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AN EXPLORATION OF THE QUANTITATIVE SIMULATION OF SCHEMA FORMATION - A CASE OF EARLY CHILDHOOD CHINESE LITERACY LEARNING

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Abstract:
A schema is an intrinsic cognitive structure that helps an individual to organize all the messages absorbed and form a knowledge structure, which functions in helping one to learn and comprehend new things. Most studies of schemas have focused on schema-based teaching and explored learning outcomes, but few studies have discussed the development and construction of such schemas. This study centers on the issue of young children learning Chinese characters, explores the formation process of a schema, and attempts to quantify the establishment of a schema in an innovative research design. This study adopts an experimental approach with the process of intervention teaching, and makes comparisons between the pre-test and post-test to measure learning effectiveness. The results of this study verify that the schema theory does not exist only as an abstract concept, but also as one which can be recorded and described quantitatively. The result also indicates the number of teaching times and the accumulation of learning experience that are required in the establishment of a schema for young children learning Chinese characters. This study proves again that the schema theory has a positive impact on learning effectiveness.

Keywords: schema formation; schema measurement; establish schema; Chinese literacy learning

1. Introduction

1.1 The concept and meaning of schema

In the field of cognitive learning, the schema concept is not unknown, but rather very familiar. In 1932, British psychologist Frederic Bartlett first brought the schema theory into cognitive learning theory. Some scholars have agreed that Jean Piaget was the first to present the function of schema in 1926, and later in the 1970s, the American

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educational psychologist Richard Anderson further developed the concept. Rumelhart (1980, P.34) defined a schema as "*a data structure for representing the genetic concepts stored in memory*". Anderson and Pearson (1984, p.42) described it as "*an abstract knowledge structure" and this knowledge structure can help us to understand new things in the process of learning. Therefore, a schema can be seen as an intrinsic cognitive framework by which an individual can organize all the messages absorbed from different sources and form the so-called knowledge structure that contains all relevant concepts and the interrelationship among these concepts*." (Fiske & Linville, 1980)

Mayer (1992) depicted schemas from the angle of memory, for he supposed that schemas are stored in the long-term memory and are the body of knowledge within a highly organized structure. That is, an individual assimilates new messages, triggers the memorized messages, and then extracts the relevant schemas from the long-term memory to interpret and understand the new experiences. In other words, a schema is one of the basic elements for an individual to carry out message-processing so as to understand the message structure of a thing and signify general concepts stored in the memory. Moreover, a schema can reveal itself in a variety of fields and various abstract concepts, including the comprehension of conceptual knowledge, cultural phenomena, the particular signification of text, patterns of English alphabet and so on. In other words, schemas are our knowledge, for most of our knowledge is embedded in our schemas.

As for the aspect of cognitive load, it is proper to see both the acquisition and the automation of schemas as one of the most significant elements that prevents cognitive overload from happening in learning (Sweller, van Merrie¨nboer, & Paas, 1998). Establishing a schema is similar to establishing a cognitive track in the brain. As these tracks of cognition are established, the learning process loses much of the weight of its cognitive load in the process of adaptation, exploration, and adjustment. Schemas, from the viewpoint of metacognition, also function as a metacognitive process which is closely related to the learner's own cognitive process of knowledge; together with his/her active control of such processes (Efklides, 2008). That is, the formation of a schemas is similar to the establishment of metacognitive regulation in building up the learning process of how to understand new things, including the ability of a person to design, monitor, evaluate, and operate the processing of information toward the goal (Kalyuga, 2009).

1.2 Classification of schemas

Most researchers have accepted the importance of schemas (Carver, 1992). However, the schema concept is often criticized for being too vague and not specific enough (Sadoski, Paivio, & Goetz, 1991). Therefore, it is necessary that the schema operation be clearly classified and described in further detail. Fundamentally, schemas are divided into two categories: formal schemas and content schemas. Formal schemas mainly refer to the "*background knowledge of the formal, rhetorical organizational structures of different types of texts*" (Carrel & Eisterhold, 1983, p.79). Namely, this category comprises both the background knowledge about differences among written structures and the

expectations of them, such as differences in genre. For example, the text knowledge acquired in the past can lead one to sufficient recognition of rhetorical structure and thus invoke formal schemas. The lack of such background knowledge may generate a lot of resistance in reading comprehension. As for content schemas, this refers to one's background knowledge about the text's content (Carreli and Eisterhold, 1983, p.80); that is, it consists of the knowledge of concepts or the information of what is usually related to a particular topic and about how these various relations interact with one another so as to form a well-organized whole. Reynolds and other researchers (Reynolds et al., 1981) again defined another category of schema, cultural schemas. Later in 1988, Carrell (1988) added a further category, linguistic schemas. Such a clear idea of well-classified schemas has just helped to make the classification of prior knowledge more obvious, but the actual operation of schemas remains a vague concept. The actual operation of schemas often serves a function of integration, collecting all kinds of background knowledge and harmonizing them into a well-organized inner work. According to the idea of schema integration, a schema reveals the pattern in which all kinds of knowledge are grouped into certain units to serve as the building blocks of cognition. As described by An (2013), a schema is based on class hierarchy in which a larger schema contains many smaller schemas and such a second-ranked smaller schema again may contain even smaller schemas.

1.3 The application of schemas and related research

The schema concept has been widely applied to various areas and has played a very important role. Particularly in the teaching area for teachers, the schema concept has already been adopted broadly to assist the reading process and many in-service teachers believe that schemas are a valuable tool in the learning of cognition and reading (McVee, Dunsmore, & Gavelek, 2005). Moreover, in the teaching of reading comprehension, when people are reading a text, the establishment of schemas and skillful use of them can help these learners become more familiar with the reading method and thus enhance reading comprehension (Afflerbach, 1990; Anderson and Pearson, 1984; Carrell, 1984; Grabe, 1991; Van Oostendorp, 1991; Tierey & Shanahan, 1991). For instance, Anderson and Pearson (1984) together examined the effect of background knowledge on reading comprehension, finding that schemas are a crucial element in the comprehension process. Moreover, Faris and Smeltz (1997) showed that schema theory is applicable to reading comprehension by claiming that it can improve learners' comprehension in various situations. Additionally, Smith & Swinney's (1992) findings showed that schemas affect textual understanding during active comprehension, not merely during passive recall.

In the application of mathematics teaching, many teachers teach students mathematics using schemas to assist and improve their problem-solving performance (Jitendra, Griffin, Haria, Leh, Adams, & Kaduvettoor, 2007). In the field of mathematics, many schema studies have focused on the effectiveness of schema-based teaching. So-called schema-based instruction involves using teaching methods developed from the background knowledge of the schema theory, especially for solving mathematical word

problems; that is, to classify math questions according to a schematic drawing and organize messages so as to determine the most appropriate problem-solving procedure (Jitendra, Star, Rodriguez, Lindell & Someki, 2011). For instance, Hill(2012) explored the learning effectiveness of schema-based instruction of mathematical issues, dealing with math word problems, and Jitendra et al.(2013) adopted schema-based instruction to explore the issue of proportional reasoning and examine its effectiveness. The study objects of schema-based instruction can include ordinary students, students with learning disabilities, students with emotional disorders, and students of a variety of ages. The findings of such studies indicate a very positive influence on learning.

1.4 Problematic issues in the study of schemas

In general, most studies of schemas have focused on schema-based instruction and its learning outcomes; that is, with the schema theory as the background, researchers have developed sets of teaching methods and teaching schemas to explore the effectiveness of learning. Such discussions center on exploring the explicit designs of schemas, such as schematic drawings, formulas, principles, and so on. However, the development and construction of schemas have rarely been discussed. McClelland and Rumelhart (1986) claimed that while these "structures of knowledge" have been critically discussed, we are still rather unclear about what can be counted as a schema and what a schema should contain. Sadoski et al. (1991) also mentioned that the schema concept is equivocal, with limited or no clear referents.

As discussed above, we are aware that a schema is a human cognitive structure, which is built from previous experiences and the organized knowledge and which helps to process new information and check previously stored old information so that we may gain new knowledge and new experience. Namely, a schema is constructed from old experiences; therefore, we want to find out, in the aspects of practical learning and application, how many old experiences or how much knowledge is needed before we can form a schema. About this issue, the relevant research and literature is very limited. In other words, a quantitative measure of the establishment of schemas, and how much practice or the amount of experience necessary prior to schema formation is completed, remain undiscovered.

1.5 Research purpose

Therefore, this study focuses on the exploration of the process of schema formation through by studying young children learning to recognize Chinese characters. This study also tries to quantify schema formation so that the required number of teaching times, together with the amount of accumulated experience, can be estimated before the schema is eventually formed. The above goals make up the research direction and theme of this study. In addition, the research design of this study may offer significant implications for the quantitative measurement of schemas. The research questions of this study are as follows:

1. Do schemas exist? Can the process of schema formation be quantified?

2. What are the required number of teaching times and the necessary cumulative experiences for young children to establish the schemas when learning Chinese characters?
3. What is the influence establishing a schema for Chinese character recognition on the learning outcomes of young children learning Chinese characters?

2. Method

2.1 Research design

This study explores the quantitative measurement of schema formation; that is, we aim to measure the amounts of learning or cumulative learning experience is required before a schema is formed. As previously discussed, schema formation comes from cumulative old experiences; once a certain amount of old experiences are accumulated, learning becomes an automatic instinct. Then the effectiveness of learning will be enhanced. This amount of experience is a key to the establishment of a schema, which is the target of this study. This study centers on the issue of learning Chinese characters and measures how many times and how much learning is required to format a schema for young children learning Chinese characters. By the method of experimental design, we undertake interventional teaching and then proceed to test the learning effectiveness by examining the phenomenon of schema formation. Firstly, we conducted a pilot study by using a single case to explore whether the schema can be quantified; then we adopt multiple cases to explore the procedure of schema formation and to quantify the construction of the schema. Secondly, this study compares the differences in the effectiveness of Chinese character learning between those who have established the schema and those who have not.

2.2 Participants

This study aims to measure a schema of Chinese character learning for young children. In early childhood, literacy learning has not been formally taught, and schemas have not yet been formed. Thus, young children are ideal for participating in this study. Prior to the study, participants' recognition the characters to be taught was first examined. If the correct ratio of a young child was more than 20 percent (that is, two clusters of Chinese characters), it revealed that he/she was not a beginner and may have already established a schema of Chinese literacy. These children were ruled out. The final participants included 48 children of ages 5 or 6, selected from 4 kindergartens in central Taiwan. 24 of them formed the experimental group to establish the learning schema, and the others served as the control group to compare differences in learning effectiveness; the proportion of girls and boys selected was random.

2.3 Experimental tools

The tools used in this study include instructional media for teaching Chinese characters and pre- and post-test tools, all of which were designed by the researchers. The teaching tools include multiple groups (at least 7 groups) of Chinese characters, each group

consisting of 6 clusters of Chinese nouns. For example, one of them is a cluster of kinds of fruit, including 6 kinds of fruit (carambola, sugar apple, loquat, lychee, etc.). This is illustrated in Figure 1 and presented with digital instructional media comprised of elements of graphic representation, characters, and pronunciation. Each noun was taught three times, and then the teaching went on to the next one until all 6 nouns were completed, thus completing one teaching cycle.

Figure 1: A screenshot of the instructional material in the fruit group

The measurement tools include two sections, the reading and comprehension of Chinese characters, as shown in Figure 2 & 3. In the reading section, the tester pointed to the word cluster of Figure 2, and the subject reads them out. As for the word comprehension section, the experiment involved picture matching (Figure 3). Characters and pictures were placed on both sides of the text, and the subject used a pen to connect each noun to the image with the correct meaning. Before the experimental teaching, there was a pre-test, and after that, a post-test.

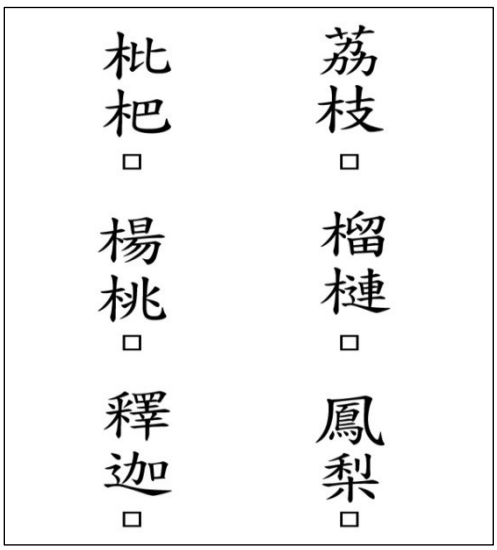

Figure 2: A screenshot of the word reading test

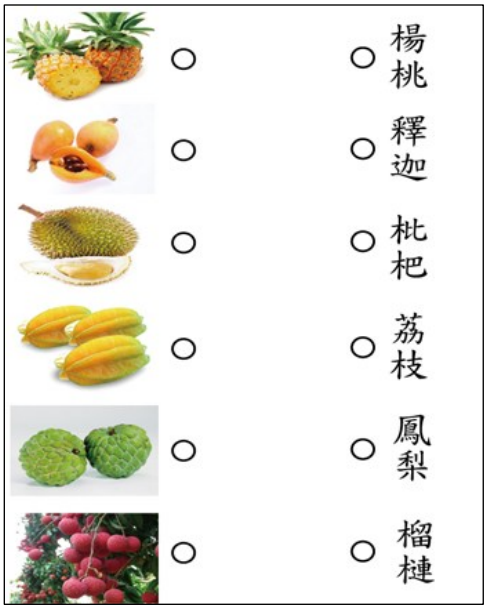

Figure 3: A screenshot of the word comprehension test

2.4 Procedure

This study aims to find the amount of old experiences required to establish a schema, as well as the number of learning groups and the teaching times for each group. The first pilot study was undertaken with one participant only, and the procedure of the performance is described as follows:

a) First, a pre-test of the learning content was conducted. If the pre-test results included correct answers for more than 1 group of word-clusters, the subject was replaced.
b) Second, the first group of Chinese noun-clusters was taught, and each time two cycles of teaching were performed. After every two cycles, a post-test was given. For the word-reading section, the teacher pointed to the chosen Chinese characters, and the subject read them out loud. As for the comprehension section, the method of picture matching was applied to examine whether the young child could correctly connect the picture to the word with the right meaning (Figure 3). After a five-minute break, we preformed the second round of teaching. The same procedure was carried out continually until the post-test results were entirely correct. Then we recorded of the number of teaching times needed before the subject recognized all the words in the first group.
c) The next day, the same young participant was taught the second group of Chinese words following the same procedure used for the first group (pre-test, teaching, & post-test). At last, we recorded the number of teaching times before the test result showed all correct answers. This teaching was repeated for third group of Chinese words, the fourth, the fifth, the sixth, and so on until the number of teaching times became stable, i.e. the number of teaching times stopped decreasing. When the learning number dropped to a stable level, no matter how many groups of Chinese words may have been taught, we stopped

the intervention teaching. This indicated that the schema for learning Chinese words had been established completely. Then we recorded of the number of teaching times after each group of Chinese word were taught and after the post-test questions were all correctly answered. Furthermore, we recorded the number of word-teaching groups once then learning became stable.

d) Once the single pilot study case succeeded, the following experiment on multiple cases could proceed. In the following experiment, with the same procedures mentioned above, an experimental group consisted of two students, and the teaching times and the number of learning groups were recorded after the construction of the schema of Chinese learning became stable. Nevertheless, because the learning speed of each person varies, the number of teaching times needed for each student to complete a single cycle is different. Therefore, when the first student completed the task, he/she no longer did not receive further teaching, but the other student had to go on completing the next cycle. After that, the next group of teaching and testing continued until all the data appeared to reach a stable level, which means the number of teaching times and the number of word-teaching groups converge and are similar compared with the following participants.

The second phase compares the Chinese word recognition learning outcomes between the participants before and after establishment of the schema. The experimental group (i.e., the participants whose schema was previously established) and the control group (i.e., the participants whose schema was not yet established) to pre-test for the same learning content. After that, intervention teaching (three teaching cycles) was performed, and then a post-test of learning outcomes was conducted.

3. Results of analysis

The results of this study respond to the following three research questions about young children's learning of Chinese characters: (1) How can we examine the establishment of a schema?; (2) What number of teaching times and amount of cumulative experiences required?;and (3) How can we measure the learning outcomes after the establishment of the schema? Based on the data analyzed in this study, explanation of the results is provided as follows:

3.1 Measurement of the schema

The learning of Chinese characters is divided into two aspects, reading and comprehension. Figures 4 and 5 show the results of a single subject in the schema of his/her word reading and comprehension. In the figures, the horizontal axis (X-axis) indicates the number of teaching groups, and the vertical axis (Y-axis) shows the number of teaching times (i.e., the number of teaching times required for the subject to correctly read out loud all the nouns in the groups). As shown in Figure 4, for the 1st group of Chinese characters, the subject needed 12 teaching times before all the answers were correct; for the 2ndgroup, 8 teaching times were need; for the 3rdgroup, it took 6

teaching times; for the 4th, the 5th, 6th and 7th groups, they already gave all the correct answers after just 4 teaching times. This single case shows that the establishment of a schema begins in the 2ndgroup of Chinese characters and reaches a stable state after the 4th group.

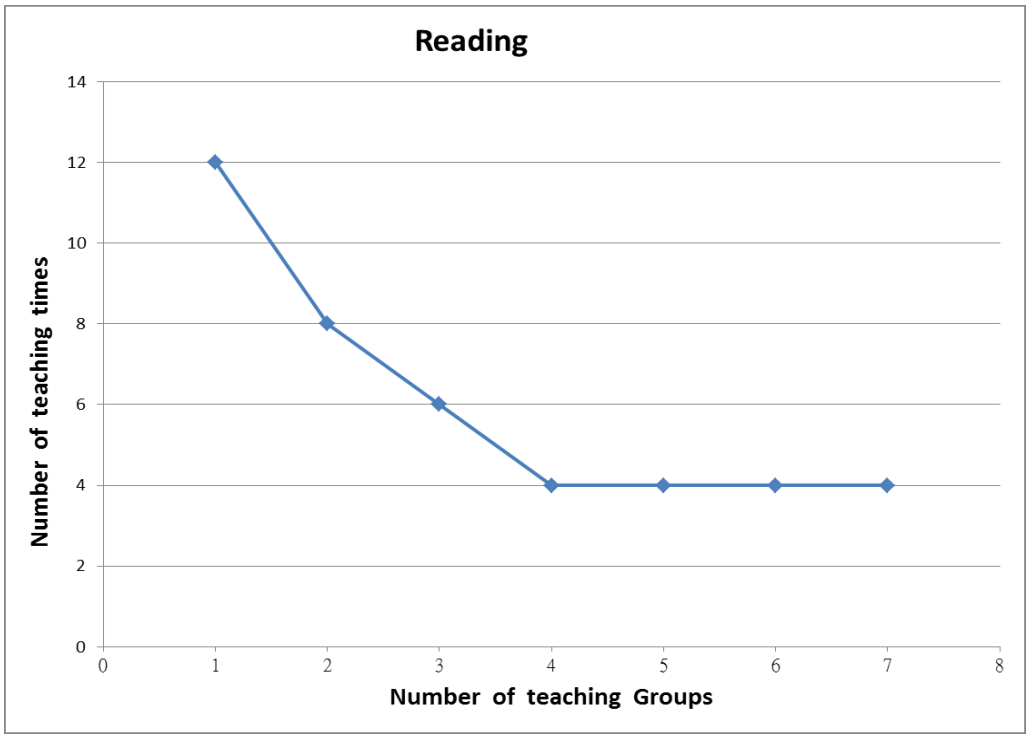

Figure 4: The establishment of reading schema for Chinese characters in a single case

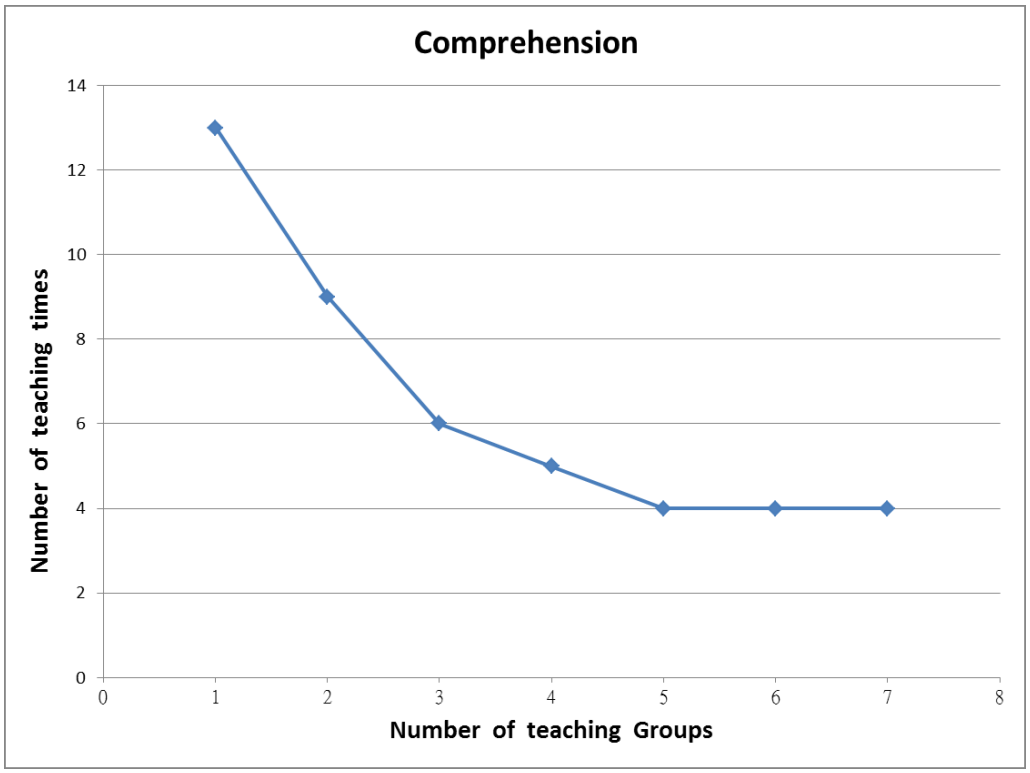

Figure 5: The establishment of comprehension schema for Chinese characters in a single case

The comprehension section, as shown in Figure 5, indicates a similar tendency. That is, in the 5th, 6th or 7th group, the learners have already given all the correct answers within 4 teaching times; at this point, the establishment of the comprehension schema has become stabilized.

3.2 The teaching times and the amount of cumulative experiences required to establish the schema

Figure 6 shows the results 24 subjects' schema tests in the Chinese word-reading section. The horizontal axis (X-axis) shows the number of teaching groups, and the vertical axis (Y-axis) shows the number of teaching times. The results of the independent samples t-test are shown in Table 1. The t-test of the 1st group and the number of the 2nd group shows t = 5.367 (p = 0.000<0.05), which means that there is a significant difference between the two. The t-test of the 2nd group and the number of teaching times of the 3rd group shows t=3.956(p=0.000<0.05), which means that there is a significant difference between the two. The t-test of the 3rd group and the number of the 4th group shows t=4.923(p=0.000<0.05), which means that there is a significant difference between the two. The t-test of the 4th group and the number of the 5th group shows t=1.738(p=0.089>0.05), indicating that there is no significant difference between the two, which means the schema establishment has reached a stable state.

Table 1: The result of the independent samples t-tests of reading and comprehension

Reading					**Comprehension**				
Group	**Mean (times)**	**SD**	**t-value**	**Significance**	**Group**	**Mean (times)**	**SD**	**t-value**	**Significance**
1	11.88	2.88			1	11.67	2.58		
2	8.04	1.99	5.367	0.000	2	8.21	2.02	5.167	0.000
3	6.13	1.30	3.956	0.000	3	6.04	1.40	4.319	0.000
4	4.42	1.10	4.923	0.000	4	4.17	0.64	5.979	0.000
5	3.92	0.88	1.738	0.089	5	3.88	0.61	1.617	0.113
6	3.71	0.81	0.855	0.397	6	3.54	0.93	1.465	0.150
7	3.63	0.71	0.380	0.706	7	3.29	0.69	1.056	0.296

The t-test of the 5th group and the number of the 6th group shows t=0.855(p=0.397>0.05), which indicates that there is no significant difference between the two, and the schema establishment remains in a stable state. The t-test of the 6th group and the number of the 7th group shows t=0.380(p=0.706>0.05), which indicates that there is no significant difference between the two, either. Thus, after the 4th learning group, the number of teaching times for Chinese word-learning reaches a stable state; that is, the schema of Chinese word-learning is established completely. According to Figure 6 and Table 1, after teaching 4 groups of Chinese words, it takes about 4 cycles of teaching for the subjects to be able to finish learning a new group of Chinese characters (a cluster of 6 nouns) and give all correct answers. Based on the results of the t-test in Table 1, it is clear that the schema of Chinese word-reading appears stable after the 4th group of Chinese characters is finished. Further, after the schema is established completely, the

participants can give all correct answers in the word-reading test after 3 to 5 cycles of teaching.

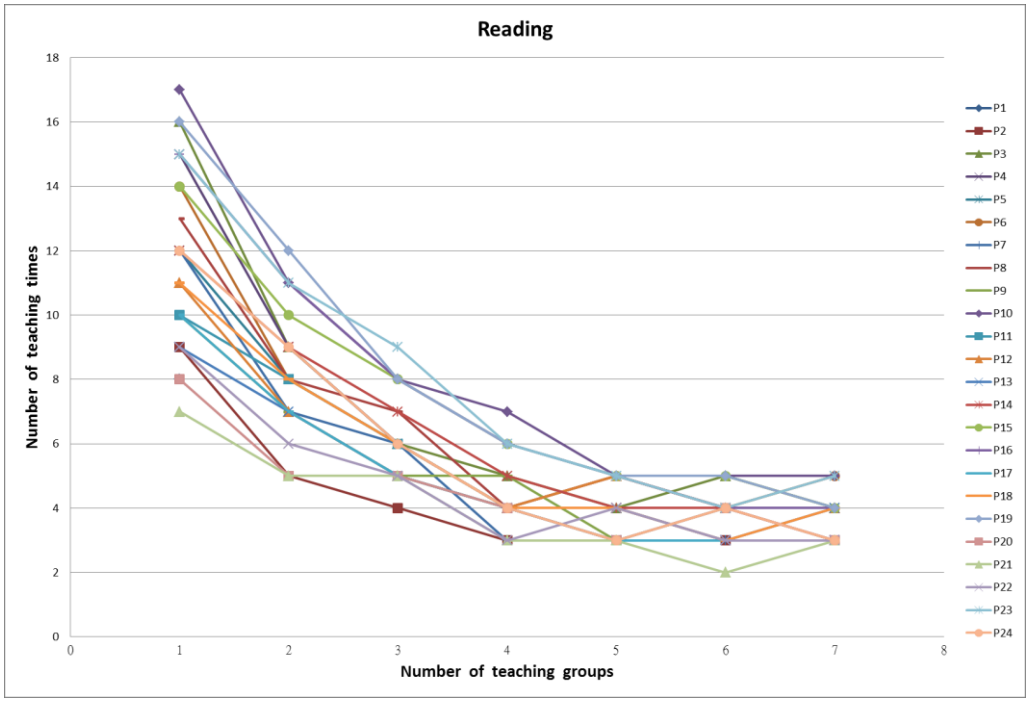

Figure 6: The schema establishment of Chinese character reading in 24 multiple cases

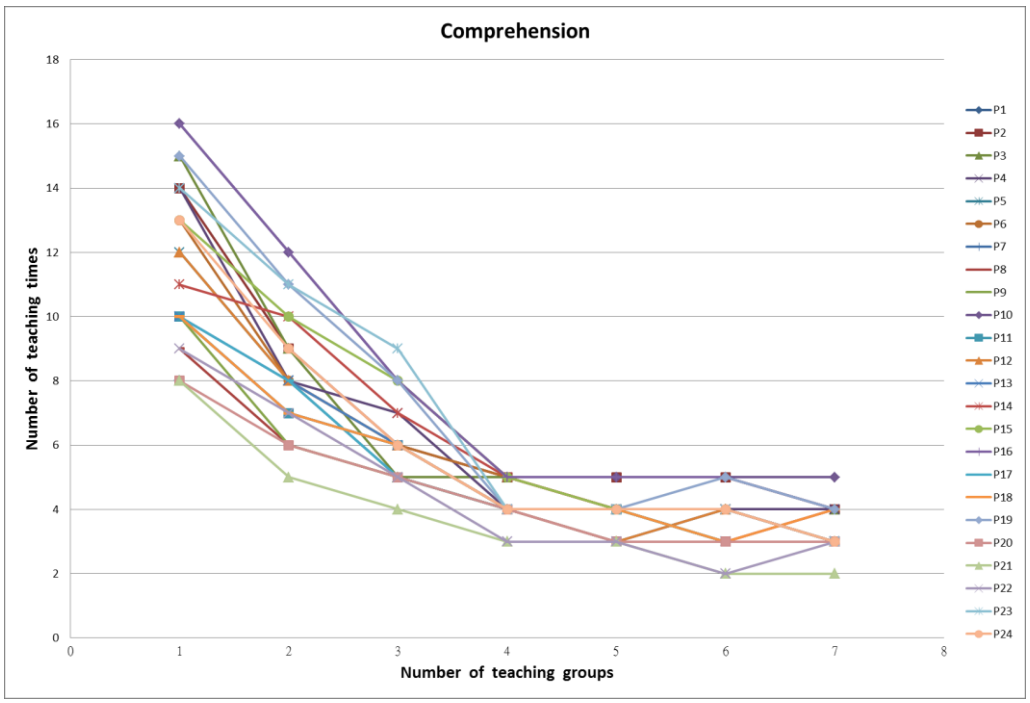

Figure 7: The establishment of a schema of Chinese character comprehension in 24 multiple cases

Figure 7 shows the test results of the comprehension section. To measure differences in teaching time results on the Chinese character comprehension test, for

each group, the number of teaching times is recorded (till all answers are correct). The results of the independent samples t-test are shown in Table 1. The t-test of the difference between the means of the 1st group and the number of teaching times of the 2nd group shows t = 5.167 (p = 0.000 <0.05), which indicates that there is a significant difference between the two and, namely, that the schema is being established, but not completed yet. The t-test for the 2nd group and the number of teaching times of the 3rd group shows t=4.319 (p=0.000<0.05), which indicates that there is a significant difference between the two. The t-test of the 3rd group and the number of the 4th group shows t=5.979 (p=0.000<0.05), which indicates that there is a significant difference between the two. The t-tests of the 4th group and the 5th group show 1.617(p=0.113>0.05), which indicates that there is no significant difference between the two, and the schema establishment has reached a stable state. The t-tests of the 5th group and 6th group show t=1.465(p=0.150>0.05), which indicates that there is no significant difference between the two, and the schema establishment remains in a stable state. The t-test of the 6th group and the number of the 7th group shows t=1.056(p=0.296>0.05), which indicates that there is no significant difference between the two, either. Thus, after the 4th group, the number of teaching times for Chinese words arrives at a stable state; that is, the schema of Chinese word-comprehension is well-established and stable. According to Figure7 and the t-test results, after learning 4 groups of Chinese characters, the subjects' comprehension schema is already in a state of stability. As to learning new Chinese characters (a clusters of 6 nouns), when the schema is constructed completely, it takes an average of about 4 teaching times (from 3 to 5 times) for the subject to be able to give all correct answers on the comprehension test.

3.3 Comparison of differences in learning outcomes before and after establishment of the schema

In order to compare differences in learning outcomes before and after establishment of the schema, we compare the Chinese word tests of the experimental group (whose schema is established) and the control group (whose schema is not established). The mean scores of the word reading and word comprehension for two groups are summarized in Table 2. A test of the assumption for homogeneity of regression in word-reading was conducted, which is nonsignificant (data of a*x): $F(1,45) = 2.922$; $p = 0.094 > 0.05$. This indicates that the assumption for homogeneity can be fulfilled. The result of the analysis of ANCOVA shows that the difference of word-reading scores among two groups is significant ($F(1,45) = 140.09$, Eta Squared $\eta 2 = 0.757$, $p = 0.00 < 0.05$), which indicates that there is a significant difference before and after schema establishment in the learning of word reading. In the comprehension section, the assumption for homogeneity can be fulfilled ($F(1,45) = 2.922$; $p = 0.094 > 0.05$), and the analysis of covariance on word-comprehension can be conducted further. The result of ANCOVA in word-comprehension shows that the difference among two groups is significant ($F(1,45) = 165.26$, Eta Squared $\eta 2 = 0.786$, $p = 0.00 < 0.05$), which also indicates a significant difference in word comprehension before and after the establishment of the schema for learning Chinese characters.

Table 2: The results of ANCOVA test
between the control group and experimental group

			Reading		Comprehension	
	Group	**N**	**Mean (SD)**	**Adjusted Mean**	**Mean (SD)**	**Adjusted Mean**
Pre-test	Control	24	0.13 (0.34)		0.21 (0.41)	
	Experimental	24	0.21(0.41)		0. 21(0.41)	
Post-test	Control	24	1.75 (0.74)	1.76 (a)	2.0 (0.59)	2.0 (a)
	Experimental	24	4.38(0.77)	4.37 (a)	4. 46(0.72)	4.46 (a)

4. Discussion

4.1 The establishment of a schema and its quantitative representation

As shown by the results, the establishment of a schema can be quantified by a digital presentation. The learning process diagram that includes word reading and word comprehension (Figure 1& Figure 2) clearly imitates the formation process of the schema, from subject being totally unfamiliar with Chinese word learning to eventually being familiar, when the schema has taken shape. According to the results of the pilot experiment, in the 1st group of Chinese literacy learning (a cluster of 6 Chinese nouns), it took about 12 teaching times for the subject to complete the word learning. This is mainly because young children are very limited in learning Chinese characters. Nevertheless, as they enter the 2nd group of Chinese literacy, they apply the experience from the 1st group to their learning, for their schema of learning Chinese words has started to form. Therefore, in the 2nd group, the teaching times are reduced to 8 times before they completely learn the words. This experience is repeated, and upon reaching the 4th group, the young children can totally comprehend the words with just 4 cycles of teaching and learning. Accordingly, in the 5th or 6th groups, the teaching times remain at 4 times; namely, the schema has now been stably established. Such results prove that schemas do exist. Schemas are not mere abstract ideas; instead, they can be represented quantitatively. In Figure 1, the cumulative increase in the number of teaching groups leads to the gradual reduction of teaching times; such results also show that learning experiences are indeed key elements to schema establishment. The finding mentioned above is consistent with Barlett's (1932) definition of a schema as an active organization of past reactions or experiences. Also as defined by Anderson & Pearson in 1984, a schema is the background knowledge or the prior knowledge of learners. In other words, a schema is a kind of mental structure that helps expose how readers adopt accumulated knowledge to learn and comprehend the text at present, as described by Rumelhart (1980). Therefore, the formation and establishment of a schema can only appear through old experiences.

4.2 Verification of the concepts of schemas and long-term memory

From the perspective of cognitive load, the results of this study demonstrate the concepts and functions of schemas and long-term memory (LTM). The so-called long-term memory, generally, like the tracks of a car, is impressed in our minds to form a knowledge schema. As we continue to practice or operate a particular kind of learning,

this learning or knowledge can form a special framework of knowledge and become long-term memory. By retrieving and applying the LTM schemas available, we can efficiently acquire relevant new knowledge. In this manner, the above-mentioned pattern is analogically adopted in this study; that is, by repeated teaching, using the same teaching methods with the similar contents, and under the same teaching rhythm, the learners can build up the structure of knowledge, i.e., a so-called schema, and the formation of long-term memory. After the teaching several groups of Chinese characters, the learners become more familiar with the literacy contents, the teaching methods, as well as the teaching procedures. Thus, the learning process turns into a mechanism for automatic learning so that the learners do not have to expend to much effort before they can comprehend the teaching contents (as compared with the situation when they were beginners); namely, the very limited working memory can be applied entirely to new Chinese text learning. This concept is consistent with the functional description of schema by certain scholars who confirmed that a schema kept in LTM effectively allows people to decrease their working memory load. This is because a schema can organize various known small units of knowledge or information into some bigger or higher-leveled units, and these later formed units are, then, held as the parts of working memory (Chi, Glaser, & Rees, 1982; Kalyuga, 2009). With constant practice, the learners build up a knowledge structure that can operate automatically, reduce the required load of the learning process, and thus enhance the efficiency of the use of working memory (Kotovsky, Hayes, & Simon, 1985; Shiffrin & Schneider, 1977). Furthermore, this study implies an idea: repeating the same teaching method is good for the learners, for this enhances learning outcomes. From the viewpoint of schemas, the same teaching procedure or method leads learners to establish schemas, therefore, reducing their cognitive load, and helping them to achieve better outcomes. The reason is that with repeated teaching by the same method, learners gradually develop a formal schema in the learning process. Once the schema is established, the learning process becomes an automatic mechanism.

4.3 The stability of schemas

This study demonstrates another very important concept. That is, the establishment of a schema can reach a stable state. Although every learning experience, indeed, can be accumulated to increase the formation of schemas, the establishment of a schema tends to reach a stable state when the accumulation of practice or experience reaches a certain amount. Then, when even more practice or experience is increased, there is still no way to accelerate the learning efficiency. These findings suggest that in Chinese literacy learning, if we aim for young children to form a stable schema or an automatic learning mechanism, the young learners must first learn 4 groups (i.e., clusters of 24 words) of Chinese characters. After the schema is established, when it comes to Chinese literacy, it takes about 4 cycles of teaching for young children to fully memorize the words of 1 group (a cluster of 6 nouns). In other words, when young children have established their schema for Chinese characters learning and are ready to learn a new cluster of words, a teacher needs only about 4 teaching times to complete effective education.

Teaching too many times does not necessarily increase the effectiveness of the subject's learning. This offers significant implications for teachers in their future teaching.

4.4 Comparison of learning outcomes between those who have schemas and those who do not

Comparing learning outcomes in Chinese characters learning between those who have schemas and those who do not, the results of this study show that those who have established schemas have better outcomes in word reading and comprehension than those who do not. Such a result is consistent with many conclusions of schema related studies. Schemas are effective tools for learning to read and comprehend (Anderson & Pearson, 1984; Tierey & Shanahan, 1991). The findings of Stevens (1980) showed that learners who have great amounts of schemas can better understand texts when compared with those who keep only smaller amounts. Concisely, Shen (2008) revealed that the text becomes easier to understand when the teacher improves the students' prior knowledge. Further, oftentimes the more background knowledge one has, the more linguistic weakness one can conquer (Grabe, 1991). This result also indicates that teachers should first put their efforts into the establishment of schemas, (with the same teaching method as suggested by this study). When schemas are formed, the effectiveness of learning will be enhanced.

5. Conclusion

This study aims to explore the quantitative process of schema formation. With young children learning Chinese characters as the target sample, we discuss the process of schema formation. The research design of this study is innovative. We record the amount of learning experience and the number teaching times and thereby clearly show the process of schema formation. The results are referentially useful to teachers of young children who teach Chinese characters. The findings suggest that for young children who are beginners to learning Chinese characters, it takes about 4 groups (of 24 words in total) to establish a schema for Chinese character learning. After the establishment of the schema, each teaching group of Chinese characters requires about 4 teaching times before learners can give all correct answers. This study also proves that the schema theory does not only exist as an abstract concept, but as one which can be quantitatively recorded and described. This study further shows that schemas have a positive impact on learning effectiveness. However, there are some limitations in the present study. Although this study focuses on the saturation of the sample, it may be more convincing if the sample size is increased. Furthermore, the schema research of this study emphasizes the issue of learning Chinese characters; however, future research should extend the study of schema establishment to other topics, such as mathematics, problem solving, and so on.

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