of the present study is consistent with other findings from research studies of using dual coding theory based computer animation to teach Chinese characters. Chuang and Ku (2011) conducted a study using two computer tutorials created based on Paivio's dual coding design theory to teach Chinese characters and results showed both computer tutorials were effective in Chinese character acquisition. L. Wang (2006) conducted a quantitative and qualitative study to evaluate the effectiveness of four different multimedia presentation strategies in teaching Chinese characters. She found out the integration of both auditory input and visual input was the most effective strategy to present pictured-related Chinese character and the animation aids were the major factor that affected students' test performance. Within the current study, the Chinese character stroke sequence was presented with visual animation along with auditory pronunciations of the strokes. As with L. Wang's study, the result of the current study indicated that the computer animation with visual and audio presentation had a significant effect on students' performance of Chinese characters learning.

Computer multimedia technologies have been widely used in education and more and more computer multimedia have been developed and used for teaching and learning Chinese characters for CFL learners. Lam et al. (2001) believed that technology could play an important role in language acquisition. The result of students' test performance in this current study showed computer multimedia technology combined with appropriate learning pedagogy (dual coding design and interactivity design) can become good instructional tool to advance CFL students' learning achievement.

The Effect of the Program on Speed of Production of Chinese Characters

The second research question asked if there was an effect of computer animation program on the speed of production of Chinese characters by CFL learners. The result showed that no significant difference was found between the treatment group and control group in ANOVA result.

By searching the research studies related to using computer animation to learn Chinese characters in literature, no evidence was found for the effect of computer animation program on the speed of production Chinese characters. This may mean that there is no relationship between computer animation programs and the speed of production of Chinese characters. Also, the non-significant result on the speed of production of Chinese characters may be explained by the small numbers of questions and limited types of questions in the posttest. The posttest only had 15 questions including 10 multiple choices questions and 5 numbering stroke sequence questions and students were able to quickly finish the 15 questions in short amount of time (M=3.11 mins.) in the test. Therefore, it was not surprising that it was hard to identify the difference of test completion time between the two groups. With this finding, additional research with more questions and more types of questions might be needed in order to fully evaluate the speed of production of Chinese character by CFL learners.

The Effect of the Program on Students' attitudes

The third research question was concerned with the effect of the custom-designed computer animation program on the students' attitude towards learning Chinese characters, and the finding is that there was no significant difference on the students' attitudes between the treatment group and the control group. In addition, for the students in the treatment group, there was no significant difference on the attitudes towards learning Chinese character before and after using the computer animation program. However, the students in the treatment group responded positively towards the custom-designed computer animation program.

The non-significant result of the students' attitudes towards learning Chinese characters is consistent with the finding of L. Wang's (2006) study that showed no significant group difference regarding students' attitudes towards Chinese character learning. This can be explained by the results of data analysis from the pre and post attitude surveys in which the majority of students in both groups thought Chinese characters were meaningful and interesting and they could succeed and master Chinese characters. This is comparable to L.Wang's statement in her study that no matter what presentation strategy the students had, all students showed interest in learning Chinese characters. Another possible reason for the non-significant result of the students' attitudes could be that the computer animation program was not a required task for the students to use in the class. As Yin's (2006) research study showed, since the use of the computerized flashcard software became required to students, the percentage of students with positive feelings about their experience of learning Chinese changed from 50% to 90%.

The result of students' positive attitude towards the computer animation program is also consistent with the findings of several prior research studies on learning Chinese language using computer animation. The mean scores of the 10 attributes in this study earned from 3.12 to 4.19 on a 5-point Likert scale. This is comparable with Chuang and Ku's (2011) study that showed the second language learners in both groups had positive attitudes toward the computer-based multimedia tutorials. In their study, the average scores of the tutorial design factor for the text group and narration group were high, 4.47 and 4.28 respectively, and the positive attitudes from both groups could also be found from responses to the open-ended questions. Also, the two highly scored attributes in the current study, "the computer program makes Chinese characters easier to learn and more interesting" and "easy to learn to use this program", are consistent with students' comment in Y. Wang's (1999) study that *Chinchar,* a computer multimedia software, was "easy to use, simulation and interesting" (p.12). Another attribute, "satisfaction of the materials used in the program", was also highly scored (*M*=4.00). This can be explained by the fact that the learning materials used in the program met students' needs as it was selected from students' textbook. This is consistent with the findings of X. Li's (1999) study that students suggested the computer program should include examples of Chinese characters containing each of the radicals that students encountered in their daily study.

Limitations

As multimedia technology is integrated into various educational subjects, educators and researchers in Chinese language learning have begun to use and investigate the effectiveness of those multimedia technologies—including computer animation—for Chinese language learning. Relatively little is known about computer animation for Chinese language learning, especially its effectiveness for learning Chinese characters by CFL beginning learners. Thus, the present study contributes to the literature about the effectiveness of computer animation on Chinese character learning.

Despite its contributions, this study has several limitations. First, it is limited to students who were enrolled in the Chinese language program at George Mason University and the results of this study might not apply to other Chinese language learners at other U.S. institutions. Secondly, the target Chinese characters employed in the custom-designed computer animation program and the posttest were chosen from the textbook currently used in the single course and do not represent all the Chinese language textbooks on the market. Therefore, study results are not generalizable to all Chinese language textbooks.

In addition, although the Elementary Chinese course was offered for students without prior knowledge of Chinese language, there was no guarantee that the two groups of participating students had exact same start out situation for learning Chinese characters. Therefore, this study might have the limitation via participants' selection.

Lastly, the custom-designed computer animation program was not required for each participant to use through the research study, 32.3% of participants only used the computer program once. Thus the limited usage of the computer animation program by participants might influence the effectiveness of using the computer program on students' Chinese characters learning.

Future Research

Based on the research study findings and limitations, this study suggests four future research opportunities. First, the study can be extended to more higher education institutions with more college level CFL learners in order to get broader view of the effect of computer animation program on Chinese character learning. Also, the custom-designed computer animation program can be designed to cover more Chinese characters besides the Chinese characters chosen from single class text book. The CFL learners can learn more Chinese characters with stroke by stroke animation and the posttest can test more complicated Chinese characters and give advanced challenge to the students' Chinese characters writing skills. Therefore, the generalizability of the study would be improved.

Second, the study can use a pretest in the research design that can provide the researchers with a better understanding of the participating students' starting point for learning Chinese characters. There was no pretest in this current study because the Chinese elementary class was offered for students without prior knowledge of Chinese language. With pretest, a future research study may show more accurate effects on students' Chinese characters learning.

Third, the study can assign the computer animation program as a required task for the participating students in the Chinese class through the research study. The participants will use the computer animation program more often and then it will reinforce students' Chinese character writing skills. Accordingly, more usage of the computer animation program by participating students could make the results more powerful.

Finally, it will be worthwhile to supplement the research study with a qualitative approach. For instance, the researcher can conduct focus group interviews to explore the students' extensive views and experience of using the computer animation program. The open-ended questions, such as "what part or feature of the computer animation program do you like or not like to use?" and "when and how do you use the computer program to support your learning after class?" can be asked to the participating students. The answers from the students can help the researchers to better understanding the process with which students use the program. Also, the computer animation program can be upgraded to have better design for students' exact needs based on their feedback.

In summary, the present study serves two kinds of audiences. First, it can help educators or instructors in higher education institutions in designing Chinese language courses. The findings from this study could be used to help select the most efficient instructional computer animation program that is available to be implemented into Chinese language course for CFL beginning learners. Secondly, the present study can be beneficial to beginning CFL learners who can use the computer animation program to learn Chinese characters.

APPENDIX A

Syllabus CHIN110-001 2011 Spring
Course website: http://mason.gmu.edu/~kzhang/program.html

Course Materials

1. *Integrated Chinese* Level I, Part I (3rd edition): Textbook, Workbook, Character workbook (required).

2. Audio CDs or tapes for *Integrated Chinese* Level I, Part I (3rd edition) (optional).

Course Description

This course is designed for students with no prior knowledge of Chinese. CHAPTER 1 – CHAPTER 7 of the main textbook are covered. The course focuses on developing basic four skills in language and culture necessary to communicate orally and in writing with native mandarin Chinese speakers. It includes practice in writing Chinese characters using essential vocabulary and elementary grammar for oral and written communication, exploring aspects of Chinese culture and society, and comparing between the Chinese language and culture and those of the students. In addition, authentic text or audiovisual materials are used to enhance development of communicative competence.

Course Objectives

Language Objectives

- Be able to read and write pinyin form premier Chinese and to recognize around 300 characters.

- Be able to understand and use words and expressions introduced in Chapters 1 to 7.

- Be able to understand and use basic sentence structures introduced in Chapters 1 to 7.

Communication Objectives

- Be able to communicate in writing and speaking in a culturally appropriate manner.

- Be able to understand authentic texts or audiovisual materials presented in class.

Culture Objectives

- Understand different aspects of Chinese culture such as manners and daily life of Chinese people.
- Appreciate the richness and beauty of Chinese culture

Course Requirements

As students, your strong commitment, hard work, and consistent cooperation will be the key to the success of this course; otherwise, it not only hurts your own individual progress, but can also negatively affect the morale and progress of the entire class. In order to ensure your learning experience enjoyable and fruitful, it is highly important and imperative that you meet the requirements and follow the rules outlined below.

1. Attendance. Attendance of class sessions is crucial. Students should keep in mind that part of their grade is based on attendance and that absences count against them regardless of the reasons. There will be no penalty for the first two missed classes. After that, however, each absence will reduce the final grade by one percentage point.

2. Preparation & In-Class Performance. Students are required to preview and review the materials covered in each session. A detailed session-by-session schedule is provided for this purpose. Besides, they are also expected to participate in all class activities. Students' in-class participation and performance will be graded on a 15-point scale for each session. Absence, of course, scores a zero. Pagers and cell must be turned off before the beginning of class.

3. Quizzes and Tests. At the beginning of each session, there will be a quiz on a ten-point scale on speaking, listening, vocabulary and character recognition. After each lesson, a test on a 100-point scale will be given. There will be no make-up quizzes or tests. Students are allowed to drop two quiz grades and one test grade (including zero for a missed quiz or test).

4. Homework Assignments. Homework will be due on the due day as marked in the session-by-session syllabus. We'll do the listening and speaking exercises in the workbook together in class. Students are responsible for sections of the reading comprehension, grammar and usage, and translation for which help is available from the course website (http://mason.gmu.edu/~kzhang/homeworkanswers.html). The last section of essay writing listed in the workbook is optional and just for extra credits. Late homework will be corrected, but penalized 50% of the possible score.

5. Oral Presentations and Oral Test. In order to encourage students to use what they have learned and also to improve their speaking, students are required to give an oral presentation after each lesson. Students are expected to incorporate as much of the studied material/ grammar/vocabulary as possible, be creative in terms of the form and content of their presentations. For example, the presentation can be a role-play, the telling

of a story, the description of a picture or scene related to what is covered in each lesson. At the end of the semester, in addition to a final oral presentation in front of the class, there is an oral test. Students are required to have a one-on-one meeting with the instructor. The conversation covers the topics we have learned in class. Besides, students are asked to read a dialogue/text of their choice, followed by another dialogue/text of instructor's choice.

6. Final Exam. There will be no midterm but a final written exam. 40% of the final exam will cover Lessons 1-6, and 60% of the final exam will cover L7. The comprehensive exam will test each student's listening, reading, and writing skills, and knowledge of grammar and cultural aspects. More details will be given in class.

7. Honor Code. The George Mason University Honor Code is in effect throughout the entire duration of the course and applies to all course work carried out inside and outside the classroom. It is the responsibility of each student to be familiar with the GMU Honor System and Code as laid out in the Student Handbook. Please refer to http://www.gmu.edu/mlstudents/handbook/honor.html for detailed information.

8. Policy on Disabilities. Students with disabilities who seek accommodations in a course must be registered with the GMU Disability Resource Center (DRC) and inform the instructor, in writing, at the beginning of the semester. Please see www.gmu.edu/student/drc or call 703-993-2474 to access the DRC.

Coursework Breakdown

Students' final grades are composed as follows:

Class Participation	10 %
Homework	20 %
Quizzes and Tests	30 % (Quizzes 10%；Tests 20%)
Oral Presentations	15 % (Presentations for L 1-6 9%; final presentation 6%)
Individual Oral Test	10 %
Final Exam	15 %

APPENDIX B

Demographic and Pre Instruction Attitude Questionnaire
For each question, please circle one from each of the following items.

1. Your mother tongue is:
a. Chinese
b. Asian (other than Chinese)
c. English
d. Others (Please Specify): ____

2. Have you ever tried to learn Chinese before?
a. Yes
b. No

3. Do you have computer at home?
a. Yes
b. No

4. I think Chinese characters are
a. meaningful and interesting writing scripts.
b. just like some other foreign writing systems.
c. not interesting.
d. still meaningless lines and dots to me.
e. still (something) I don't know.

5. I feel Chinese characters
a. are difficult to learn.
b. can be mastered with practice.
c. are easy to learn.
d. are something I still have no idea about.

6. Confidence in learning Chinese writing system
a. I am very positive that I can master it.
b. I think I can learn it.
c. I can succeed in learning it if I try hard.
d. I don't think I can succeed in learning it.
e. I'm not sure how I feel about it.

APPENDIX C

Post Instruction Attitude Questionnaire
For each question, please circle one from each of the following items.

1. I think Chinese characters are
a. meaningful and interesting writing scripts.
b. just like some other foreign writing systems.
c. not interesting.
d. still meaningless lines and dots to me.
e. still (something) I don't know.

2. I feel Chinese characters
a. are difficult to learn.
b. can be mastered with practice.
c. are easy to learn.
d. are something I still have no idea about.

3. Confidence in learning Chinese writing system now
a. I am very positive that I can master it.
b. I think I can learn it.
c. I can succeed in learning it if I try hard.
d. I don't think I can succeed in learning it.
e. I'm not sure how I feel about it.

APPENDIX D

Post Instruction Supplementary Questionnaire for the Experimental Group
I. Please circle one from 1 to 5 for the following statements: (1) Strongly Agree; (2) Agree; (3) Not sure; (4) Disagree; (5) Strongly Disagree

	1 Strongly Agree	2 Agree	3 Not sure	4 Disagree	5 Strongly Disagree
1. The custom-developed computer animation program makes Chinese characters easier to learn and more interesting.	1	2	3	4	5
2. The practice exercise is very helpful.	1	2	3	4	5
3. It is easy to learn to use this program.	1	2	3	4	5
4. The materials used in the program were satisfactory.	1	2	3	4	5
5. This program helped me a lot in understanding and remembering the Chinese characters.	1	2	3	4	5
6 This program arouses my interest in Chinese characters.	1	2	3	4	5
7. This program maintains my motivation in learning the characters.	1	2	3	4	5
8. This program reduces the time needed to learn the radicals.	1	2	3	4	5
9. This program provides experiences not otherwise available.	1	2	3	4	5
10. This program arouses my interest in exploring modern instructional technology.	1	2	3	4	5

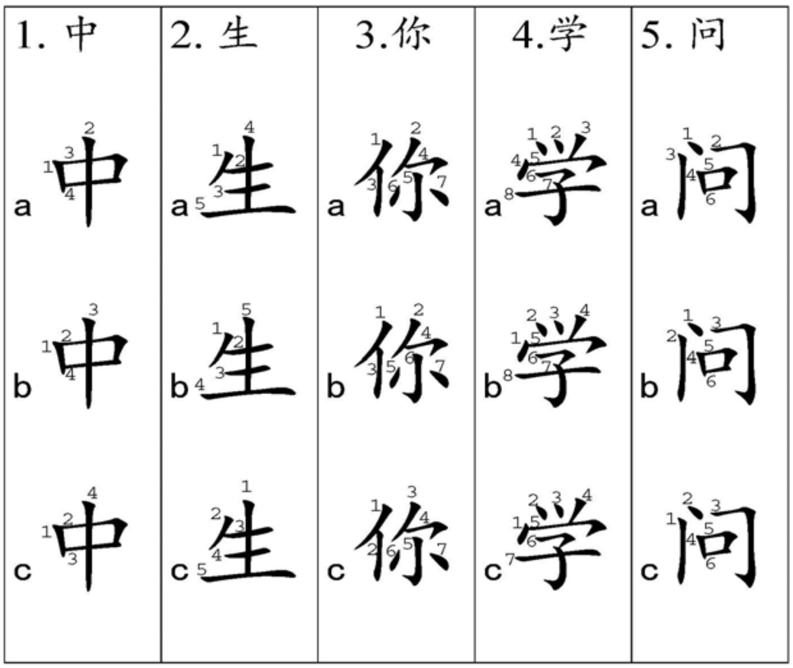
II Please circle one from each of the following 5 items.
How do you feel about Computer Assisted Instruction (CAI) in Chinese after using the custom-developed computer animation program?
a. I believe that it is a good idea to use computer programs to teach Chinese
b. I can accept the idea now.
c. I am still not sure. (I don't know.)
d. I don't think CAI can help me with my study.
e. I think it's disturbing to use CAI.
(Further feedback is welcome at any time.)

III Please give the most appropriate response.
How many times have you used the custom-developed computer animation program?
a. Once
b. Twice
c. Three times
d. Four times
e .More than four times, please specify ________times

APPENDIX E

Post-Test CHIN 110 Student Name: ___________________________

I. Please select the correct stroke sequence number for the Chinese character



1

II. Please select the correct total number of strokes for the Chinese character

1. 几 a. 2 strokes b. 3 strokes c. 4 strokes	2. 吃 a. 5 strokes b. 6 strokes c. 7 strokes	3. 妈 a. 5 strokes b. 6 strokes c. 7 strokes
4. 爸 a. 7 strokes b. 8 strokes c. 9 strokes	5. 我 a. 7 strokes b. 8 strokes c. 9 strokes	

III. Please number the correct stroke sequence for the Chinese character

Sample : 儿 (1, 2)

1. 十	2. 工	3. 片
4. 日	5. 人	

2

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