Chinese Character Composition Game with the Augment Paper

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ABSTRACT

This paper discusses the design of a digital Chinese character composition game with the paper-interface named as ARC (Augmented Reality-based Chinese Characters) and its implementation in a Singapore primary school. The ARC game is designed to help beginning Chinese as second language (L2) learners to develop Chinese orthographic knowledge and improve quality of collaboration. Underlying sociocultural perspectives of learning, it seeks to enable learners to complete the game collaboratively in classrooms, and in this process to build a deep understanding of linguistic knowledge in solving in-situ language-related problems that emerge in language use. The results of a quasi-experiment indicate that ARC is an effective system for improving Chinese character learning performance and collaborative learning quality. It suggests that the augmented paper, enabling natural interactions, allow more and potentially young students to engage with educational content and collaboration. The problematizing scaffold should be embedded in the game design to elicit more opportunities for collaborative dialogue.

Keywords

Game-based language learning, Chinese character learning, Second language learning, Collaborative learning, Tangible interfaces

Introduction

With the development of technology and the evolution of new generation literacy, trends in educational research indicate an increasing interest in effects of digital game-based learning in various domains (Cornillie, Thorne, & Desmet, 2012; Godwin-Jones, 2014; Qian & Clark, 2016). Language learning is no exception. Contextual game-based language learning tends to positively influence language learning (Lan, 2015). Yet there is a dearth of more empirical evidence concerning how to well design the educational game to support active learning. Moreover, some researchers point out possible negative effects of digital games on learning. For example, students or players are distracted by the lavish entertainment factor and pay little attention to learning content (Kim, Park, & Baek, 2009). It is therefore highlighted the necessity of integrating instructional or pedagogical strategies into the educational game design (Hwang, Hsu, Lai, & Hsueh, 2017; Kim et al., 2009). Curriculum fit, readiness of teachers and students, and appropriateness of content should be taken into account when designers develop a game for specific educational purpose or bring digital games into the classroom (De Grove, Bourgonjon, & Van Looy, 2012; Godwin-Jones, 2014).

This study introduces a Chinese character composition game for second language (L2) learning called ARC (Augmented Reality-based Chinese Characters). It is designed by our research team in line with new Chinese language curriculum for Singapore primary 1 and 2 students. It is concerned with Chinese character learning for Chinese character recognition is a major hurdle for non-native learners. Chinese, as a kind of logographic language, is distinctive from English and other alphabetic languages. In Chinese, distinguishable types of strokes combine in different ways to form components (some of them are radicals) that are the fundamental elements to construct characters. Innovations in language education have been targeted towards ways of enhancing learners' structural understanding of the logographic system beyond rote learning and mechanical practice (Lam et al., 2001). 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. Meanwhile, collaboration is a commonly used game design element for engaging player in social interactions, and it is also 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 designed as a table-top game with tangible paper interfaces for enabling collaborative L2 learning in classrooms.

The ARC system has been using in two primary schools in Singapore over five months. In this paper, we will first introduce the theoretical and pedagogical foundations of the game design and installation. After that, a quasi-experiment conducted in one primary school will be presented to demonstrate the effect of the gameplay 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.

Theoretical underpinnings and practical approaches

Contextual game-based language learning

Educational game or game-based learning refers to a learning environment where game content and gameplay 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). Many advantages of the educational game have been evidenced in empirical studies (e.g., Hwang, Shih, Ma, Shadiev, & Chen, 2016; Yang, Quadir, & Chen, 2015; Zheng, Wagner, Young, & Brewer, 2009). Compared with traditional instruction, the educational game can help offer more engaging learning environments. (Barab et al., 2009; Steinkuehler, 2006). The level of students' participation increases in such a learning environment for it makes learning fun and relaxing, and it, in turn, increases students' learning outcomes (Erhel & Jamet, 2013; Sandberg et al., 2014).

From the sociocultural views of learning, language learning is viewed as a semiotic process attributable to participation in social activities, rather than internal mental processes solely by the individual (Lantolf & Thorne, 2006). Digital game environments can help provide rich and vivid contexts, which extend the traditional classroom, help students realize the importance of learning content by connecting it to real scenarios, and encourage more communication and meaningful interactions (Hwang, Chiu, & Chen, 2015; Thorne, Black, & Sykes, 2009). 3D virtual context, for example, has been evidenced to be beneficial for students' foreign language learning as it immerses students in a brand-new world to use the target language with less anxiety and frustration (Lan, 2015). The portability of mobile devices and the popularisation of augmented reality (AR) technology also have been proposed to bring students compelling language learning experiences, by creating a stronger connection between the digital content and the real contextual environment (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014).

Augmented paper for language learning

AR as one kind of technologies that combine or supplement real-world objects with virtual objects has been widely developed for education (Bacca et al., 2014; Cuendet et al., 2013). Bacca et al. (2014) summarized in their review paper that research on AR has demonstrated its advantages for increasing students' motivation, learning gains, interaction, and collaboration. AR is used in language learning because of the possibility of combining augmented information with contextual information to provide new experiences in language learning. Over the years, an increasing number of studies has been published suggesting possible mode for integrating AR techniques in subject learning (e.g., Bujak et al., 2013; Wang, 2017), and the use of this technique in classrooms is on the rise (e.g., Wojciechowski & Cellary, 2013). However, the possibilities that AR can benefit to learning remain to be discovered. Its effect depends on what we can imagine and devise as pedagogical applications (Cabero & Barroso, 2016).

This study focuses on the augmented paper-based Chinese character learning. The paper interface is emphasized because the paper-based tabletop not only uses paper as a document with digital capabilities for augmenting its content but also keeps paper's intrinsic properties, e.g., tangibility, manoeuvrability, and flexibility (Prieto et al., 2014). 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, they provide an additional channel for conveying information, increase flexibility, empower students to process and organize information at their own pace, facilitate abstraction and improve memory through physical action (Manches et al., 2010; McNeil & Jarvin, 2007). On this basis, Bujak et al. (2013) further elaborated that augmented objects can offer immediate kinaesthetic feedback, while virtual objects include additional information built right into them, and in this way to help memory encoding.

Collaborative language learning

ARC is designed for enabling collaborative learning in classrooms. Vygotsky's sociocultural theory implies that collaborative learning provides the foundation upon which all learning is built (Stahl, Koschmann, & Suthers, 2015). Analyzing and modelling interaction by which learning takes place are essentially emphasized in collaborative learning research. In collaborative language learning, however, language is not only the learning content but also the learning medium. Therefore, this makes it challenging to analyze how a group of students engage in thinking together about a problem or task, how they produce knowledge artifacts (e.g., in verbal,

textual, or graphic form) that integrate their different perspectives on the topic, and how they represent the shared group products that they have negotiated and made a consensus to construct. This may be the reason why many studies on pair/group work in language classrooms are focused on examining learners' attitudes to pair/group work in general, rather than exploring the nature of the collaboration process or the role of technology when students participate in a jointly intellectual activity (Wen, Looi & Chen, 2015; Storch, 2005; Shehadeh, 2011).

In this study, the concept of collaborative dialogue is adopted to help examining the effect of collaborative language learning process. Swain (2000) argued that not all dialogue was equally conducive to cognitive and linguistic development. Collaborative dialogue emerged from learners' interactions when learners were engaged in a problem-solving activity as the kind of interaction that could potentially lead to the co-construction of linguistic knowledge (Gutiérrez, 2008). In Swain's words, "collaborative dialogue is where language use and language learning can co-occur. It is language use mediating language learning. It is cognitive activity and social activity" (2000, p. 97). Together with the concept of collaborative dialogue, language related episodes (LREs) were postulated as a unit of analysis for investigating learner-learner interaction. LREs referred to any part of a conversation where language learners "talk about the language they are producing, question their language, use, or correct themselves or others" (Swain and Lapkin, 1998, p. 326). It has been extensively used as unit of analysis for investigating language learner-learner interactions in which L2 learners used language to shape linguistic knowledge by talking about, questioning, or reflecting on the linguistic properties of the target language (e.g., Dobao, 2012; McDonough & Sunitham, 2009; Swain & Deters, 2007; Wen et al., 2015).

Chinese character composition game: ARC

Undergirded by the belief in the merits of contextual learning in L2 and augmented paper for learning, ARC game was designed to provide multimedia and multimodal contexts for L2 learning and, it was designed for collaborative learning to create authentic contexts for L2 use. Concerning specific Chinese character learning strategies, the radical-derived Chinese character learning approach was adopted to guide all the system-based activity design.

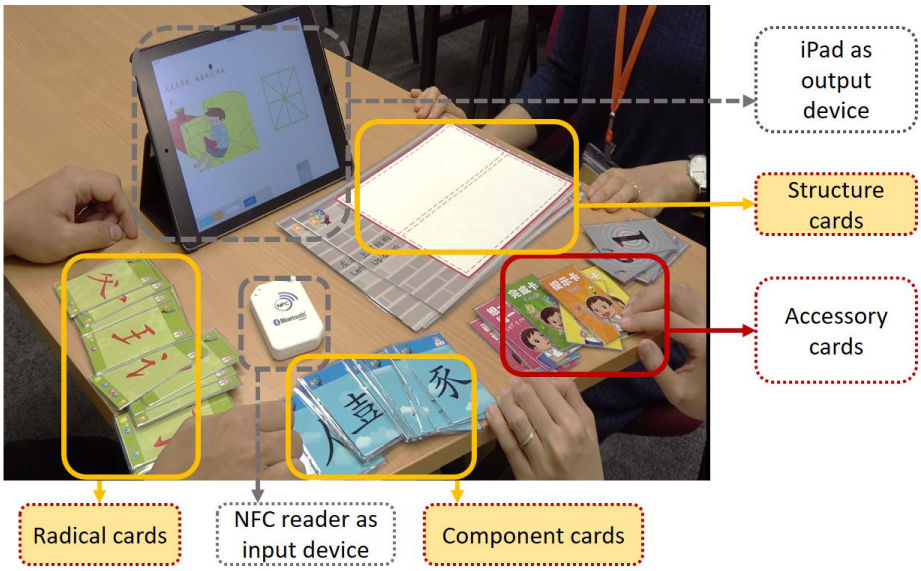


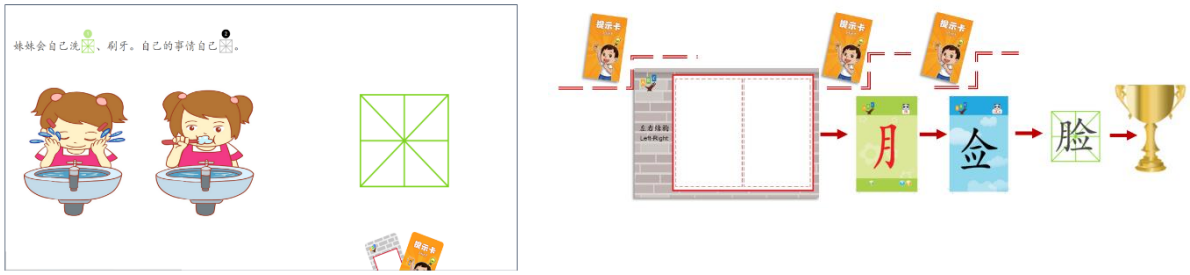
Figure 1. ARC setting within a small group

Research has shown that knowledge of radicals plays a vital role in enhancing character learning achievement not only for young school children but also for adult L2 learners (e.g., Jiang & Cohen, 2012; Shen & Ke, 2007; Su & Kim, 2014; Taft & Chung, 1999; Wang, Liu, & Perfetti, 2004). With limited 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 (Huang, 2003; Shen & Ke, 2007; Wang, Perfetti, & Liu, 2003). Therefore, in the radical-derived character learning approach, every ARC-based activity was designed to help the student recognize radicals, structures and compound Chinese characters. A total of six sorts of activities

was designed, and three kinds of paper cards were prepared for students to complete these activities. They are 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 2.

To "augment" cards, near-field communication (NFC) readers were used in our system. Like RFID, NFC has advantages of cost-effectiveness and stability of data communication. Every single card was 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 an 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 2a shows one kind of the activities, "filling characters in a sentence," as an example. In such activity, a sentence and its corresponding picture are displayed on iPad screen to provide students with the contextual information of the target character. The typical workflow of the activity is shown in Figure 2b. 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.



(a) Task example (b) Activity workflow

Figure 2. An example of "filling characters in a sentence" and its activity workflow

After the target Chinese character having been constructed successfully, the group members can use accessory cards to select any exploratory task that they would like to follow (see Figure 3). We also prepare a card named as "Finish." With it, students of different groups can decide by themselves when to finish the current task and start the next character. In the first few lessons, we suggest that the teacher hold the finish card. In other word, students could not enter the next task without the teacher's permission. After students have some awareness of collaboration, they can keep the card by themselves.

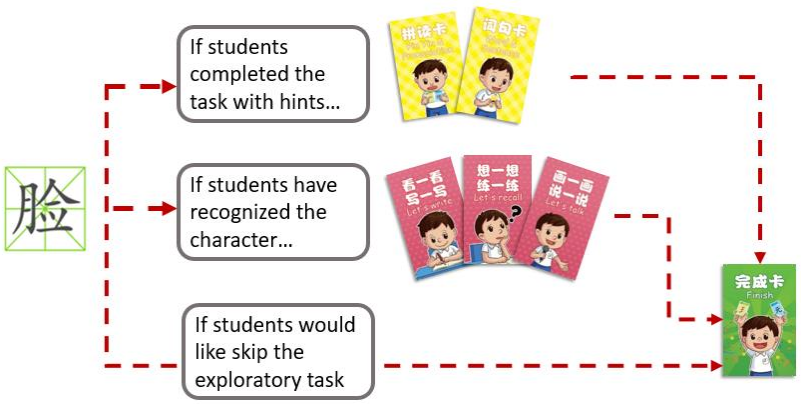
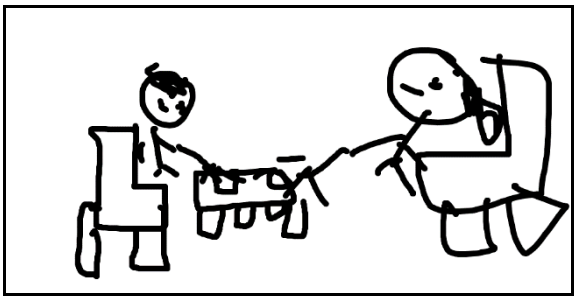


Figure 3. Self-directed work pace

Also, in Figure 3, if a group of students is uncertain about the pronunciation or the usage scenario of the character composed, they can use the "Pin Yin" card or the "Word & sentence" card to learn how the character should be pronounced, or how the character could be used in a concrete scenario. Whilst for those students familiar with the characters, they can autonomously choose one or more pink colour cards to generate their

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. Figure 4 demonstrates one group of students is working on the “Let talk” activity in the classroom.

(a) Group work scenario



(b) The generated group artifacts

Figure 4. A group working on an exploratory task

Research design

A quasi-experimental design was adopted in this study. Multiple data sources were collected and triangulated to examine the affordances of the ARC system and their effects on students’ learning.

Participants

The participants of this study were grade one students (aged between 7 to 8 years) from a government primary school in Singapore. Forty-nine students from two classes were involved in our study. The overall Chinese language proficiency of these two classes was not high. English was the family language for most students in the classes. During the experimental period, these two classes were taught by the same teacher, Mr A. who was a tech-savvy. He was a computer science engineer, and then came to teach in this school three 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).

Procedure and settings

This study is situated in an ongoing 2-year project about designing and developing the ARC game, and its implementation in primary schools. The ARC game is designed to help students to review the Chinese characters they learnt, and it includes four sections for primary 1. 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 5.

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, 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. We conducted a focus group discussion to get students’ feedback about the learning experience as well. 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. Besides, after each lesson, our research team had a quick post-lesson discussion with Mr A, exchanging ideas with him and improving the activity enactment in both classes.

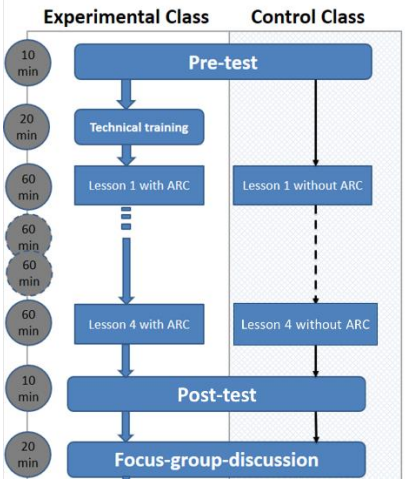


Figure 5. The procedure of class intervention

Data sources and analysis

Data about the learning outcome and processes were collected and triangulated to examine the ARC affordances and effects. All the data sources are listed in Table 1.

Table 1. Data sources

Purpose / Data sources	Language learning performance	Collaborative learning	Technological affordances
Pre-and post-test results	*		
Field notes	*	*	*
Videos and transcripts of group work	*	*	*
Students' focus group discussion	*	*	*
Teacher's post-interview	*	*	*

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, Allport, & Marshall, 1996; Chen et al., 2013; Jin, 2007). 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 the students' Chinese language proficiency, and the tests were validated by a primary school master teacher. Forty questions were included in the test with a total score of 40. The gain analysis was used to examine students' learning performance.

In 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 analysed 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 about technical coordination, since it was not suitable for assessing the quality of collaborative processes happened in the control class (see Appendix 1). Two trained researchers assessed the recorded data using the rubric for a total of 7 lessons in both the experimental and control classes (see Appendix 2). 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 *r* was 0.79.

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 LREs. We described the occurrence of LREs when L2 learners were participated in group activities 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.

Meanwhile, the focus group discussions and the teacher's post-interview were conducted to address how the participants perceived the learning and teaching experience using ARC and without using ARC. 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. The results showed that the ARC class students gained mean = 8.61 (n = 23, SD = 5.92) scores from the learning while the control class students gained mean = -5.43 (n = 22, SD = 4.12) (see Figure 6). 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 a low difficulty level as it was for students who just started primary school. The overall results indicated that students learnt Chinese characters with the ARC game made an obvious improvement in orthographic knowledge and awareness.

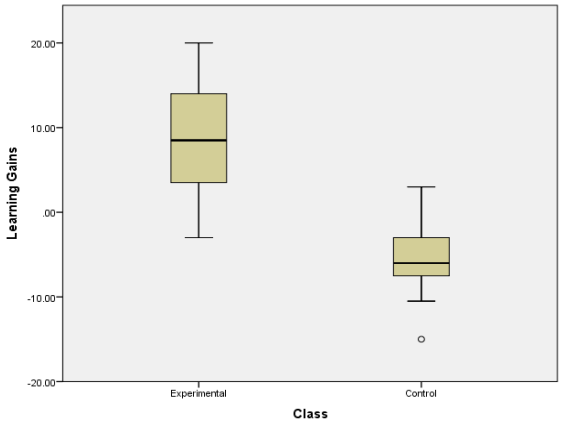


Figure 6. Learning gains

Collaborative learning process

The histograms in Figure 7 show the mean score of the quality of collaborative learning of each dimension for the ARC and control 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. According to the 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 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 observation, we reasoned that it might be due to the difficulty of the activity. Students were able to complete the task without splitting the task. Yet it was 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 8. 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, 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. Students continually tapped the cards without discussing with others, but soon they realized that this way of playing affected their group's leaderboard ranking.

Students at this age were particularly concerned about badge displayed in games. In the following ARC lessons, we observed that they began to learn to discuss with others before using the cards. More dialogues about action management could be observed in the ARC class. However, the change of interaction modes in the control class was not obvious.

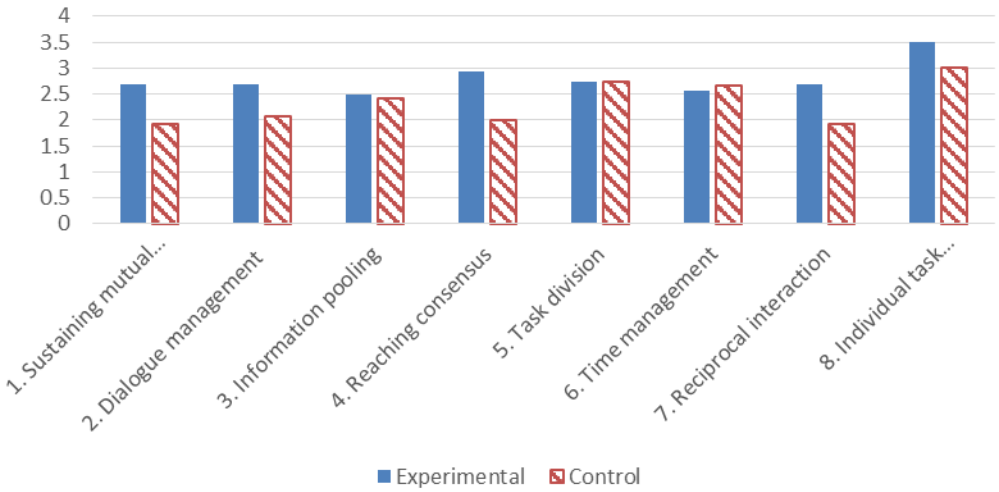


Figure 7. The comparison of the score in each dimension between the two classes

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 the teacher when they got stuck. The activity of the last lesson was about word puzzle, in which few hints could be found from the textbook. Maybe because of that, students in the control class were less engaged. On the contrary, with the hints and contextual animation simulation, students in the ARC class were well engaged in the word puzzle game.

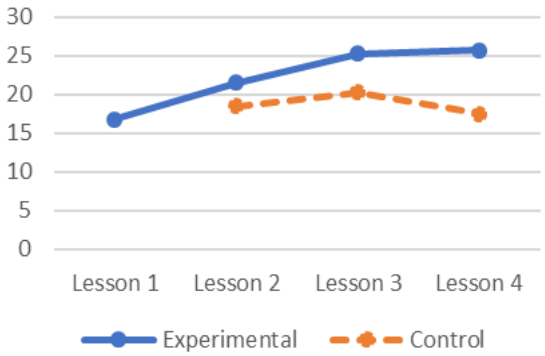


Figure 8. The quality of collaborative learning in each lesson

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 8). 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 a 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 2, 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 (*M* = 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.

Table 2. 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

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 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 generating own group artifacts, for instance, in the process of writing the target Chinese character or making oral sentences. An increasing number of the LREs could be observed when students were choosing radical cards to compose characters. It suggested that the students became more aware of their physical actions with the manipulatives.

Feedbacks from the teacher and students

All the students in the focus group said that they enjoyed playing the ARC game and learning Chinese language in this approach. Yet not everyone participated in the pen and paper-based activities felt satisfied. One of the reasons for dislike given by the students was that they were required to do too many works in the activities. Half of the students from the control class said they preferred to have a lecture rather than do the activities by themselves. One of the students from the control class, who preferred to do the activities, said we could play games in the class like this. In other words, without the feature of a digital game, the similar activity design per se was unable to attract students adequately. All the students played the ARC expressed that they liked the pictures and animations embedded in the game, and they believed that the multimedia could help them to understand tasks or texts. It was worth noting that all the interviewed students from the ARC class said they preferred playing with the paper-interface to using iPads directly. Yet constrained by their ages, these interviewees could not explain the reason behind it.

With regard to collaborative learning awareness, all the students from the ARC class expressed that they liked to play the game with group members together. Two students said in this way, they could get help from others when they had no idea about how to continue the game. On the contrary, all the students from the control class said they preferred to learning individually rather than in a group. One boy from the control class said that in the group activities, all other members learnt from him, but he learnt nothing from others.

In the post-interview, the teacher also provided us with quite positive feedback about the ARC game. According to him, ARC helped students to be more engaged in learning, and the adoption of the paper interface provided all the participant with an equal opportunity to join the game. He explained that he noticed some students who usually could not follow teacher's instruction in the traditional class, but still tried to play the game via picking up cards and trying them on the card reader. He highlighted that since ARC game could provide students timely feedback, it was easier for teachers to facilitate collaborative learning in the ARC class than in the non-ARC class. The teacher stated that though students at this age were not very good at group work, there were obvious improvements of the students' collaborative learning competency after the ARC game playing.

Discussion and conclusion

This study demonstrated a work in progress of how a Chinese character composition game with the paper-interface was designed and implemented in a primary school. The study not only substantiated AR potential as a carrier of educational content but also appropriated it to the pedagogical need of Chinese character learning. Though AR technology has been improving, more studies related to the development and usability of AR application are still needed (Akçayır & Akçayır, 2017). The study evidenced that the use of ARC was not difficult for young students and the tangible paper interface could help increase the game playfulness.

From the experimental results, it was evidenced that playing ARC game helped to improve Chinese orthographic knowledge and collaborative learning competency for L2 beginning learners. Regarding the quasi-experimental design, we needed to state that we looked forward the improvement of the control class as well since radical-driven strategy and active learning approach used in the control class had been proven to be effective (Shen & Xu, 2014). Meanwhile, we assumed that the teacher's user experience of ARC might also help him to enact collaborative learning activities in the control class. In the control classroom, however, even though the teacher enacted the activities smoothly and managed the classroom well, the students seemed to need a longer time to develop interaction awareness and cultivate collaboration culture. The effect of ARC on learning was examined through investigating the user's content knowledge improvement and collaborative learning development. These two aspects were taken into account as collaboration occurs when learners are involved with social interactions, which would result in improved learning capabilities (Lave & Wenger, 1991).

ARC experiences leveraged situated cognition, by allowing users to connect to the virtual educational content and communicating with peers using their own language. The results supported the views of many scholars in the field of game-based language learning, that interactive multimedia create contextual learning environments can effectively help language learners construct knowledge (Chen & Lin, 2016). Moreover, the empirical data suggested that augmented papers, enabling natural interactions, allowed more and potentially young students to engage with educational content and collaboration. The tangible interface, together with the badge mechanism, required more coordination during the game play and resulted in the improvement of collaboration.

The practical significance of this study was that it suggested an effective approach to improving L2 learners' Chinese orthographic knowledge. It contributed to existing studies on making use of technology to enhance contextual game-based L2 learning. It also extended this work to suggest that beyond representing contextual information, the appropriation of tools for collaborative learning can help promote language use context where users would build a deep understanding of linguistic knowledge. "Contextualized learning is learning that is directly connected to the real-world context in which it occurs" (Leighton & Crompton, 2017, p. 286). The game like ARC with augmented paper can help to engage students in interact with the surroundings around them and triggers more social interaction and communication.

Nevertheless, in the context of L2 learning, it also appeared that not many in-situ language-related problem solving or discussion emerged spontaneously in language use. In this study, it was only observed that a growing number of LREs regarding the semantic meaning of the radicals emerged in composing Chinese characters. It suggested that the students learnt to evaluate the radicals selected and thought about ways to compose characters. In other words, they were gradually able to reflect on their actions of manipulatives. Nevertheless, they seldom discussed the meaning or the context in which the target character could be used without the teacher's intervention. These 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, future game design needs to 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).

Some limitations of this study should be dealt with in the future. The qualitative rating scheme was used to generate a quantitative manure, but it still had the limitation of requiring human judgement. 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 language learning. Beyond simplified Chinese, the similar design can also be tested and implemented to traditional Chinese learning. Beyond Chinese character learning, the augmented paper can be adopted in more gamed design to convey contextual information and elicit social interactions.

Acknowledgements

This present research is supported by the Ministry of education, Singapore Ring-Fenced Fund (RFF). I would like to thank ARC team members Mei Wan Ng, Yee Au Su, Lucy Sim and Yanyan Wang who helped collecting and analysing data. I also would like to thank our collaborative school teachers.

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Appendix 1

Dimension	Elaboration	Examples in this study
1. Sustaining mutual understanding	Speakers make their contributions understandable for one another.	A: "Yah, this should be "拍". It is relevant to hands" B: "I know. I know it is radical '扌'." A: "Yes!"
2. Dialogue/action management	A smooth "flow" of communication is maintained in which little time is lost due to overlaps in speech or confusion about whose turn it is to talk or do the activity.	A: "Later I do the second, can?" B: "Can!" C: "Everybody can write."
3. Information pooling	Students try to gather as many solution-relevant pieces of information as possible.	Students work together to make a sentence using the target character.
4. Reaching consensus	Decisions for alternatives on the way to a solution after a critical discussion.	A: "We write with pens. It is a pen." B: "No. We are not eating with pens. It is not a pen." A: "Then what is it? Chopsticks?" B: "No lah, we don't write using Chopsticks. …" B: "Table! It is a table! We eat and write on a table. It is the Chinese character "桌"."
5. Task division	The task is divided into subtasks.	• "I draw the picture and then you say the sentence."
6. Time management	Students monitor the remaining time throughout their cooperation.	• "Hurry up! We just finished one character."
7. Reciprocal interaction	Students treat one another with respect and encourage one another to contribute their opinions and perspectives.	• "BH, do you want to write?" • "Do you want to play?"
8. Individual task orientation	Each student actively engages in finding a good solution to the problem, thus bringing his or her knowledge and skill to bear.	• Looking for clues in the textbook • Exploring answers with radical or component cards

Appendix 2

Researcher	Class	Lesson	Dimensions							
			1.Sustaining mutual understanding	2.Dialogue management	3.Information pooling	4.Reaching consensus	5.Task division	6.Time management	7.Reciprocal interaction	8.Individual task orientation
A	1	1	2	2	2	2	2	2	2	4
B	1	1	1.5	2	2	1.5	2	2	1.5	3
A	1	2	2.5	2.5	2	3	3	2	2.5	3.5
B	1	2	3	3	2	3	3	2	3	3
A	2	2	1.5	2	2.5	2	2	3	1.5	3
B	2	2	2	2	2.5	2	3	3	2	3
A	1	3	3.5	3	3	4	3	3	3.5	3
B	1	3	3	3	2.5	3.5	3	2.5	3	4
A	2	3	2	2	3	2	3	3	2	3.5
B	2	3	2	2.5	2.5	2	3	3	2	3
A	1	4	3	3	3.5	3	3	3.5	3	3.5
B	1	4	3	3	3	3.5	3	3.5	3	4
A	2	4	2	2	2	2	2.5	2	2	3
B	2	4	2	2	2	2	3	2	2	2.5