Chinese Character Composition Game for Collaborative Language Learning

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Abstract: This paper presents an innovation implementation of whether and how the use of a tabletop game combined with tangible cards help novice Chinese language learners to develop Chinese orthographic knowledge and collaborative learning skill. A positive relation between children's orthographic awareness and character recognition has been widely acknowledged. Collaboration is a commonly used game design element and a frequently targeted game design element regarding 21st century skill development. Nevertheless, little is known regarding how games should be designed for collaborative Chinese character or vocabulary learning, and how game design may influence student collaborative learning skill development. The results of a quasi-experiment in a primary school indicate that the designed ARC (augmented reality-based Chinese character composition game) is an effective system for improving students' Chinese character learning performance and collaborative learning quality. The findings provide insights into game-based learning design for young learners and language learners.

Keywords: Game-based language learning; Chinese character learning; collaborative learning; Tangible interfaces

Introduction

Educational game or game-based learning refers to a learning environment where game content and game play help enhance knowledge creation and skills acquisition, and where game activities involve problem solving spaces and challenges that provide learners with a sense of achievement (Qian & Clark, 2016). There has been an increasing interest in effects of digital game-based learning in various domains (Cornillie et al., 2012; Godwin-Jones, 2014; Qian & Clark, 2016). Language learning is no exception. Contextual game-based language learning tends to positively influence language learning (Ericson et al., 2016; Lan, 2015; Wen, 2017). Yet there is a dearth of more empirical evidence concerning how to well design educational game integrating instructional or pedagogical strategies to support active learning (De Grove et al., 2012; Godwin-Jones, 2014).

This study introduces an augmented reality-based Chinese character composition game (ARC), which is designed for Chinese as a second language (L2) learners. It is designed by our research team in line with new Chinese language curriculum of Singapore (The first language in Singapore is English). The study is concerned with Chinese character learning, because Chinese character recognition is a major hurdle for non-native learners and beginning learners. Chinese, as a kind of logographic language, is distinctive from English and other alphabetic languages. The effectiveness of using technological tools on improving learning and teaching of Chinese character has been reported (Zhan & Cheng, 2014). The instantiation of technological use ranges from web-based reading tasks with glossing support to online personal vocabulary learning games or applications. Furthermore, collaboration is a commonly used game design element for engaging player in social interactions, and it is a frequently targeted game design element regarding 21st century skill development. However, little is known regarding how games should be designed for collaborative Chinese character or vocabulary learning, and how games may influence student collaborative learning skill development (Qian & Clark, 2016).

ARC is a tabletop game with tangible paper interfaces designed for enabling collaborative L2 learning in classrooms. It has been using in two Singapore primary schools for one year. In this paper, a quasi-experiment in one Singapore primary school will be presented to demonstrate the effect of the game play on Chinese character learning and collaborative learning. The study aims at not only contributing to the research literature in Chinese character teaching for L2 learners but also shedding light on game-based language learning design for young participants.

Related studies

Coupling physical and virtual objects in character learning

The interactive tabletop environment can provide interesting ways to represent learning content, and thus motivate learners to be engaged in language learning. Multimedia vocabulary learning environments can help

learners construct connections between the verbal and visual representational systems, resulting in an increase in vocabulary knowledge (Chen et al., 2013). Furthermore, interactive tabletops are designed for co-location, multiple user participation, integrating hands-on activates and enabling multiple modes of communication, and their benefits to education have been evidenced as well (Dillenbourg & Evans, 2011).

As for the interactive interface, various arguments have been put forward for why manipulatives (defined as physical objects that can be touched or moved by students to reinforce a concept) may support learning, for instance, providing an additional channel for conveying information, increasing flexibility, empowering students to process and organize information at their own pace, facilitating abstraction and improving memory through physical action (Manches et al., 2010). In the context of language teaching and learning, Corrales (2008) stated that the manipulative can provide opportunities for students to process and organize learning information on their own and at their own pace. Actually, in traditional language teaching, using foreign language flashcards and other manipulatives is a common method to make learning a foreign language fun and exciting. In this study, with the paper interface, the tabletop game not only uses paper as a document with digital capabilities for augmenting its content, but also keeps paper's intrinsic properties, e.g., tangibility, maneuverability, and flexibility (Prieto et al., 2014).

Character composition for character recognition

Though Chinese character learning is particularly challenging for beginning learners, characters are not random symbols without pattern and regularities. The structure of Chinese characters can be classified by a 3-layer hierarchy: character, component, and stroke. A character is basically constructed by strokes and their combination. Some components are Chinese characters by themselves and these characters are called simple characters or integral characters. Those composed of more than one component are called compound characters. The vast majority of Chinese characters (in the range of 80% to 90%) are compound characters, which are usually composed of a phonetic or semantic component (Shu & Anderson, 1999). Radicals are defined as the meaningful orthographic units that play semantic or phonetic roles in compound characters (Shen & Ke, 2007, p.99). Theoretically, a radical represents the sound of a character or a clue to the meaning of the character (Chen et al., 2013). Radicals have two major features: (1) habitual positions with characters, and (2) function of encoding phonetic information or semantic information of characters (Su & Kim, 2014).

A positive relation between Chinese children's orthographic awareness and character recognition has been widely acknowledged (Chen et al., 2013). Research also has shown that knowledge of radicals plays an important role in enhancing character learning achievement not only for young school children but also for adult L2 learners (e.g., Shen & Ke, 2007; Su & Kim, 2014). In Gobert et al.'s opinion (2001), it is based on the principle of chunking, in which a chunk refers to a collection of elements having a strong association with one another. Because of chunking, learners can utilize familiar character with a phonetic radical or semantic component to learn and memorize those characters with the identical component but they have not learned yet.

With restricted vocabulary, it may not be easy for beginning learners to realize the importance of character's radicals. Yet some studies have tested the beginning Chinese learners' sensitivity to the structures of Chinese characters. They found that the development of semantic radical awareness helped Chinese learners guess the meaning of unknown or unfamiliar characters and revise what has been learned while learning the new (Shen & Ke, 2007). The studies (Ke & Li, 2011; Su, 2010) suggest that the development of orthographic awareness could begin at the first year of study for non-native learners. Indeed, radical-derived character teaching, this instruction approach has become more and more popular in teaching Chinese children characters (Huang, 2008). The effectiveness of this approach was also evidenced by Zhao and Jiang (2002) in their study on investigating 124 non-native learners. It was found that Chinese language use, including summarizing characters with similar pronunciation, meaning or graphic features, appeared to be the most effective in character learning. The findings of Shen's study (2005) also suggested that systematically introducing radical knowledge to beginning learners can help make sound-shape-meaning connections and greatly facilitate character learning.

In language classrooms, it is sometimes the case that teachers explicitly deliver the radical knowledge to learners. Nevertheless, classroom pedagogy has gradually shifted from knowledge transmission to knowledge construction. Shen & He (2007) compared three types of encoding strategies used in character learning: rote memorization, student self-motivated elaboration, and teacher-guided elaboration. Her findings indicated that elaboration resulted in significantly better retention of sound and meaning of characters than rote memorization. Between student self-motivated elaboration and teacher-guided elaboration, retention of sound and meaning was significantly better with teacher-guided elaboration in study intervals of 20 minutes, but this advantage disappeared at 48 hours recall interval. In a recent study, Shen and Xu (2014) further provided empirical evidence to support the effectiveness of active learning in classroom vocabulary learning for beginning-level

Chinese L2 learners. In other words, student self-directed elaboration can be deemed as an effective approach to learning Chinese characters. Therefore, all the system-based games are designed in radical-derived character learning approach, and students are able to generate and record their own elaboration of the target characters with the support of the ARC system.

Chinese character composition game: ARC

In the radical-derived character learning approach, every ARC-based activity is designed to help the student recognize radicals, structures, and compound Chinese characters. A total of six sorts of activities is designed. They are (1) filling characters in a sentence; (2) classifying characters in a paragraph; (3) guessing the character to a raddle; (4) recognizing characters according to the picture; (5) character family; and (6) character connection. Meanwhile, three kinds of paper cards are prepared for students to complete these activities, including structure cards, radical cards, and component cards (see Figure 1). Based on the new Chinese language curriculum of Singapore, the designed ARC game covers approximately 50% compound Chinese characters and over 70% radicals that students need to recognize in primary 1 and primary 2.

To "augment" cards, near-field communication (NFC) readers are used in our system. Like RFID, NFC has advantages of cost-effectiveness and stability of data communication. Every single card is attached to an NFC tag. With this technology, when many cards are on the table at the same time, card information will not be read without mutual interference. Once students tape a card on the NFC reader, its related information will be identified and represented on the iPad screen immediately. In the ARC classroom, students are divided into small groups to play the game together. They are encouraged to exchange cards to complete the activity collaboratively. On the basis of the literature, we assume that students will communicate and exchange ideas a lot with one another. Thus, they would have a good understanding of the target character.

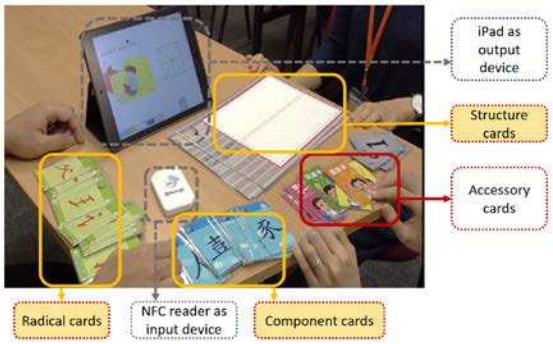

Figure 1. ARC setting within a small group

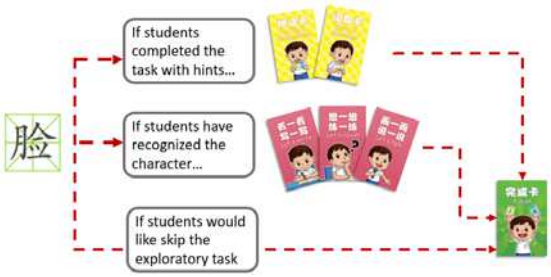

Figure 2. Self-directed work pace

The activity "filling characters in a sentence", as an example, in this activity a sentence and its corresponding picture are displayed on iPad screen to provide students the contextual information of the target character. Within a group, students need to discuss the missing Chinese character. After making a consensus, they pick up the structure card for the Chinese character first, and then selected its corresponding radical and compound sequentially. During this entire process, whenever the group cannot make a decision or have no idea about how to continue, they can seek help from the system using the hint card.

After the target Chinese character having been constructed successfully, the group members can use accessory cards to select the exploratory task that they would like to follow. As shown in Figure 3, if a group of students with low language proficiency, they can use the "Pin Yin" card or the "Word & sentence" card to get how the character should be pronounced, or how the character could be used in a concrete scenario. Whilst for a group of students with high language proficiency, they can select those pink color cards to generate their own group artifacts related to the target Chinese character. The card "Let talk", for example, can be used, when students would like to draw a picture of scenario and verbally make a relevant sentence with the given Chinese character.

Research design

A quasi-experimental design was adopted in this study to examine the affordances of the ARC system and their effects on students' learning performance and competency of collaborative learning. Multiple data sources were triangulated, and the combination of the quantitative and qualitative analysis was used to analyze them.

The participants of this study were grade one students (aged between 7 to 8 years) from a neighborhood primary school in Singapore. Forty-nine students from two classes were involved in our study. During the experimental period, these two classes were taught by the same teacher, Mr A. He is a tech-savvy. He was a computer science engineer, and then came to teach in this school 3 years ago. Both classes received an equivalent amount of instructional time and participated in the similar activities, but the experimental class used ARC game system (N=24), and the control class did not (N=25).

The ARC game designed for primary 1 consists of 4 sections. To keep consistent with school syllabus, our school-based intervention spanned approximately five months, from April 2017 to September 2017. The intervention procedure related to the two classes is detailed in Figure 3. At the beginning, all the students spent 10 minutes to complete a pre-test for testing their Chinese orthographic knowledge. One technical training session (20 minutes) was conducted by our researchers to the experimental class. In the experimental period, each class received an equivalent amount of instructional time and participated in the similar activity design. In both classroom environments, on the basis of the students' language proficiency, 3 to 4 students were heterogeneously grouped by the teacher and sat together. After the intervention, a 10-minute post-test was delivered to all the participants. Considering the age of students, we conducted a focus group discussion rather than a survey for all the students. Four students per class were randomly selected to participate in the focus group discussion to share with us their attitudes towards playfulness, collaboration, and the game design (20 mins per group).

Additionally, a one-hour professional development session was conducted to Mr A before ARC lesson, to help him being familiar with the system and its design principles. Semi-structured post-interview was administered to get his reflections on teaching and feedback about using ARC.

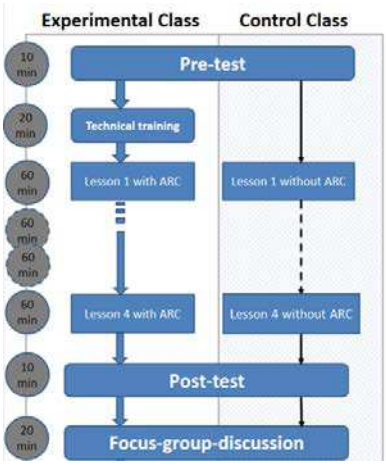

Figure 3. Procedure of class intervention

Data sources and analysis

Data in relation to the learning outcome and processes were collected and triangulated to examine the ARC affordances and effects. Concentrating on the learning outcome, pre-test and post-test were designed to measure students' Chinese orthographic knowledge. A positive relation between children's orthographic awareness and Chinese character recognition has been widely acknowledged (Chen et al., 2013). The tests were developed by our research team, referencing a series of tests created by Hung and Fang (2006) and the test created by Chen et al. (2013). We modified the original tests by considering local students' Chinese language proficiency, and the tests were validated by one primary school master teacher. A total of 40 questions were included in the test with a total score of 40. Gain analysis was used to examine students' learning performance.

To collect learning process data, during each class, a video-camera was set up at the back of the classroom to record the class process. Meanwhile, two other video cameras were set to record two small groups in each class. The video data of face-to-face group interactions were the main data sources for this study. The video data-based analysis of this study consists of two steps. First, we analyzed and assessed small group collaboration by the rubric developed by Meier et al. (2007). They proposed 9 dimensions to capture the main characteristics of collaboration, and each dimension was rated on a 5-point scale (1=lowest; 5=highest) and the sum of these formed the final collaboration score of each group. In our coding, however, we only included 8 dimensions and excluded the dimension of technical coordination, since it was not suitable for assessing the quality of collaborative processes happened in the control class. Two trained researchers assessed the recorded

data using the rubric for a total of 7 lessons in both the experimental and control classes. The first lesson of the control class was not included because the class grouping had a change after the first lesson. The inter-rater reliability of Cronbach's Alpha was 0.89.

Second, the data about small group interactions were transcribed verbatim and coded in terms of the concept of collaborative dialogue and the analytical unit of language related episodes (LREs). Collaborative dialogue was proposed by Swain (Swain & Lapkin, 1998; Swain & Deters, 2007) to investigate the act of producing spoken/written language that is the key to students' understanding of complex linguistic concepts/knowledge. In this study, we described the occurrence of LREs when L2 learners were participated in group activities, in order to examine students' language learning process in both classes. The qualitative analysis of the video data and field notes helped to explain when the interactions took place or why they did not happen. To make sure the reliability of the data analysis, during the entire coding process, two experienced researchers examined the data, completed the coding independently, and then collaborated and built a consensus on their coding. To make sure the reliability of the data analysis, during the entire coding process, two experienced researchers examined the data, completed the coding independently, and then collaborated and built a consensus on their coding.

Results

Language learning outcome

The learning gain per student was computed by subtracting the post-test score by the pre-test score. Results showed that Mr. A's ARC class students gained mean=8.61 (n=23, SD=5.92) scores from the learning while the control class student gained mean=-5.43 (n=22, SD=4.12). The independent t-test revealed that the ARC class students made significant improvement compared with the control class students ($t=9.19$, $p<.01$). The learning gain of the control class showed negative. This might be caused by the inconsistency of difficulty level of the tests. The pre-test was designed with low difficulty level because it was for students who had just attended primary school. The overall results indicated that students learned Chinese characters with the ARC game made an obvious improvement in orthographic knowledge and awareness.

Collaborative learning process

The histograms in Figure 4 show the mean score of the quality of collaborative learning of each dimension for the two classes. They indicated that groups in the ARC class outperformed than in the control class in most dimensions. Regarding the score of the dimension of time management, however, groups in the control class performed better than in the ARC class. In our class observation, sometimes students in the ARC class spent too much time on the tasks they interested in, especially those exploratory tasks that required students to generate their own group artifacts. We designed the ARC game to provide students with sufficient autonomy that every single group could learn at own pace. Nevertheless, we also noticed that the time management competency of the students at this young age was still weak, let alone in the game-based environment.

No difference was found between the two classes in the score of task division. Based on the class observation, we reasoned that it might be because the problems provided to students were not complicated enough, so they did not have to divide the task to subtasks. Yet it is worth noticing that students in the ARC class did better than the control class in the dimensions of *sustainable mutual understanding*, *dialogue/action management*, *research consensus*, and *reciprocal interaction*.

Taking time into consideration, we aggregated the numerical scores of all 8 dimensions to obtain a single score to each lesson and displayed them in Figure 5. At the beginning of the intervention, there was no much difference between the two classes. Then the quality of collaborative learning of the ARC class constantly improved. As we observed, with the paper interface, all the students had an equal opportunity to participate, so they were actively engaged. Hence, compared with the control class, the game playing in the ARC class was less dominated by one or two students whose language proficiency were comparatively high. At the first ARC lesson, we observed many students scrambled for playing the game. They continually tapped the cards without discussion, but soon students realized that this way of playing affected their group's leader board ranking. Students at this age were particularly concerned about badge displayed in games. In the following ARC lessons, we observed that they learned to discuss with others before using the cards. More dialogues about action management could be observed in the ARC class. However, the change in the control class was not obvious.

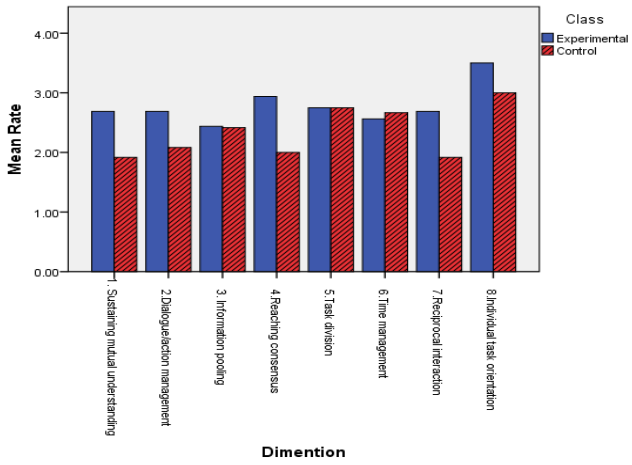

Figure 4. The comparison of the score in each dimension between the two classes

Figure 5. The quality of collaborative learning in each lesson

The score retrogression of the control class in the last lesson might be caused by the type of game design. In the control class, students did the tasks without the hints or immediate feedback provided by the system, and thus most often they needed to seek help from the textbook or their teacher when got stuck. The activity of the last lesson was about word puzzle that was difficult to find hints from the textbook, so students in the control class were less engaged in this activity. On the contrary, with the hints and contextual animation simulation, students in the ARC class were well engaged.

Besides, though an obvious increment of the collaborative learning score was detected in the ARC class, we had to point out that there was still room for improvement in students' collaborative learning (see Figure 5). Even at the end, the aggregated score of all the dimensions was only 25.75, which was about 64% of the full score 40. Except for the factors of age and activity design, the characteristics of L2 learning might affect students' collaborative learning performance as well. As shown in the video data, even though the majority of students in the ARC class were consistently engaged in the activity, not much collaborative dialogue (LREs) took place without teachers' intervention.

Language-related episodes

The time of each lesson of both the ARC and control classes was approximately 60 minutes. As shown in Table 1, in the ARC class, the average time the teacher provided for student group work was about 44.0 minutes (SD=1.99). Less time of activities was provided for students in the control class and more deviation among the lessons was found (mean=33.94, SD=2.39). According to our classroom observation, the teacher spent less time on introducing the rules of the activities and it was easier for him to provide feedback to students' work at the class level in the ARC class.

The average number of LREs observed in the ARC class was 5.38 (SD=1.41), and it was 2.50 (SD=1.05) in the control class. Though LREs happened more frequently in the ARC class than the control class, generally speaking, they did not happen frequently during group work process. In other words, even though the ARC game was designed for collaborative learning, the context of L2 Chinese character learning, students talked little about the language they were producing, they seldom questioned their language use or corrected themselves or others. The LREs in the ARC class were more observed when students were selecting radical cards or were generating own group artifacts, for example, in the process of writing the target Chinese character or making oral sentences. An increasing number of the LREs could be found when students were choosing radical cards to compose characters. It suggested that the students became more aware of their physical actions with the manipulatives. Nevertheless, the result was unexpected that the LRE seldom took place when students looking at the pictures or animations providing contextual information about the target character.

Table 1. Activity time distribution and LREs frequency

Class	Activity Time				Group	LREs Frequency			
	L1	L2	L3	L4		L1	L2	L3	L4
Experimental	41.14	44:35	45:55	45:14	A	5	6	5	7
					B	3	4	4	5

Control		36.59	32:05	33:19	C		3	3	4
					D		1	2	2

Discussion and conclusion

This study demonstrated an innovation implementation of the use of a tabletop game combined with tangible cards helped novice Chinese language learners to develop Chinese orthographic knowledge and collaborative learning skill. Pedagogically, this study suggested an effective approach to improving L2 learners' Chinese orthographic knowledge. It provided empirical evidence to support the views of many scholars in the field of game-based language learning, that interactive multimedia and multimode can help to create a contextual learning environment, which can effectively help learners construct knowledge.

Regarding the game-based learning design for young learners and language learners, the results of the study revealed that the tangible interface, together with the badge mechanism, helped to increase the quality of group collaboration. They helped to trigger more coordination during the game play. The use of the tangible cards enabled natural interactions and potentially allowed young students to engage with educational content and collaboration.

From our results, however, it also appeared that in the context of L2 learning, not many in-situ language-related problem solving or discussion emerged in language use. Our initial assumption was that the more language-related discussion or language use would take place when students could collaborate well to complete a task. Yet it was only observed that more LREs regarding the semantic meaning of the radicals emerged in composing Chinese characters. It suggested that students learned to evaluate the radicals selected and thought about ways to compose characters. It revealed that the students were able to reflect on their actions of manipulatives, but they seldom spontaneously discussed the meaning or the context in which the target character could be used. The students showed more concentration on whether the character was correctly composed or not. After that, they paid little attention to the feedback information provided by the game, such as the multimedia contextual information about how to the generated character could be used. Therefore, the future game design could pay more attention to scaffolds that may problematize the subject matter by causing students to pay more attention to critical ideas and connection between new contextual information and existing knowledge of the Chinese character. The type of problematizing scaffold may create opportunities for deeper processing and more productive learning (Reiser, 2004).

As for the limitation of the study, the qualitative rating scheme was used to generate a quantitative manure, but it still had the limitation of requiring human judgment. The findings were drawn based on the ARC implementation in a primary one class. Further multiple studies and relevant work will be planned and conducted in the collaborative schools. As the data gets richer, the following studies will further explore the correlation between students' system-based learning trajectories and their learning outcomes, and place more emphasis on investigating how the manipulatives could be designed and used to encourage students to reflect on their experiences in the game play. The findings will have a broad range of possible implementations for gamed-based L2 learning, beyond Chinese character learning.

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