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Source	*Technology Pedagogy And Education, 25*(1), 61-77
Published by	Taylor & Francis (Routledge)

Citation: Wong, L. H., & Hsu, T. C. (2016). Effects of learning styles on learners collaborative patterns in a mobile-assisted Chinese character forming game based on flexible grouping approach. *Technology Pedagogy And Education, 25*(1), 61-77. http://dx.doi.org/10.1080/1475939X.2014.963661

Effects of Learning Styles on Learners Collaborative Patterns in a Mobile-Assisted Chinese Character Forming Game Based on Flexible Grouping Approach

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This paper reports a novel mobile-assisted game-based learning design for Chinese character learning. In playing the "Chinese-PP" game in a 1:1 (one-smartphone-per-student) setting, each of the 31 target students in Primary 3 (9-year-old) is assigned a Chinese character component. A student may make use of his/her own and peers' character components to form a legitimate Chinese character, and invite the peers with matching components to join his/her group. The intention is to assist the students in developing general orthographic awareness (understanding in the structures of Chinese characters) through social negotiation. In this paper, the students' collaborative learning processes in three game sessions were analysed. The relationships between students with varied learning styles and their game behaviours and learning gains were unveiled as a result. Through the Chinese-PP learning activities that stimulated active peer coaching and social learning, we found that all the target students became active learning participants and achieved high learning gains towards the last game session. Recommendations to the future development of such a novel learning approach will also be given.

Keywords: Collaborative learning, mobile learning, learning style, Chinese characters recognition, game-based learning

(final draft)

Citation: Wong, L.-H., & Hsu, C.-K. (2016). Effects of learning styles on learners' collaborative patterns in a mobile-assisted Chinese character forming game based on flexible grouping approach. *Technology, Pedagogy & Education, 25*(1), 61-77, DOI: DOI:10.1080/1475939X.2014.963661.

Background

Chinese Language has long been regarded as one of the most challenging languages to learn, where the logographic and component-based nature of Chinese characters pose a major difficulty, especially for students who are learning Chinese Language as a second language (L2) or as a foreign language (Shen, 2005). Hence, the main challenges facing learners who are learning Chinese Language is the component structure and spatial configuration of the Chinese characters (Shen, 2005; Wong, Chai, & Gao, 2011). The appearance of Chinese characters is generally characterised by a logographic ('square-boxed') structure. Most of the characters are formed by a combination of two or more components in this structure, with approximately 15 types of commonly used configurations (Zhang, 1987). One of the most commonly seen configuration is the "left-right" configuration where components are placed side by side to form a character (Example: 堆 or 吐). Many of the complicated Chinese characters are made up of several simple components, for example, the Chinese character "警" is made up of 4 components, "艹; 句; 父; 言". From the perspective of Chinese character learning, the component is a unit that lies between that of a basic stroke and a whole Chinese character. These components are the clues to decoding the Chinese language and are the functional orthographic unit to recognising Chinese characters (Chen, Allport, & Marshall, 1996; Shen, 2005). As theoretical research on character components is gradually mature, the concept of component-based learning has been more extensively applied in practice (Koda, 1996).

The objective of this study is design novel learning activities to foster orthographic awareness which includes understanding the ways which components can be combined to form

characters correctly, and also the commonly used structures in these formations. The moment the learners establish orthographic awareness of the Chinese characters, it is as if learners have activated the meta-cognitive process where Chinese character knowledge is internalised (Jiang, 2006). One example of orthographic rule of Chinese characters is “phonogram”. More than 90% of the existing Chinese characters belong to the phonogram category. Such a character is typically comprised of a phonetic component and a semantic component to hint its pronunciation and meaning respectively. For example, the phonogram character “抬” is pronounced as “tai”, same as the pronunciation of its phonetic component “台”; and means “to lift up”, relevant to its semantic component “扌” (which means “hand”).

In turn, we designed a mobile-assisted Chinese character forming game, namely, “Chinese-PP”. In playing the “Chinese-PP” game in a 1:1 (one-device-per-student) setting for Chinese character learning, each is assigned a character component on their smartphones. Students must attempt to use their own component and components of their peers to form correct Chinese characters, inviting these peers to form a small group. The student who invited others, known as the ‘leader’ hereafter, must negotiate with the ‘invitee’, and explain to the invitee on the proposed character in case it is unfamiliar to the latter, thereby convincing the invitee to join the group and score points. We refer to this novel game setting as “flexible grouping”, which means that students are not pre-assigned to groups. Instead, students form groups in a spontaneous, emergent manner, which is also of a transient nature. This leads to a higher degree of open-ended-ness and flexibility in the synergistic interactions of students and game process as students are not limited in pursuing standard answers determined by the teachers. According to our literature research, this form of

"flexible grouping" or other similar designs has yet to be seen in the earlier studies of the international academics arena.

31 Singapore Primary 3 (3rd grade, 9-year-old) students in a public school with Chinese as a second language standard participated in the pilot study of Chinese-PP. The students are typical Singapore children who are more well-versed in English, which is taught as a first language in their school. They were also enrolled the formal Chinese (as a second language) class in their school for two years and yet the amount of Chinese characters they had learnt and mastered were limited. Instead of drilling them in behaviourist character writing practices as they went through in the last two years, which was a cumbersome and ineffective way of character memorising approach, we decided to introduce Chinese-PP as a means of enacting component-based Chinese character learning to establish their orthographic knowledge (i.e., general knowledge on the structures of Chinese characters and individual components).

This paper focuses on using thorough quantitative and case studies to compare the roles that the students play in the Chinese-PP game according to the various learning styles of the students. In particular, through the use of post-tests and comparison of learning styles, we investigate which learning styles has resulted in more effective learning, and whether students of these particular learning styles played the role of a leader or invitee most of the time. Recommendations to the future development of mobile/game-based language learning on a flexible grouping approach will also be given.

Collaborative Learning

Despite the long-espoused benefits of peer-to-peer cooperation and collaboration within academic

contexts, there is still much to know about the nature and forms of effective collaborative learning from the perspective of the researcher and the practitioner (Alexander, 2013). Collaborative learning is generally learner-centred with an emphasis on proactive learning. Students are willing to commit to the learning goals of the team and encourage one another to pursue even higher levels of performance (Slavin, 1995). In a collaborative learning activity, the interaction among individuals influence the way the group is organised which further determines the outcome of the activities, with "social interdependence theory" as the reason and foundation towards such sociological learning (D. Johnson & Johnson, 2009, 2011).

Social interdependence exists when the outcomes of individuals are affected by their own and others' actions (Johnson & Johnson, 1989, 2005). There are three types of social interdependence: positive interdependence, no interdependence, and negative interdependence (Deutsch, 1949, 1962; Johnson & Johnson, 1989, 2005). First, positive interdependence (i.e., cooperation) exists when there is a positive correlation among individuals' goal attainments. Positive interdependence results in promotive interaction (i.e., individuals encouraging and facilitating each other's efforts to achieve the group's goals). One's actions may promote the success of others (Deutsch, 1949,1962; Johnson & Johnson, 1989).

Second, no interdependence (i.e., individualistic efforts) exists when there is no correlation among individuals' goal achievements. These individuals perceive that the achievement of their goals is unrelated to the goal achievement of others. One's actions may not have any effect at all on the success or failure of others (Deutsch, 1949, 1962; Johnson & Johnson, 1989). The students working by oneself to accomplish goals unrelated to the goals of others. There is no correlation

among participants' goal attainments. Each individual perceives that he or she can reach his or her goal, regardless of whether other individuals attain or do not attain their goals.

Third, negative interdependence results in oppositional interaction (i.e., individuals obstructing each other's efforts to achieve their goals). No interdependence results in no interaction. One's actions may obstruct the success of others (Deutsch, 1949, 1962; Johnson & Johnson, 1989). The students working against each other to achieve a goal that only one or a few can attain. Each individual perceives that when one person achieves his or her goal, all others with whom he or she is competitively linked fail to achieve their goals.

Positive interdependence tends to result in promotive interaction, while negative interdependence tends to result in oppositional or contrient interaction, and no interdependence results in an absence of interaction. As such, it is important to design collaborative learning activities in the way that every learner is aware that the only way to achieve an individual goal is to cooperate with their peers to achieve the group goal. Such positive interdependence drives group members to collaborate with one another and to encourage and help other group members learn (Janssen, Kirschner, Erkens, Kirschner, & Paas, 2010).

Learning Styles

Learning style refers to the learners' individual learning preference. Students of varied learning styles affect other students in terms of accepting external stimuli, receiving, memorising, thinking and problem solving. There have been studies since more than 30 years ago on the various types of learning styles (Coffield, Moseley, Hall, & Ecclestone, 2004) to facilitate the teachers' design of

curriculum activities, with the aim of catering to the needs of different students with varying types of learning styles. This has contributed to the potential development of technology-mediated and personalised learning. Academics feel that learning styles play an important role in the learning process (O'Keefe & Nadel, 1978) as learning styles describe how students learn in a teaching situation (Hunt, 1979).

The learning style is partly governed by the student's native ability, which is the way that a student prefers to accept and process the outside information. Several scholars systematically categorised the various learning methods of human beings and subsequently determined the learning styles of learners. Some examples are: Kolb learning style index; Felder-Silverman learning style index and VARK Questionnaire (Felder & Silverman, 1988; Fleming, 2001; Kolb, 1984) . Among the many learning style classification models, Felder & Silverman (1988)'s index of learning style is most commonly adopted. It consists of 44 questions, with one question each across the four dimensions "Active/Reflective", "Sensing/Intuitive", "Visual/Verbal", and "Sequential/Global" for 11 cycles. This study uses The Index of Learning Styles, ILS, by Soloman and Felder (2001) which was developed based on Felder and Silverman (1988) learning styles index (Hosford & Siders, 2010). The first two dimensions of the ILS are adopted as these sets of learning preferences are more relevant to the game playing behaviours and strategies for players of Chinese-PP. Other categorisations such as Keefe (1988) categorisation in cognitive, affective and psychological dimensions, and Riding and Rayner (1998) categorisation in cognitive styles and learning strategies are less pertinent to the research questions that our study intends to answer.

Specifically, Active-style learners prefer to be engaged in teamwork. Such learners learn new information well through actively discussing, applying, working together, and explaining to

other learners. Contrarily, Reflective learners absorb the new information better by independent working, thinking of the question, quietly studying. On the other hand, learners with Sensing or Intuitive learning styles perform better by leveraging learning materials with more examples than theories. Sensing-style learners understand better, if the new information can be connected to their past concrete experience and daily life. It is hard for Sensing style learner to understand the abstract concepts. Instead, Intuitive style learner has the ability to comprehend abstract materials; and they are more creative than sensing learner. They dislike learning materials that give away too many details.

The questionnaire only suggests behavioural tendencies rather than predicts the behaviour. The learning style preferences can be affected by both a learner's native desire and educational experiences. There are two principles of applying ILS (Felder & Spurlin, 2005). First, it helps instructor to identify how the class is consisted of students, and adapts different teaching strategy to properly teaching framework. Secondly, it helps students to understand what kind of learning style they are, and what kind of learning context can help themselves most. It is better for all that the students find their own way to study rather than give up the subject which they do not find interest (Felder & Henriques, 1995; Felder & Spurlin, 2005).

Learning Activity Design of Chinese-PP

31 Singapore Primary Three (9-year-old) students participated in the pilot study of Chinese-PP. We used the pre-test results (refer to the "Research Design" section) before the intervention to split the students into three ability bands. Students whose scores are among the lowest 27% (9 students) are deemed as low achievement (LA) students, whereas students with scores that are among the top

27% (11 students) are classified as high achievement (HA) students, and the remaining are considered as medium achievement students (MA) (13 students). Some HA students scored the same marks and hence resulted in a higher number of students in that group. All the students were then split into two "communities" heterogeneously with 15 students in Community 1 and 16 students in Community 2 (as the ideal total players of Chinese-PP is 15-20 [authors' prior publication]). The amounts of HA, MA and LA students in both communities were roughly the same. Each community underwent 30 minutes of Chinese-PP game with the teacher providing instantaneous feedback to the students.

The intervention was carried out in three 90-minute sessions. Each session comprised three segments – 20 minutes of pre-task activities, 60 minutes of main task activities and 10 minutes of post-task activities. First, pre-task (20 minutes) activities were carried out by the Chinese teacher as a warming up activity where students built or strengthened their prior knowledge and revised themes learnt previously before being introduced to new knowledge on character components (e.g., the phonogram structure) and how to make educated guess on the meaning and pronunciation from the components. The students then used their smartphones to carry out the Chinese-PP game to form words using a flexible grouping approach during the Main task (60 minutes) activities. Finally, the post-task activities (10 minutes) involving learning reflection and assessment were then carried out. The teacher guided the students to recall one Chinese character that was formed during the game and specifically related this back to the prior knowledge gained during the pre-task segment. The entire process is as shown in Figure 1.

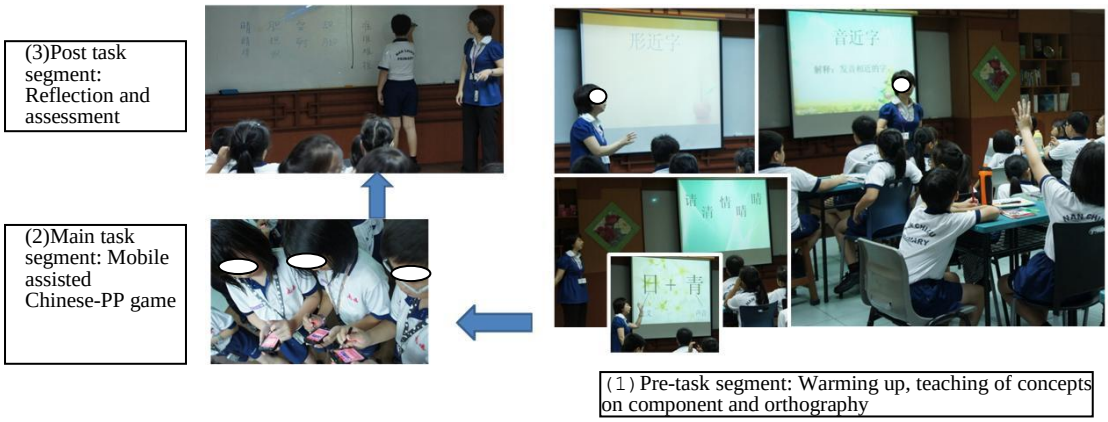

Figure 1: Chinese-PP game design flow chart

A projector screen and one laptop working as the teacher console in the classroom facilitated the projection of the teacher console management interface onto the screen during the main task activities. This was in addition to the required resources of 1:1 smartphones and 3G wireless Internet in the classroom. In every game round, the system first assigned Chinese character components to individual students' smartphone Chinese-PP interface. Students had knowledge of which components they and their peers were holding onto by referring to the interface. As presented in Figure 2(a) below, "My Character" showed that Student A was assigned the component "耳" and he pulled the component "又" into the word formation frame, with the intention of inviting student B who was holding on to component "又" to form the Chinese character "取", as demonstrated in Figure 2(b). The moment the invitation was sent by a student with a component or when he received a grouping invitation to form characters collaboratively, students will be able to see the individual groups from the "My Groups" interface as presented in figure 2(c). In addition to sending the invites through the system, leaders on most occasions, confirmed with the invitees that they were indeed joining the group through face- to- face consultation. Once student A and B both agreed that the character formed was correct (Figure 2c), the invitation will be accepted by Student B and the "confirmation" button was selected. The information will then be transmitted to the

teacher console. The teacher then provided feedback on the answers through the teacher console and awarded scores of 10 points to each student for each correct character formed by a pair of students (20 points each for a group of 3 students, 30 points each for a group of 4 students; where the larger the group of which a correct character was formed, the higher the points each student will score). The screen also reflected the accumulative scores of all students (figure 2d). In addition, the teacher gathered the students frequently to look at the characters formed by the students, asking them for the character pronunciation, and stimulating their thinking and providing appropriate hints to facilitate the continuation of the character formation. At the end of the first round of the game (approximately 10 to 15 minutes), the groups were disbanded. Students then proceeded to round 2 where the system assigned another batch of character components to the students.

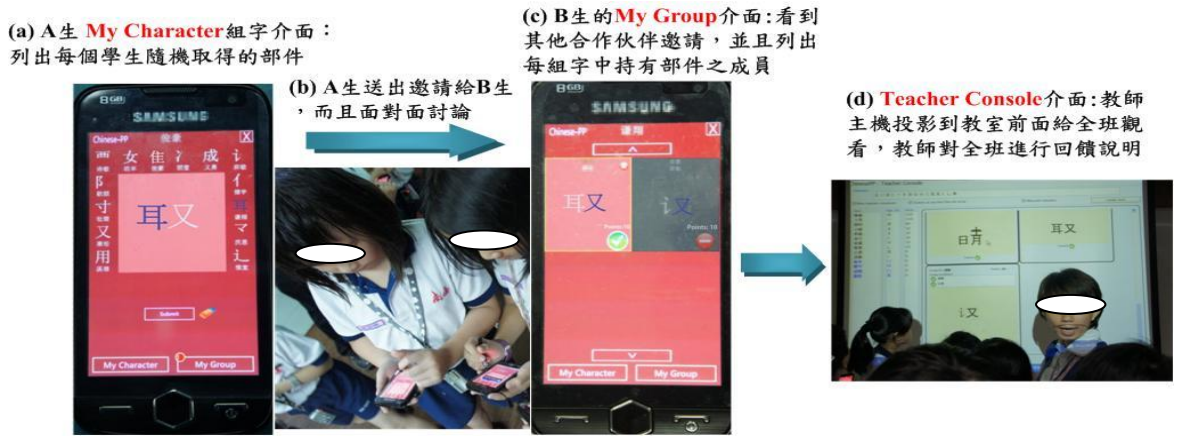

Figure 2 Mobile assisted Chinese-PP game interface

With the purpose of sorting out and describing the research findings systematically, we assigned terms and definitions according to the different characteristics and roles that the students played during the activity process. In the game community, a student who actively invites others to complete the Chinese-PP missions is known as “Leader”. A student who reactively accepts the invitation to complete the Chinese-PP missions is known as “Invitee”. Students are also classified

according to their habits of forming characters either in a guessing, risk-taking manner (termed as "Guess" students) or through a cautiously, ascertaining manner (termed as "Non-guess" students). In this study, "Guess" behaviours refer to students trying their luck in using components to form characters, guessing the pronunciation and sending out invitations even though they are uncertain about the legitimacy of such characters. However, that does not mean that these characters are formed out of plain fabrication. They often subconsciously use their prior orthographic knowledge or experience in character formation, for instance, the use of phonogram or other strategies such as guessing the pronunciation of the newly formed character using pronunciation of certain components they are already aware of. On the contrary, "Non-Guess" students often attempt to retrieve and recall the characters they had previously learnt when forming the characters, or seek consultation from their teacher or peers before sending out an invitation.

Research Design

We adopted the design-based research (DBR) method (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Design-Based Research Collective, 2003) and underwent two cycles of DBR. The first DBR cycle focused on the design, experiment, review and improvement of the game rules and system (Please refer to [authors' publication]). This publication covers the second cycle of DBR.

In the pre and post-test, students were assigned 20 components to form characters individually. They received 2 points for each legitimate character formed, 1 point for non-existing character but based on a correct orthographic rule, and 0 for non-existing character that is not based

on any rule. Also, we surveyed the students, making use of the two relevant dimensions of the ILS learning style questionnaire. Each dimension encompassed two different modalities of learning style which resulted in four different types of learning style altogether across these 2 adopted dimensions. The first and second dimensions reflected the “active/reflective” and “sensing/intuitive” learning styles respectively. Each dimension corresponded to 11 questionnaire questions which resulted in a total of 22 survey questions being used to determine which learning style the student belonged to.

In addition, we conducted post-intervention interviews with 6 students after the last game session in order to gain further insights on the mindsets of students with various learning styles in exhibiting their game behaviours that we figured out through the above-stated quantitative data. The 6 students were selected based on the maximum variation strategy, which were comprised of HA, MA and LA students with reflective, active, sensing and or intuitive learning styles. Both the quantitative and the qualitative interview data were then used to reconstruct several case studies which will be presented in a later section.

Our investigation is guided by the following research questions:

(1) Students of which learning style type resulted in better effective learning when playing the Chinese-PP game?

(2) What were the learning behaviours (leader or invitee, guessing or non-guessing) displayed by the students of various learning styles in different bands (high, medium or low achievement groups)?

Findings

Analysis on learning effectiveness

The Chinese-PP game emphasises the augmentation of students' related knowledge in orthographic awareness of the Chinese characters through social negotiation, stimulating higher-order thinking as well as timely and appropriate feedback from the teacher. Besides gathering the students frequently during the games to discuss the words formed, the teacher also carried out reflection and assessment during the post-task segments. Moreover, the teacher encouraged students to help their peers who were not able to form characters after a while by proactively providing guidance to them, or sending invites to them to form characters. In the early game rounds, the students habitually relied on and sought help from their teacher when they could not form characters. Students successively transformed from being passive learners to active learners after several rounds of activities and their active reaction and response time also shortened progressively. The 'learning-by-doing-and-peer-help' approach of the game replaced the conventional learning mode where teachers give away correct answers to the students. The increased interactions among peers during the Chinese-PP game had promoted the learning of Chinese character structures.

A paired samples t-test was conducted on the pre- and post-tests scores of 31 students who participated in this experiment. Results showed that the post test scores were significantly better than the pre-test scores ($t=-4.38;\ p<.05$). This proved that there was significant learning effectiveness after the students went through the Chinese-PP game. However, this is not the focus

of the research analysis. Rather, we want to analyse the relationship between the roles played by students of different learning styles and the learning effectiveness.

As such, an independent samples t-test was conducted on the accumulative game scores of students of different learning styles and the different social roles they played. As shown in Table 2, there was no significant difference (t=-0.6; p>.05) in the learning effectiveness between students of active and reflective learning styles. The learning effectiveness of sensing-style students was significantly better than intuitive-style students (t=2.70; p<.05). There were some characters in this experiment that the student had yet to learn at this phase. However, through student discussions and active guessing, they managed to speculate and form the correct characters (Example: "警"). The teacher acknowledged and provided feedback on these characters during the class; thus, the students achieved unexpected learning gains. On the other hand, there was no significant difference in learning effectiveness between students who were predominantly playing the "leader" and those in "invitee" role (t=1.23; p>.05). This indicates that through learning activities of this type that emphasised active peer consultation and mutual learning, all students can achieve progression equally on their learning paths, regardless of whether they were students who offered ideas or accepts ideas. The next section shall focus on further analysis of this finding.

Table 2. Comparison of learning effectiveness for different student cohorts

Information Source	Student cohort	n	mean	Standard Deviation	*t*-value
Learning Style	Active style	16	181.25	68.40	-0.60
	Reflective style	15	200.00	102.26	
	Sensing style	13	234.62	80.69	2.70*
	Intuitive style	18	158.33	75.63	
Game Role	Invitee	16	205.00	88.54	1.23
	Leader	13	167.69	71.32	

*$p<0.5$

Analysis on different learning styles and roles played in the game

We split the students into three different bands of HA, MA an LA according to the pre-test. We then found out what roles (leader or invitee) these groups of students played and the game strategies they deployed during the Chinese-PP game through studying the system logs. In addition, we split the students into Guess and Non-guess categories in the basis of the following evidences: (1) individual students' responses to the teacher's opportunistic questions during the game on whether they did recognise those Chinese characters or that they were formed through guessing; (2) students' self-reporting on their guess or non-guess behaviours through an additional item in the questionnaire.

Figure 3 shows the distribution of students' learning styles and the roles they played for HA, MA and LA bands of students. The code on the top left hand corner of each box represents the cluster in that box (A=Active style; R=Reflective style; S=Sensing style; T=Intuitive style; L=Played leader role most of the time; I=Played invitee role most of the time; G=frequently guess; N=non-guess; for example, "ASLG" refers to a type of student with an active/sensing style who played the role of leader most of the time and adopted the guessing approach on a frequent basis). There were 2 students who straddled between ATLN and ATIN and 1 student who straddled between RTLN and RTIN. This means that the number of times these students played the leader and invitee roles were similar in the games.

Through quantitative analysis, we discovered that among the students who frequently played the leader role, the proportion of intuitive- to sensing-style students is approximately 3:1 (i.e., 76.92% of the student are Intuitive); the proportion of reflective to active style students is

approximately 3:2 (Reflective students occupy 61.5%); the percentages of HA, MA and LA students are 61.5%, 30.8% and 7% respectively. Students of Intuitive style were creative and they went along with their experience or feelings to play this game (ATLN, RTLN) regardless of whether they were in the HA, MA or LA band. Only two LA students played the leader role. They were intuitive-style students who adopted the guessing approach, using their experience or prior knowledge on the structures of Chinese characters as a basis. Despite being LA students, they bravely shouldered the leader role and seldom played the invitee role. We therefore infer that the Sensing/Intuitive dimension is most highly related to whether individual students predominantly played the leader or the invitee role; while their prior knowledge is a secondary factor.

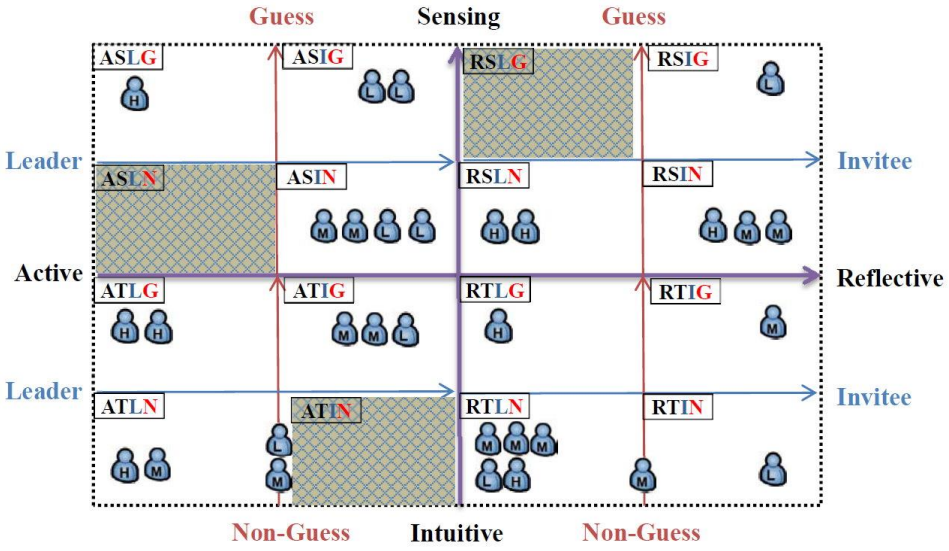

Figure 3 Distribution of roles played by students of various learning styles for all achievement groups

As for the impact of the degree of prior knowledge on the students during the game, we discovered that most of the invitees were not from the HA band. Only one HA student played the invitee role most of the time. He belonged to the reflective-sensing-invitee-'non-guess' group with a reflective-sensing learning style. 66.67% of the invitees belonged to the Sensing style groups. We therefore discovered that most of invitees in the Chinese-PP game were made up of sensing-style

students in MA and LA bands. In addition, our analysis shows that approximately 77.78% of reflective-style students adopted a more cautious (non-guess) approach in forming characters and did not take risks to guess new characters. On the contrary, 60% of the Non-guess students were of reflective style. We hence infer that reflective-style students are typically inclined to deliberate, discuss with their peers on the legitimacy of the character during the game. Furthermore, it is also noted that the proportion of leader to invitee was rather balanced for the reflective-style students.

Analysis of student behaviours during the game process

In this sub-section, we examine the variations of the students' collaborative dynamics in greater details. This is done through a consolidation of the following analyses: (1) the frequencies of the leader or invitee roles that students of different learning styles throughout the three game sessions; (2) the student interactions during the games as seen in the video and audio recordings. The results echo the findings presented in the earlier sub-sections. Several case studies on representative students are also presented here to elaborate the findings.

Table 3 summarises the number of invitations sent according to the records retrieved from the main game console. We discover that sensing-style students played the invitee role on a significantly higher frequency compared to intuitive-style students. There is no significant difference between active- and reflective-style students in playing either role; and neither in the case of sensing- versus intuitive-style students in playing the leader role.

Table 3. Analysis on Roles played for 2 Groups of students with different learning styles

Game role	Learning style	N	Mean of frequency	Standard deviation	*t*-test
Leader(L)	Active (A)	16	5.44	3.72	-.73
	Reflective (R)	15	6.33	3.02	

Game role	Learning style	N	Mean of frequency	Standard deviation	*t*-test
	Sensing (S)	13	6.62	3.15	1.05
	Intuitive (T)	18	5.33	3.51	
Invitee(I)	Active (A)	16	7.81	3.35	-1.18
	Reflective (R)	15	10.00	6.43	
	Sensing (S)	13	11.54	4.74	2.72*
	Intuitive (T)	18	6.94	4.57	

$^{*}p<.05$

Furthermore, triangulated by on-site observations, video recordings and system logs, we discovered the continuous changes in the switches of roles that the students played (leader or invitee) in the communities. A salient phenomenon is that with the flexible grouping approach, HA, MA and LA students were all engrossed in searching for the right partner(s) to form the correct character in order to score points. This defies the findings of most of the previous collaborative learning studies as the Chinese-PP activities were not just the stage for HA students to shine exclusively. Due to the fact that each student held a different component, even the LA students were much needed in this activity. This shows that the design of Chinese-PP would minimise the impact of the students' varying linguistic abilities to collaborate and to communicate on the outcome of collaborative learning, thus resulting in a natural collaborative way of working together while everyone was working towards the common personal goal of scoring high.

Next, a few typical student cases are given to delineate the trajectory of the dynamic transition in social interactions over the three game sessions as a result of the varied student behaviours.

Case 1 & 2: A comparison of students ID 3 and ID 30

Case 1: Student ID 3 (HA / ATLN - active-intuitive; predominantly leader type; non-guess)

Case 2: Student ID 30 (MA / ATIN – active-intuitive; predominantly invitee type; non-guess)

Student ID 3 of active-intuitive-leader-'non-guess' type predominantly played the leader role within

Community 2 throughout the three game sessions. This matches our general finding in previous section that intuitive-style students were frequent leaders in the games. In addition, he exercised a non-guess behaviour by always making sure that the character formed was indeed valid before sending it to the teacher's console. To illustrate, an excerpt of our post-interview with him is given below,

> Researcher: It seems that you know a lot of Chinese characters. You are frequently inviting friends as well. Do you think you are inviting friends more than being invited?
>
> Student ID 3: I'm not sure. Half-half?
>
> Researcher: Do you know all the characters that you composed and 'submitted' for invitation? If not, did you ask the teacher or your classmates?
>
> Student ID 3: I would discuss with my classmates first. If we were not sure, I would not submit it.

After further probing, we learned that Student ID 3 treated asking teacher as the last resort because the teacher once advised the class to seek help from classmates rather than always relying on the teacher. The advice was working as whenever he was not sure about the legitimacy of the character that she composed, he would always began with discussing with his classmates, thus reinforcing peer interactions and collaborative learning.

In many other occasions, this HA student was very sure about the characters that he composed and was able to make the connection with the orthographic knowledge that he learned during the pre-task phases. As he needed to obtain the other components, perhaps being held by the MA and LA students, he often introduced to his potential team members the form, pronunciation and meaning of the character that he intended to form. Whenever necessary, he further explained the general orthographic knowledge related to the Chinese character. This is the emergent peer guidance commonly found in the games, which obviously increase the ability and self-efficacy of

the MA and LA students in their game participation.

Two other active-intuitive-leader-'non-guess' students in HA band, student ID 10 and student ID 20 (both in Community 1), exhibited similar behaviours throughout the three game sessions.

On the contrary, albeit also a student of active-intuitive type, student ID 30 in Community 2 was far behind student ID 3 in the first game session for being a passive invitee throughout. This is perhaps due to her lack of self-efficacy (for being a MA student) in the beginning. Nevertheless, we observed an increase of her level of activeness in the second and third game sessions where she made two and five invitations respectively. Eventually, the accumulative number of times that she played the leader role and the invitee role was close (6 and 8 times respectively). In general, through the system logs, we discovered that there was an increasing trend in in the level of peer interactions among the students regardless of the respective levels of their prior knowledge. Of which, 100% of the MA students had made improvement in this aspect.

Case 3: ID27 (LA; RSIG – reflective-sensing; invitee-type; guess)

Student ID 27 in Community 1 was a typical student who liked to guess for potential characters. Albeit belonging to LA band, she participated in the game actively, patiently noting down and guessing all possible combinations of characters. Throughout the whole series of games, she seemed to comprehend the rules of the game well and appreciated the fun element of this game. Her leader-to-invitee record stands at 8:13 - while being categorised under the invitee-type, she braved herself in assuming the leader role frequently. She was not afraid to commit mistakes and consequently learned from the feedback the teacher and her peers.

Case 4: ID2 (LA; ASIN – active-sensing; invitee-type; [predominantly] non-guess)

Student ID 2 of Community 1 exhibited a relatively inconsistent pattern. She was less active in the first game session - only sent out one invitation and was invited once. She played the invitee role throughout the second game session. However, in the third game session, she became very active by inviting different students and accepting invitations from different peers. It was not only due to her faster actions, but more so of her courage to adopt the guessing approach eventually. She had the initial impression that she had to heavily rely on her peers as she was from the LA band. However, in the third and final game session, the number of times she invited others was the same as the occasions she played the invitee role (2 times each). To illustrate, an excerpt of the post-interview with her is given below,

> Researcher: Do you think you have recognised more Chinese words after playing Chinese-PP?
>
> Student ID 2: Yeah.
>
> Researcher: How did the game help you in recognising more words?
>
> Student ID 2: The teacher taught us how to assemble or replace components in Chinese words. So I learned more words.
>
> Researcher: So you felt that you benefited a lot from the teacher during the game. Didn't your classmates teach you as well?
>
> Student ID 2: Yeah, a bit.
>
> Researcher: So did you learn more from your teacher or your classmate?
>
> Student ID 2: I was asking my classmates more. After I composed a word, I might first asking the teacher. She only told me the word was wrong. Then I proceeded to ask my classmates to see if there is any similar word that is correct one *(note: for example, by replacing, reducing or adding a component, etc.).*

Another case with a similar pattern was seen in Student ID 22 in Community 2, who is also of active-sensing-invitee-'non-guess' type though belonging to the MA band. Both Case 3 and Case 4 show that during the games, MA and LA students were still willing and had the courage to try.

Discussion

Based on the findings presented in the previous section, the factors affecting students' learning in the Chinese-PP game are indeed complex. Nonetheless, the flexible grouping approach stimulated the students of various learning styles and achievement levels to actively interact with peers after several rounds of games, where the effect of zone of proximal development (Vygotsky, 1978) prevailed. Specifically, the Sensing-style students played the invitee role more often than intuition-style students. However, the learning outcomes of the sensing-style students were significantly better than intuitive-style students (See Table 2). As such, it can be seen from the game that students who played the invitee role may not learn less than students who played the leader role. This game promotes the premise of "learning from doing and learning from mistakes". Even if characters cannot be formed with 100% accuracy (perhaps due to the guessing approach), there are still learning gains. The teacher should encourage the students to engage in deep discussions during character formation and not adopt a repressive attitude towards characters formed via the guessing approach. Every student should be given the opportunity to receive constructive comments from the teacher and their peers, which may include feedback on analysing if certain wrong characters formed do fit the concept of the Chinese characters structure, which will benefit the students in constructing and strengthening this higher level of knowledge in order for the students to further attempt character formation in the correct direction.

Indeed, the flexible, rapidly altered grouping model of the Chinese-PP game is a novel approach in mobile and game-based learning. Even within the general collaborative learning field,

existing studies have been focusing on fixed, often pre-determined student groupings, perhaps for easier classroom/learning management by the facilitators or more robust execution of collaboration scripts. In Chinese-PP, it was intended to leverage more on emergent peer negotiation as a form of positive interdependence to keep the learning activities going. Each student possesses a resource (a character component) and assumes full control on it. Nevertheless, in order to achieve the game goal of forming characters with the rest of the available resources (the other components possessed by her/his peers), (s)he will not only need to draw upon her own knowledge of Chinese characters and problem solving skills, but also her social skills to negotiate with her peers to identify and form groups. Without convincing others to join her group (and perhaps sharing her knowledge to others in the process), her goal of winning the score would not be attained. This can be attributed to 'positive resource dependency' as posited by Johnson and Johnson (1994). Such a game design is meant for balancing competition and collaboration – a major characteristic of Chinese-PP. In particular, the groupings are flexible; henceforth, there is 'no permanent allies and no permanent competitors' (unlike typical game-based learning designs with fixed groupings where a learner's fellow group members are fixed allies while learners in other groups are fixed competitors). Mapping this game characteristic to the social interdependence theory, we see this as an innovative means to promote positive interdependence and minimise negative interdependence.

From the point of Chinese character acquisition, students displayed their orthographic awareness through the character transformation activities (Jiang, 2006). Strategies for figuring out more characters include the splitting of components; the replacement of components; the addition or removal of components, among others. The teacher strengthened the students' awareness of the

concept on the character structure during the pre-tasks activities segment. Results show that students were able to apply these concepts effectively, forming many characters using the replacement of components method. For instance, when a student combined the two components "扌" and "隹" to form the character "推" (push)，the student holding on to the component "扌" sought out another student holding on to component "立" to form the character "拉" (pull). According to the structural pattern of phonogram, they need to be aware that "扌" can only be placed on the left side of the semantic component (隹 and 立). In short, through collaborative learning, the Chinese-PP game design transforms the foundational theory and rules of the Chinese character structure into the practical implementation of the game, enabling students to master the concept of Chinese character and its structural rules through trying out various configurations of components.

However, not all research findings are generalisable. Figure 3 shows that in this research sample, none of the students with Active-Sensing learning style played the role of the leader during the Chinese-PP game. Also, none of the students of Reflective-Sensing learning style preferred the "Guessing" approach and none of the Active-Intuitive students played the role of the invitee. Neither did these Active-Intuitive students adopt the "guessing" approach. It is suspected that this could be due to the size and the characteristics of the sample group.

For potential educators who are keen to enact Chinese-PP in their classes, the following implementation guidelines are distilled from our empirical experiences and findings,

- *Facilitating the full cycle of "pre-task – game – post-task" in each session, rather than just playing the game*: This is to help the students in closing the loop of "learning – application– reflection". Playing the game (application) without learning

the orthographic knowledge beforehand (pre-task), or playing the game without making reflection afterward (post-task) would undermine the effectiveness of the game design itself, as students may not be able to internalise the orthographic knowledge.

- *Focusing on component-based character learning, not rote learning and memorisation of overall patterns of individual characters*: Facilitate the students in constructing the orthographic knowledge during the pre-tasks and reinforce that during the post-tasks. For example, the students should learn about the functionalities of individual components (e.g., semantic and phonetic components) and how they are fitted into typical character configurations.
- *Promoting peer interactions throughout the games*: In our empirical study, we observed that during the earlier game sessions, students often resorted to enquire the teacher when they had doubt in the legitimacy of their newly composed characters. We advised the teacher that rather than directly giving them an answer, she should encourage them to consult their peers, particular those who are holding the other components that they need to form the proposed character (i.e., those are their potential group-mates). The teacher adopted this principle from the second game session onward. We then observed the students gradually established a more positive game behaviour of peer assistance in the later sessions. Their self-efficacy in playing the games without over-relying on teacher's guidance has also increased. We see this as a crucial strategy for any teacher to facilitate genuinely socio-constructivist Chinese-PP learning activities.

- *Tapping on the advantages of trial-and-error*: Encourage the students to carry out trial-and-error in character composing by applying their orthographic knowledge. Even if a student group have formed an illegitimate (non-existing) character, the teacher may facilitate a brief discussion to analyse whether the character configuration is conformed to certain orthographic rules, thus enhancing their understanding in the rules. From there, the students may try to replace one or more components to yield a legitimate character.

Conclusion

This study concludes that the flexible grouping game design, the mobility of the devices and game participants, enjoyment of the game, sense of achievement in winning the game and helping peers, are key reasons to outstanding learning outcomes of students through the Chinese-PP games. From the perspective of learning through play, Chinese-PP differentiated itself from the typical model of education games that geared towards self-entertainment of students amidst the sound and light effects of multimedia and also the need to fulfil standard answers specified by the overall teaching plan. Instead, through a comparatively simpler game model and interface design which stimulates peer negotiation, multi-disciplinary thinking, and timely feedback from the teachers, students can even achieve unexpected learning gains such as forming characters they have never learnt before. The objective of the game is not at determining who can recognise the highest number of characters; who memorised more characters or who has higher retrieval ability. Instead, it is to enhance the general knowledge on orthographic awareness of Chinese characters through the guidance of the teacher, social learning and peer support. This is an inspiring form of demonstration

where learning is designed to bring about interactive support learning across peers, teachers and technology.

In the future, we intend to collate the 3 sessions of game process information and conduct a more comprehensive and in-depth qualitative analysis. We will also incorporate the theories of second language acquisition into the analysis so as to investigate completely the characteristics that are not only related to mainstream computer-supported collaborative learning (CSCL) field, but also make a better sense of the unique nature of flexible grouping model. This will provide future reference to aid such application to the learning of other subject areas. Besides, we will also analyse the interaction models and learning strategies that can be learnt and deployed by other students, and incorporate them into future teaching strategies so as to provide better learning conditions for students learning the Chinese characters.

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