THE EFFECTIVENESS OF MOTION GRAPHIC IN LEARNING CHINESE CHARACTER STROKE ORDER THROUGH COGNITIVE LOAD THEORY ASSESSMENT

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by

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LIST OF ABBREVIATIONS

LAS	Learner Acceptance Scale
LSS	Learner Satisfaction Scale
ATS	Animation Technology Scale
IPS	Instructional Plan Scale
USM	Universiti Sains Malaysia
CCSOMG	Chinese Character Stroke Order Motion Graphics

LIST OF APPENDICES

KEBERKESANAN APLIKASI GERAKAN GRAFIK DALAM PEMBELAJARAN SUSUNAN STROK HURUF CINA MELALUI TEORI BEBAN KOGNITIF

ABSTRAK

Penyelidikan ini bertujuan untuk menyiasat kesan CCSOMG terhadap prestasi pembelajaran dan beban kognitif pelajar. Guratan watak Cina adalah banyak dan kompleks. Menghafal susunan strok aksara Cina merupakan cabaran utama bagi pelajar bukan bahasa ibunda. Untuk tujuan ini, penyelidikan ini membangunkan dan menilai enam CCSOMG untuk pelajar bukan bahasa ibunda mengingati susunan strok aksara Cina. Enam CCSOMG telah dibangunkan dengan mengguna pakai teori beban kognitif sebagai asas teori yang penting dan model ADDIE sebagai rangka kerja reka bentuk pengajaran dan dilaksanakan dalam kelas bahasa di Pusat Pengajian Bahasa, Literasi dan Terjemahan USM. Reka bentuk eksperimen yang betul telah digunakan untuk menjalankan kajian ini. Empat puluh peserta telah dibahagikan secara rawak kepada kumpulan eksperimen (kaedah CCSOMG, N=20) dan kumpulan kawalan (kaedah pengajaran tradisional, N=20). Analisis statistik dilakukan terhadap prestasi pembelajaran kedua-dua kumpulan menggunakan ujian-T sampel bebas, dan keputusan menunjukkan perbezaan markah yang signifikan bagi kedua-dua kumpulan. Prestasi pembelajaran kumpulan eksperimen adalah lebih baik daripada kumpulan kawalan. Kemudian beban kognitif kedua-dua kumpulan pelajar diukur dengan skala penilaian subjektif. Analisis statistik usaha mental dan kesukaran material kedua-dua kumpulan menggunakan ujian Mann-Whitney U menunjukkan perbezaan markah yang signifikan antara kedua-dua kumpulan. Pelajar yang menggunakan CCSOMG kurang melakukan usaha mental dan merasai kesukaran material berbanding mereka

yang menggunakan kaedah tradisional. Selain itu, lima puluh empat peserta turut menjawab LAS, LSS, ATS, dan IPS. Keputusan menunjukkan bahawa walaupun terdapat beberapa kelemahan dalam CCSOMG, secara keseluruhannya, para peserta mempunyai skor yang tinggi pada penerimaan, kepuasan, kualiti animasi dan perancangan keseluruhan CCSOMG. Ini mengesahkan lagi keberkesanan CCSOMG dalam mengajar bahasa Cina sebagai bahasa asing.

THE EFFECTIVENESS OF MOTION GRAPHIC IN LEARNING CHINESE CHARACTER STROKE ORDER THROUGH COGNITIVE LOAD THEORY ASSESSMENT

ABSTRACT

This research aimed to investigate the effects of CCSOMG on students' learning performance and cognitive load. The Chinese character strokes are numerous and complex. Memorising the Chinese character stroke order is a major challenge for non-native language learners. To this end, this research developed and evaluated six CCSOMG for non-native language learners to remember the Chinese character stroke order. The six CCSOMG were developed by adopting the cognitive load theory as the important theoretical grounding and the ADDIE model as the instructional design framework and implemented in the language classes at the USM School of Languages, Literacies, and Translation. A proper experimental design was used to conduct this study. Forty participants were randomly divided into the experimental group (CCSOMG method, N=20) and the control group (traditional teaching method, N=20). Statistical analysis was performed on the learning performance of the two groups using independent samples T-test, and the results showed a significant difference in the scores for the two groups. The learning performance of the experimental group was better than that of the control group. Then the cognitive load of the two groups of students was measured with the subjective rating scale. Statistical analysis of the mental effort and material difficulty of the two groups using the Mann-Whitney U test showed a significant difference in scores between the two groups. The learners who used CCSOMG exerted much less mental effort and felt much less material difficulty than those who used the traditional method. In addition, fifty-four participants also

answered the LAS, LSS, ATS, and IPS. The results show that although there are some flaws in the CCSOMG, on the whole, the participants have a high score on the acceptance, satisfaction, animation quality and overall planning of CCSOMG. This further confirmed the effectiveness of CCSOMG in teaching Chinese as a foreign language.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This research focuses on the impact of Chinese character stroke order motion graphics on undergraduate learning performance and cognitive load. Firstly, this chapter introduces the research background, involving the characteristics of Chinese characters, the current situation of Chinese character stroke order teaching and the learning situation of Chinese character stroke order for students, and leads to the problem statement. Then it puts forward the research questions, research objectives and research hypotheses of this paper, and justification on the usage of cognitive load theory combined with motion graphic strategy was discussed. On this basis, the significance of this research is emphasised from both theoretical and practical perspectives. In addition, this chapter also discusses the limitations and operational definitions of this research, and finally summarizes the content of this chapter.

1.2 Research Background

Since the China government implemented the One Belt, One Road policy to the world in the year 2013 (Aoyama, 2016; Ferdinand, 2016; Hong, 2016; Swaine, 2015; Tsui et al., 2017; Winter, 2016), it has created a new trend of Chinese language learning in many countries (Dos Santos, 2019; Liu et al., 2020). Many scholars have begun to pay attention to the research on teaching Chinese as a foreign language (Attaran & Yishuai, 2018; Baralt & Bravo, 2016; Chen & Yeung, 2015; Gong et al., 2020; Lin et al., 2014; Yang et al., 2018). The learning of Chinese character stroke order in writing is one of the important steps to mastering the Chinese language (Hao et al., 2010). It is related to whether the Chinese characters are written correctly and

beautifully (Chen et al., 2008), which is the focus and difficulty of Teaching Chinese as a Foreign Language (Zhang, 2014). Currently, the academic research on the stroke order of Chinese characters mostly stays at the level of strategy theory, and the research on how to use motion graphics to solve the problem of remembering the stroke order of Chinese characters is still unveiled. This remains a gap in the research.

1.2.1 Characteristics of Chinese Characters

People who are exposed to Chinese characters for the first time will have a feeling like: “Oh, my God, what's this? Is this a picture? Or a symbol, I have no clue.” This is a common intuitive response from many non-native language learners (Unger, 2003), which would make them have negative emotions about learning the Chinese characters. This phenomenon may be closely related to the characteristics of Chinese characters.

The Chinese language is one of the oldest languages in the world (Wang, 1973). Chinese characters originated from pictures (Xiao & Treiman, 2012). It was originally a form of recording things used by the ancients to express thoughts, purposes and emotions. As pictures are increasingly unable to meet the needs of recording events, the ancients began to express specific intentions through graphic symbols. At this time, graphic symbols already possessed the simple characteristics of words. With the development of the times, Chinese characters came into being. Chinese characters are written by following the stroke order of the character (Giovanni, 1994; Hsiung et al., 2017). However, in the process of writing Chinese characters, the strokes are written continuously according to the standard of strokes and the correct sequence of the order. The smallest unit of the Chinese character, according to Shu (2003), Shu and Anderson (1999), Chan et al. (2008), Shu et al. (2003) and Tan et al. (2001), is the stroke.

According to the *Chinese Character Turning Stroke Standard of GB 13000.1 Character Set* issued by the Ministry of Education of the People's Republic of China and the State Language Commission on December 19, 2001, the strokes of Chinese characters are divided into 32 kinds. Some characters gave simple strokes and there are also characters with complex strokes. In the *Commonly Used Modern Chinese Characters List*, the character with the most strokes is "nàng" (figure 1.1), which has a total of 36 strokes. In China's real life, the most frequently used Chinese character is “biáng” (figure 1.1), which is the name of the biáng biáng noodles, a famous snack in a place near central Shaanxi city, which has 56 strokes.

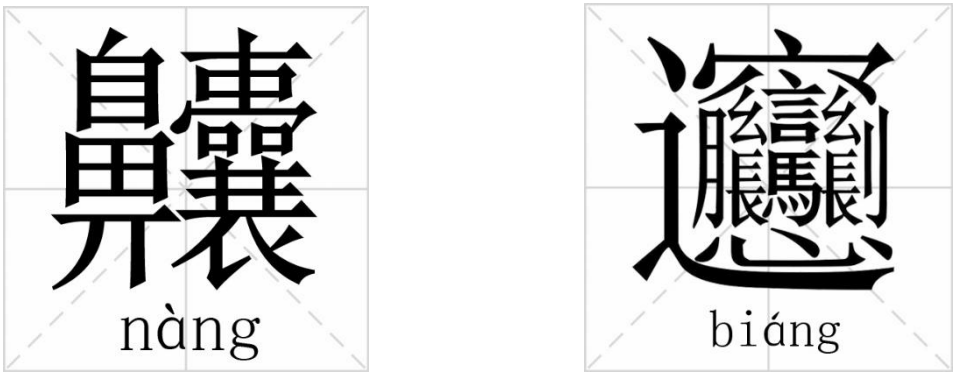

Figure 1.1: Character of "nàng" with 36 Strokes and “biáng” with 56 Strokes

From the perspective of the structure of Chinese characters, Chinese characters are square-shaped characters composed of strokes (Chen, 2021; Zhang, 2019) or components (Lam et al., 2001; Yu et al., 2017), which can be divided into undecomposable Chinese characters and compound characters (Su & Zeng, 2015). Undecomposable Chinese character is a whole, which cannot be separated again (Tong et al., 2016). The compound character (Sung & Wu, 2011; Taft & Zhu, 1997) is composed of two or more parts, some of which are transformed from undecomposable characters, with complex structures (Cao et al., 2020; Tao & Tang, 1999) such as up

and down, left and right, semi enclosing and surrounding. The same component or single stroke can form different Chinese characters through different arrangements and combinations. The stroke order also changes. Therefore, the meaning of Chinese characters after the combination is also different.

With so many strokes of Chinese characters and changes in combination, it is even difficult for most non-native language learners who are only familiar with the form of linear hyphenation to master the stroke order (Razali, 2015).

1.2.2 The Current Situation of Chinese Character Stroke Order Teaching

In the actual teaching plan of Chinese teachers, the traditional practice is to teach the basic knowledge of stroke and stroke order of Chinese characters only in one or two classes. In the later course, the Chinese characters listed in the textbook are written on the blackboard, and then the students are asked to imitate the teacher's writing (Chen et al., 2008). There is no specific method to memorise the stroke order of Chinese characters in the whole process. However, each student's receptive ability is different. It is impossible for everyone to read it once and remember the stroke order of each Chinese character. In addition, if the teacher repeatedly writes each Chinese character in the class, this is not allowed due to time constrain. In this way, it is easy for beginners to have more strokes, fewer strokes and inverted strokes in writing (Ch'ng et al., 2018). This is very demotivating in the learning process. According to the classroom observation, the above phenomenon also exists in Chinese language teaching in Malaysia.

According to the response from the USM Chinese teachers, the Chinese textbook adopted by the USM School of Languages, Literacies, and Translation is the *New Concept Chinese* published by Beijing Language and Culture University Press.

The basic structure of the textbook design is divided into scene dialogue, keywords, grammar and Chinese characters. It can be seen that this textbook is compiled according to the teaching concept of literacy with text. However, this textbook has no instructional design specifically for the stroke order of Chinese characters.

1.2.3 Learning Status of Chinese Character Stroke Order for students

Due to the particularity of the stroke order of Chinese characters, it is impossible for Chinese teachers to monitor each student's writing progress. They can only observe the completed Chinese characters written by the students but not the writing stroke order as during the writing process (Jaganathan & Lee, 2014). Even though the stroke order has little influence on the final formation of Chinese characters (Ran & Yunming, 2007), it is a crucial learning step in Chinese language education (Hie-Ling & Unin, 2020) and an inevitable process in learning. Mastering the correct stroke order of Chinese characters will help to improve writing efficiency and write correct and beautiful characters (Hwa et al., 2012). The memorisation of the stroke order of Chinese characters is complicated for non-native language learning (Zhang, 2014). Many students try to ignore the rules of stroke order. To them, as long as the number of strokes is correct, then it is good enough. Once the habit is formed, it is difficult to correct it (Jager, 2003). This causes the students to write slowly, and cannot correctly produce the character in a proper way as it should be (Lin, 2009).

1.3 Problem Statement

Chinese characters are recognised as difficult to recognise, remember, and write in the teaching of Chinese as a foreign language (Chua & Tan, 2015; Li, 2014; Sung & Wu, 2011). It has become the biggest obstacle for learners who learn Chinese as a foreign language (Packard, 1990). Chinese characters have many strokes, and they

are complicated. Each of the strokes exists independently. The students need to remember the appearance and the order of the strokes when learning Chinese characters (Chu, 2006). For many years, in the traditional teaching method teachers write the stroke order of each Chinese character on the blackboard and let the students imitate it. The students can only memorise it by rote (Allen, 2008; Chu, 1999; Mori & Shimizu, 2007; Shimizu & Green, 2002; Xu & Padilla, 2013). Many students give up learning Chinese characters due to the complexity of Chinese characters and the conventional teaching methods (Dai et al., 2007). It has increased the cognitive load of non-native language learners. It has become the reason why students are having difficulty in memorising the Chinese character stroke order.

To solve this problem, the authors proposed a new approach, based on the cognitive load theory, to design and develop a Chinese character stroke order motion graphics that can improve traditional Chinese character stroke order teaching and improve teaching and learning efficiency.

1.4 Research Questions

1.4.1 Question 1

How to identify the non-native learners' views on the stroke order motion graphics of Chinese characters?

1.4.2 Question 2

How to develop the design of Chinese character stroke order motion graphics?

1.4.3 Question 3

Does the use of the Chinese character stroke order motion graphics affect the learning performance and cognitive load of non-native language learners?

1.5 Research Objectives

1.5.1 Objective 1

To identify the non-native learners' views on the stroke order motion graphics of Chinese characters.

1.5.2 Objective 2

To develop the design of Chinese character stroke order motion graphics.

1.5.3 Objective 3

To analyze the effects of Chinese character stroke order motion graphics on learning performance and cognitive load for non-native language learners.

1.6 Research Hypotheses

1.6.1 Hypothesis 1

There is a significant difference between the experimental group and the control group in the mean of learning performance score.

1.6.2 Hypothesis 2

There is a significant difference between the experimental group and the control group in the mental effort score.

1.6.3 Hypothesis 3

There is a significant difference between the experimental group and the control group in the material difficulty score.

1.7 Justification on the Usage of Cognitive Load Theory Combined with Motion Graphic Strategy

In this research, the researchers developed Chinese character stroke order motion graphics based on cognitive load theory and evaluated its impact on students' learning performance and cognitive load.

Cognitive load theory is about how the human brain learns and stores knowledge. The cognitive load theory holds that working memory capacity is limited, and only 5-9 pieces of little information can be saved at a time (Baddeley, 1992; Miller, 1956). Kalyuga (2011) points out that learning is usually ineffective when the amount of information processed exceeds the capacity of working memory. In addition, working memory is also used for the processing of highly interactive elements (Sweller et al., 1998), and actually, there may be less than 4 pieces of information that can be processed at the same time (Cowan, 2001; Kirschner et al., 2006).

Chinese characters are developed on the basis of graphics, each stroke of Chinese characters can be regarded as a graphic. In turn, these graphics are interwoven through arrangement and combination to form Chinese characters. Remembering the stroke order of each Chinese character is an essential process in learning a new Chinese character. The number of strokes of Chinese characters is very large, and the largest number has reached 172 strokes. Through experiments, the researcher found that when the number of strokes of Chinese characters is greater than or equal to 5, non-native language learners cannot remember the stroke order of Chinese characters. This result is consistent with the view of cognitive load theory.

Motion graphics is a comprehensive art that follows the principles of graphic design in vision and adopts animation design methods in technology. This means that motion graphics have inherent advantages in graphic expression, and can reflect more

intuitively on the strokes of Chinese characters by associating common objects in real life and converting them into graphics. Digital stories are used in animation design. According to Balaman (2016), students can easily remember digital stories. The function of the digital story is to present the reference objects of each stroke in sequence through a short story. Once learners memorize the short story, they will naturally remember the stroke order of Chinese characters.

Therefore, combining the cognitive load theory with the stroke order motion graphic of Chinese characters is feasible. This was also demonstrated in this research. The insights gained in this research are not only beneficial to teachers and students but also helpful to follow-up researchers.

1.8 Significance of the Study

The main purpose of this research is to explore the impact of Chinese character stroke order motion graphics on students' learning performance and cognitive load. The research found that the stroke order motion graphics of Chinese characters designed based on cognitive load theory can effectively promote learning.

1.8.1 Theoretical Significance

This thesis discusses the problems existing in teaching Chinese character stroke order in teaching Chinese as a foreign language. The proposed motion graphic method for the teaching of Chinese character stroke order in teaching Chinese as a foreign language will enrich the motion graphic design theory of Chinese character stroke order teaching in teaching Chinese as a foreign language to a certain extent and become a reference and guidance for researchers in future.

1.8.2 Practical Significance

Using motion graphics to assist the teaching of stroke order of Chinese characters is an effective way to solve students' rote memorisation, forget and then remember, and remember and forget. This motion graphic shows the process of the appearance of Chinese strokes more effectively and enables learners to remember the stroke order of Chinese characters inadvertently, which can significantly improve the efficiency of Chinese character learning. Through the combination of this motion graphic and classroom teaching, the existing teaching method of Chinese character stroke order will be improved.

1.9 Limitations of the Study

One of the limitations of this study is the motion graphics used in the study. Chinese characters are structurally divided into undecomposable Chinese characters and compound characters, and the number of Chinese characters is huge. Because undecomposable Chinese characters are the basis of compound characters, the Chinese characters for making motion graphics in this study are selected from undecomposable Chinese characters. Therefore, the stroke order motion graphics of Chinese characters in this study cannot represent all types of Chinese characters, but can only represent undecomposable Chinese characters.

Another limitation is the number of participants in this study. This study was conducted using a sample of only one university, USM, so the findings cannot represent the general situation of all universities in Malaysia.

This study is further limited to the classroom teaching environment. Due to the influence of COVID-19, the teaching was conducted online. Face-to-face teaching and online teaching may have different effects on the research results.

1.10 Operational Definitions

1.10.1 Cognitive Load

Cognitive load refers to the working memory resources actually consumed in the execution of tasks, which is related to the amount of information processed in a period of time (Reif, 2010). There are three kinds of cognitive load, which can be divided into intrinsic, extraneous and German (Paas et al., 2004; Sweller et al., 1998).

1.10.2 Cognitive Load Theory

Cognitive load theory is an instructional design guideline, which is based on human cognitive structure (Sweller, 2005a; Van Merriënboer & Sweller, 2010). The theory assumes that human working memory resources are limited and long-term memory is infinite (Sweller, 2002). This theory provides instructional design principles and strategies to solve the problem of limited working memory, thereby transforming it into long-term memory.

1.10.3 Cognitive Load Theory Effect

Cognitive load theory effects are some teaching suggestions put forward by researchers in the field of cognitive load through empirical research (Sweller et al., 2019). Proper cognitive load management can prevent working memory overload and improve learning efficiency. Split attention and redundancy effect are mainly involved in this research.

1.10.4 Chinese Characters

Chinese characters refer to simplified characters in the Chinese mainland.

1.10.5 The Stroke Order of Chinese Characters

The stroke order of Chinese characters refers to the sequence in which each stroke appears (Hsiung et al., 2017). The implementation standard is to follow the

Stroke Orders of the Commonly Used Standard Chinese Characters issued in 2020 from the Chinese mainland.

1.10.6 The Stroke Order Motion Graphics of Chinese Characters

The stroke order motion graphics of Chinese characters show the stroke order of Chinese characters through motion graphics in a story-telling manner.

1.10.7 Learning Performance

Learning performance is a measurement of the learner's performance after learning the stroke order motion graphics of Chinese characters or the learner's performance after learning the stroke order of Chinese characters under the traditional teaching method. Learning performance is an effective way to evaluate the teaching effect of the two teaching methods. The results are all from the post-test.

1.10.8 Instructional Design

Instructional design is defined as the use of systematic methods to solve instructional problems in this research.

1.10.9 ADDIE Model

In this research, the ADDIE model is called a systematic method for instructional design, which represents five stages in the development of effective learning aids.

1.11 Summary

This chapter aims to provide a general overview of this research. This chapter first stated the background, research questions, research objectives and research hypotheses of this research, trying to investigate the problems of non-native learners in Chinese character stroke order learning, and put forward solutions. Secondly,

justification on the usage of cognitive load theory combined with motion graphic strategy and the significance of this research were discussed. Whether from the theoretical level or the practical level, the research results of this research may make a certain contribution. Finally, it summarised the limitations in the research process and the operational definitions that need attention.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The main purpose of this research is to develop Chinese character stroke order motion graphics and evaluate their impact on students' learning performance and cognitive load. Before developing the stroke order motion graphics of Chinese characters, the importance of Chinese character stroke order and related teaching strategies should be clearly understood to determine the necessity of the development of Chinese character stroke order motion graphics. Then first a brief review of the development background of motion graphics. Next, a definition of motion graphics is presented and finally reviews the application research of motion graphics in the field of education. These provide a basis for this research to choose motion graphics as the expression form of Chinese character stroke order. In addition, this research takes cognitive load theory as the theoretical framework, because it provides a theoretical basis for the specific design and evaluation of Chinese character stroke order motion graphics. Therefore, the instructional design principles and strategies based on cognitive load theory are also summarised. In order to determine the basic steps of developing Chinese character stroke order motion graphics, the author uses the ADDIE model as an instructional design framework. To this end, relevant applications of the ADDIE model in the field of education are also reviewed to confirm its applicability to this research. Finally, Herbart's teaching stage theory is reviewed, because it provides a theoretical basis for the module development of Chinese character stroke order motion graphics. By reviewing the previous research results, it has laid a solid foundation for the initial basic assumption, the final landing and the evaluation of the effectiveness of the Chinese character stroke order motion graphics.

2.2 Chinese Characters Stroke Order

2.2.1 Chinese Character Stroke Order and Its Importance

As mentioned earlier, strokes are the smallest unit that constitutes a Chinese character. Only when each stroke is presented in a certain order and then a Chinese character can be formed, which means that stroke order is formed in the writing process of Chinese characters (Xin & Ruimin, 2022). The stroke order is actually a well-established rule that dates back as far as 520 AD (Zhang, 1990). The stroke order determines the starting point of each Chinese character (Ling & Jaganathan, 2014). Its appearance aims to simplify and speed up the writing process (Zhou, 2007) and to help improve the aesthetics and correctness of the Chinese characters once written (Zhang, 2014). For example, Xiao (2006) reported that the stroke order has a great influence on the final formation of Chinese characters, and stroke order errors will eventually lead to errors in the written Chinese characters. In addition, Tsai et al. (2012) argued that the stroke order is also indispensable for memorizing the shape of Chinese characters. Through the comparison of two teaching methods (traditional teaching and stroke order animation teaching), Jin (2006) revealed the positive side of Chinese character stroke order animation on Chinese character learning and found that stroke order animation improves the accuracy of Chinese character form recognition. As Qiu and Zhou (2010) explained, stroke order is very effective for extracting relevant information about Chinese characters from long-term memory at any time. Yu et al. (2011) has carried out a neuropsychological study. Through functional magnetic resonance imaging, they found that compared with writing Chinese characters in random order, writing Chinese characters in standard order can activate relevant neural networks more effectively. Therefore, emphasizing the learning of stroke order may be the best way to write and

remember Chinese characters (Ling & Jaganathan, 2014), but how to learn the stroke order of Chinese characters is also a great challenge.

2.2.2 The Teaching Strategies of Chinese Character Stroke Order

As mentioned above, the traditional way of teaching the Chinese character stroke order is for the Chinese teacher to present the stroke order of each Chinese character on the whiteboard or blackboard, while the students follow the teacher to practice writing stroke-by-stroke. Some researchers (Chu, 1999; Mori & Shimizu, 2007; Packard et al., 2006) have found that students usually use rote memorisation to remember the stroke order of Chinese characters in this process. However, with the increasing popularity of multimedia technology, significant changes have taken place in the teaching strategies of Chinese character stroke order. There are many different multimedia forms that can help to improve the effectiveness of Chinese character stroke order teaching, and there is an ongoing discussion about what the best multimedia form is. Chen et al. (2007) have developed a system to detect the stroke order errors of Chinese characters through the computerized model. The research results showed that the system can effectively support and monitor stroke order learning. A study based on digital flashcards (Zhu et al., 2012) examined the impact of stroke order animation in digital flashcards on the memory of new Chinese words. Its findings support and affirm the positive significance of computer-assisted language learning software. Shinagawa (2012) stated that mobile devices can effectively help learners with language learning, and such mobile devices play a vital role in promoting language learning to become a normal part of daily life and improving learning performance (Chung, 2013; Rahimi & Miri, 2014). Ting et al. (2020) used mobile applications based on mobile phones to test the learning effect of students from the Business and Management Faculty of UiTM. The results showed that the mobile application provided better performance, although

both the mobile application and the traditional teaching method can improve stroke learning. In addition, Zhang et al. (2020) have developed and evaluated SmartSO. The essence of SmartSO is to use the inertial sensor of the smartwatch to judge whether the stroke order is correct, so as to help learners correct their wrong behaviours. They proved the effectiveness and stability of SmartSO through experiments.

Obviously, these studies have provided a clue that both PC-based and mobile-based multimedia forms can help to improve the learning performance of Chinese character stroke order. However, most of these researches focus on how to help students practice the stroke order of Chinese characters, and the research on using multimedia to assist students to memorize the stroke order of Chinese characters in the correct order is still a blank field. That is to say, the existing research is still based on the category of rote memorisation in essence, and few studies involve effective methods of memorising Chinese character stroke order. Therefore, this study is very important to explore the influence of motion graphics on non-native language learners memorizing Chinese character stroke order.

2.3 Motion Graphic

Short videos spread quickly, are highly entertaining and are easy to access (Yang et al., 2019), catering to the fast-paced life of today's young people (Wang, 2020). Its rise is changing people's daily life and learning style (Cervi, 2021; Du et al., 2020), especially with the support of mobile Internet technology, which has accelerated the process of its development (Wang, 2020). Whether people drink coffee at Starbucks or commute, they can quickly browse and watch through their mobile phones or iPads (Li, 2018). This change is also slowly affecting the field of education (Hsin & Cigas, 2013), especially motion graphics, which has most of the characteristics of short videos and

has gradually emerged potential in the field of education. However, motion graphics also have their charm.

2.3.1 The Development of Motion Graphic

John Whitney, a famous American animator, founded a company called "motion graphic" in 1960, which was the first time that "motion graphic" appeared as a professional term (M. F. D. Shir & M. Asadollahi, 2014). However, there are still cases where other terms are used in academia, such as motion graphic animation (Firdaus et al., 2020; Nuryaningsih et al., 2020), dynamic graphics (Lowe, 2003), moving imagery (Freeman, 2015) and moving images (Enticknap, 2005). A consensus has been reached that motion graphic is generally accepted as its representative term (Betancourt, 2020). Here I have to mention Saul Bass (Horak, 2014), the pioneer of motion graphics, who first introduced motion graphics into the film field in the 1850s, opening the era of motion graphics (Yu, 2008). When technology meets art, it will produce new sparks (Lijun, 2019). With the development and popularization of computers, motion graphics began to make their mark in advertisements and music videos (Krasner, 2013). Today is the era of new media and it is also the era of the explosion of short videos, which provides various possibilities for the rapid development of motion graphics. In particular, motion graphics has been expanded to varying degrees in expression forms and application fields and motion graphics can be seen everywhere (Shir & Asadollahi, 2014). The most obvious examples are the welcome motion graphic when the mobile phone is turned on, the emoticon motion graphics in social software and the educational motion graphic UFO TALK (Han, 2020).

2.3.2 Definition of Motion Graphics

Although our study and life are inseparable from motion graphics, how to define motion graphics is a great challenge. At present, there is no unified conclusion in the academic circles.

Geng (2016a) believes that motion graphic is a creative activity, which integrates many elements such as graphics, text and sound.

According to Jahanlou et al. (2020), motion graphics is a digital media widely used in TV titles, the Internet, outdoor advertising, games and other fields.

American artist Matt Frantz defines motion graphics as a visual design that changes over time, which is visually non-narrative and non-representational (Wurman, 2001).

For Curran (2000), motion graphics is emphasized as a technology to make still images produce motion.

According to Wiana (2017), motion graphics can be presented in two-dimensional form or three-dimensional form.

It can be seen from the above definition that inclusiveness is the main feature of motion graphics, which is reflected in vision, technology and application fields. This means that the definition of motion graphics needs to be considered from these three aspects. Therefore, the author believes that motion graphics is defined as a comprehensive art that follows the principles of graphic design visually and adopts the animation design method technically, which can be displayed in almost all media.

2.3.3 Motion Graphics in Education

The researchers pointed out that motion graphic is very effective in promoting the dissemination of knowledge (Bian & Ji, 2021). Visualizing a large amount of text information and highlighting the key information in the picture with the help of

narration, graphics and text for arrangement and combination make the viewer focus more (Azahari et al., 2020; Hanna & Coman, 2021; Yang, 2020). It is convenient for the audience by controlling the length of time to use the fragmented time to watch and learn (Shi & Gu, 2021), and the learning task can be completed in a very short time (Chen & Cha, 2019). The motion graphic adopts concise graphics, plot content and narration, which not only makes it easy for the audience to understand the information conveyed by the designer but also improves the viewing experience (Han, 2020). In addition, motion graphic combines dynamic beauty and formal beauty into a strong visual effect to attract the attention of the audience and make them have a strong desire to watch (Bui, 2021).

At present, a few researchers begin to pay attention to the practical application of motion graphics in education. Fang et al. (2021) applied motion graphics to education science for young children and compared the learning effects of two groups of young children after watching motion graphics and traditional style animation. The research results show that motion graphic has a more significant impact on children's attentional perception of key information than conventional animation. Hapsari and Hanif (2019) applied a study of motion graphics to natural science education in elementary schools, which showed that it improved students' learning performance in fifth grade using motion graphic teaching. In Indonesia, an application effect of interactive multimedia applications based on motion graphics in clothing design showed that, compared with traditional teaching methods, interactive multimedia based on motion graphics is more effective for mastering clothing design concepts and skills (Wiana et al., 2018).

These findings show that motion graphics have an excellent effect on promoting students' subject learning, especially in improving students' learning performance, attention and understanding of complex concepts. However, it also reflects that the

relevant research of motion graphics in the field of education is very limited, especially the empirical research on the use of motion graphics in the field of teaching Chinese as a foreign language because no one project research is found to involve teaching Chinese as a foreign language. This study attempts to compare the use of motion graphics and the absence of motion graphics to explore the impact on Chinese students' learning performance and cognitive load in the stroke order of Chinese characters, which has particular practical significance for teaching Chinese as a foreign language.

2.4 Theoretical Framework

In this research, the cognitive load theory provides a theoretical basis for the development of Chinese character stroke order motion graphics. The researchers used the cognitive load theory to understand the Human cognitive architecture, the types of cognitive load, the instructional effect and measurement, and designed and developed Chinese character stroke motion graphics, so as to provide optimal learning performance.

2.4.1 Theoretical Basis of Cognitive Load Theory (Human Cognitive Architecture)

The term “cognition” (Posner, 1973) must be clearly understood before understanding the cognitive architecture. Cognition means that when the brain needs to know objective things or obtain knowledge from objective things, it may go through mental processes such as memory, thinking, perception, recognition, reasoning and so on (An & Wu, 2015; Greeno et al., 1996; Robbins, 2011). For example, remember a new place name, know a new animal, or solve a mathematical problem. In short, cognition is a way or an experience for the brain to understand objective things. The result of cognition may form new memories, get new ideas and make new decisions (Shettleworth, 2009). Human cognition has a certain cognitive structure. Navaneedhan

and Kamalanabhan (2017) define cognitive structure as the mental models of organizing information. A typical example of cognitive structure is a schema (Busselle, 2017; Dobson & Mastikhina, 2015; Tennyson & Volk, 2015). Singers need to have schema reserves so that they can easily sing various songs through memory search at concerts is a schema example. While the organization of cognitive structure is considered to be the cognitive architecture of humans (Sweller, 2002). Anthony Jr (2008) and Josephsen (2015) stated that working memory, long-term memory and schema are important components of the cognitive architecture.

2.4.1(a) Working Memory

Working memory (Atkinson & Shiffrin, 1968; Miller et al., 2017), also known as short-term memory, as the name suggests, is to save a small amount of new information temporarily in a short time (Baddeley, 2010). In other words, it is a temporary memory, which focuses on the ability to remember information in the present, rather than whether it can be recalled later. An obvious example is memorizing English words. The students memorized eight English words taught by the teacher 10 minutes ago. After 10 minutes, maybe the students can only remember a few or even none. Working memory is the main place of information processing (Alloway, 2009; Swanson & Alloway, 2012). When humans receive new information, they always have to go through the processing of working memory first (Anmarkrud et al., 2019). However, the capacity of working memory is limited, and only 5-9 pieces of limited information can be saved at a time (Baddeley, 1992; Miller, 1956). Kalyuga (2011) points out that learning is usually ineffective when the amount of information processed exceeds the capacity of working memory. In addition, working memory is also used for the processing of highly interactive elements (Sweller et al., 1998), and actually, there may be less than 4 pieces of information that can be processed at the same time (Cowan,

2001; Kirschner et al., 2006). The researchers also discussed the duration of working memory and believed that unless through repeated training, otherwise the information will be lost in around 20 seconds (Driscoll & Burner, 2005; Josephsen, 2015; Peterson & Peterson, 1959; Van Merriënboer & Sweller, 2010). In order to avoid the limitation of working memory hindering learning, we must consider reducing the load imposed on working memory in instructional design (Leppink et al., 2013; Sweller, 2011).

2.4.1(b) Long-Term Memory

Long-term memory is the main place to store information (Bower, 1975; Li et al., 2015). It can store information for a long time or even indefinitely (Hall & Stewart, 2010), and its capacity is almost unlimited (Anmarkrud et al., 2019; Camina & Güell, 2017). The content of long-term memory is not limited to texts, but also can be visual and sound (Gilakjani, 2012). When the information processed by working memory is transformed into long-term memory, the information is stored, and humans can easily obtain it directly through search when they need it ("Chapter 2 - A useful framework," 2013; Clarkson, 2008). An example is that when you encounter a goose on the road, the brain will subconsciously respond that it is a goose without wasting time distinguishing it because the image of the goose has been stored in your long-term memory. A study by De Groot (2014) showed that the main function of long-term memory is not only to recall information but also to solve advanced problems. In addition, the reason why experts can deal with complex problems better than novices is that experts have professional knowledge in their field of study, which has been stored in long-term memory, and novices must make up for it through training (Ericsson & Charness, 1994). Consistent with this finding, other studies have found similar results (Abernethy & Russell, 1987; Barfield, 1986; Carter et al., 1988; M.-Y. Cheng et al., 2015; del Villar et al., 2007; Diamond & Carey, 1986; Hobu et al., 1987; McPherson, 2000; Sweller &

Cooper, 1985). Therefore, the instructional design must consider promoting the acquisition of professional knowledge for students.

2.4.1(c) Schema

The schema refers to a framework or cognitive structure formed by humans after organizing or generalizing information (Plass et al., 2010; Van Merriënboer & Ayres, 2005; Widmayer, 2004). An example is when we create a schema for a flamingo. We saw the pictures of flamingos in the magazine and remembered that it has a long neck and red feathers. Next time we go to the zoo, we can recognize it without thinking. Therefore, the schema can contain a large amount of information about the relevant context (Rumelhart, 1984). It describes how the information of relevant context is put together and stored in the brain in the form of units (Hessler & Henderson, 2013), which shows that the knowledge stored in the brain is organized and not chaotic (Van Merrienboer & Sweller, 2005). Schemas help us take shortcuts when understanding or interpreting new information (Yee et al., 1996), which is convenient for us to call at any time when we need it (Norman, 1981). This is usually done unconsciously, namely, Schema Automation (Van Merrienboer & Paas, 1990). The formation of schema automation needs continuous training until it does not need the help of working memory (Sweller et al., 1998). The learning materials after schema automation don't occupy the capacity of working memory, and in turn, participate in working memory to help solve new problems. That is, when the new information conforms to or contains the existing schema, it will take the least cognitive effort to understand the new information. Once the schema automation is formed, the brain can process information quickly and work more effectively. It is well documented that schema automation has a positive impact on problem-solving (Cooper & Sweller, 1987; Kotovsky et al., 1985). In addition, schema not only help to solve general problems (Gick & Holyoak, 1983) but even expert