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How Learners of Different Learning Styles Collaborate in a Mobile-Assisted Chinese Character Game Based on Flexible Grouping

Lung-Hsiang Wong[a], Ting-Chia Hsu[b*] & Ivica Botticki[c]
[a]*National Institute of Education, Nanyang Technological University, Singapore*
[b]*National Taiwan Normal University, Taiwan*
[c]*University of Zagreb, Croatia*
[*]ckhsu@ntnu.edu.tw

Abstract: To assist young learners of Chinese Language in developing general orthographic awareness (i.e., the knowledge of Chinese character structures), a novel mobile game-based learning intervention was designed. In playing the "Chinese-PP" game in a 1:1 (one-device-per-pupil) setting, each of the 31 participating 9-year-old pupils was assigned a Chinese character component in her smartphone. A pupil may make use of her own and peers' character components to form a legitimate Chinese character, and invite the peers with matching components to join her group, resulting in rapid social negotiation. In this paper, the students' collaborative learning processes in three game sessions are analyzed. The relationships between pupils with varied learning styles and their game behaviors and learning gains are unveiled. Through the intervention that stimulates active peer coaching and social learning, we discover that all the pupils (regardless of their learning styles) became active learning participants and achieved high learning gains towards the last game session.

Keywords: mobile Computer-Supported Collaborative Learning (mCSCL); Learning of Chinese characters; learning styles; game-based learning

1. Introduction

A well-touted challenge in learning Chinese Language is the logographic (component-based) nature of Chinese characters (Wong, Chai, Chen, & Chin, 2013; Xing, 2006). There are 15 types of commonly used configurations. Most characters are formed by a combination of two or more components. One example is the "top-bottom" configuration where components are "stacked" together to form a character (e.g., 古 or 早). These components are the functional orthographic unit to recognize Chinese characters. As linguistic research on character components is getting mature, the component-based learning has been extensively applied in Chinese character teaching practice (Koda, 1996).

In this study, we designed an innovative techno-pedagogical environment to foster orthographic awareness which entails understanding of the ways which components can be combined to form characters, as well as the commonly used structures in these formations. When the pupils establish orthographic awareness of the Chinese characters, it is as if they have activated the meta-cognitive process to internalize Chinese character knowledge (Jiang, 2006). One example of the orthographic rules of Chinese characters is "phonogram". More than 90% of the Chinese characters belong to this category. A phonogram character is typically comprised of a phonetic component and a semantic component to hint its pronunciation and meaning respectively. For example, the phonogram character "沐" is pronounced as "mù", same as the pronunciation of its phonetic component "木"; and means "bath", relevant to its semantic component " 氵" (which means "water").

We developed a mobile-assisted Chinese character forming game, namely, Chinese-PP. In playing the Chinese-PP game in a 1:1 (one-device-per-pupil) setting, each pupil is assigned a character component on her smartphone. She must attempt to use her own component and components of her peers to form legitimate Chinese characters, and invite those peers to form a small group. A pupil who invites others, known as 'inviter' hereafter, must negotiate with the 'invitees', and explain to the invitees on the proposed character in case it is unfamiliar to the latter, thereby convincing them to join

the group and score points. We refer to this novel game setting as "flexible grouping", which means that pupils are not pre-assigned to groups. Instead, pupils 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 pupils and game process as pupils are not limited to pursuing standard answers determined by the teachers.

Thirty-one (31) Singapore Primary 3 (9-year-old) pupils in a public school participated in the pilot study of Chinese-PP. They were enrolled in the formal Chinese (as a second language) class in their school for two years and yet the amount of Chinese characters they had mastered were limited. This paper focuses on using quantitative analysis and case studies to compare the roles that the pupils play in the Chinese-PP game according to the various learning styles of the pupils. In particular, we investigated which learning styles have resulted in greater learning effectiveness, and whether pupils of these particular learning styles played the role of inviter or invitee most of the time.

2. Literature Review

2.1 Social Interdependence

Despite the long-espoused benefits of peer-to-peer 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 (Alexander, 2013). Collaborative learning is generally learner-centered with an emphasis on proactive learning. Pupils are willing to commit to the learning goals of the team and encourage one another to pursue higher levels of performance (Slavin, 1995). In a collaborative activity, the interaction among individuals influence the way the group is organized which further determines the outcome of the activities, with "social interdependence theory" as the reason and foundation towards such sociological learning (Johnson & Johnson, 2011).

Social interdependence exists when the outcomes of individuals are affected by their own and others' actions (Johnson & Johnson, 1989). There are three types of social interdependence: positive interdependence, no interdependence, and negative interdependence (Johnson & Johnson, 1989). 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). 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. Third, negative interdependence results in oppositional interaction (i.e., individuals obstructing each other's efforts to achieve their goals). The pupils work against each other to achieve a goal that only one or a few can attain.

Positive interdependence tends to result in promotive interaction, while negative interdependence tends to result in 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 work 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).

2.2 Learning Styles

Learning style refers to the learners' individual learning preference. Learners of varied learning styles affect each other in terms of accepting external stimuli, receiving, memorizing, thinking and problem solving. There have been studies for decades 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 pupils with varied learning styles. This has contributed to the potential development of technology-mediated and personalized learning.

The learning style is partly governed by a pupil's native ability – the way that a pupil prefers to receive and process external information. Scholars systematically categorized the various learning methods subsequently determined the learning styles. The most commonly adopted instrument is Felder

& Silverman's (1988) index of learning styles (ILS), consisting of 44 questions under "Active/Reflective", "Sensing/Intuitive", "Visual/Verbal", and "Sequential/Global" respectively. This study adopts ILS (Soloman & Felder, 2001) which was developed based on Felder and Silverman's index. The second dimension, Sensing/Intuitive, was adopted in this study as they are more relevant to the gaming behaviors and strategies of the players of Chinese-PP.

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 learners are capable of comprehending abstract materials; and they are more creative than sensing learners. They dislike learning materials that give away details.

3. Research Design

3.1 Research Context and Intervention Design

Thirty-one (31) Singapore Primary 3 (9-year-old) pupils participated in the study. Prior to the intervention, we split them into three ability bands based on their pre-test (see below) results. Pupils whose scores were among the lowest 27% (9 pupils) were deemed as low achievement (LA) pupils, whereas pupils with scores that were among the top 27% (9 pupils) are classified as high achievement (HA) pupils, and the remaining were medium achievement pupils (MA) (13 pupils). Some HA and MA pupils scored the same marks and hence resulted in a higher number of pupils in those groups. All the pupils were then split into two "communities" heterogeneously with 15 in Community 1 and 16 in Community 2. The amounts of HA, MA and LA pupils in both communities were roughly the same.

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 conducted by the Chinese teacher where pupils built or strengthened their prior knowledge and revised themes learned previously before being introduced to new orthographic knowledge on character components (e.g., the phonogram structure) and how to make educated guesses on the meaning and pronunciation from the components. The pupils 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 were carried out. Guided by the teacher, the pupils recalled the characters that they formed during the game and related them to the knowledge acquired during the pre-task.

The technological infrastructure consists of: (1) a projector screen and a laptop that facilitate the projection of the teacher console management interface; (2) 1:1 smartphones (with the Chinese-PP app installed) and Internet access; (3) the server that runs the Chinese-PP system. In the beginning of each game round, the system assigns Chinese character components to individual pupils' Chinese-PP app. The pupils may find out which components they and their peers are assigned through the app. As presented in Figure 1(a), "My Character" shows that Pupil A is assigned the component "女" and she drags the components "口" "月" which belong to Pupils B and C into the word formation frame to form the Chinese character "娟", as demonstrated in Figure 1(b). Pupil A then sends invites to Pupils B and C by clicking on the "Submit" button. The composed character "娟" then appears in the "My Groups" interface (Figure 1(c)) on all three pupils' smartphones. In addition to sending the invites through the app, the inviters would approach their invitees to negotiate with them verbally on group forming. Once the three pupils agree that the character formed is correct (Figure 1c), the invites will be accepted by Pupils B and C by clicking the confirmation button. The information will then be transmitted to the teacher console. The teacher then evaluates the answers through the teacher console and awards scores of 10 points to each pupil for each correct character formed by a pair of pupils (20 points each for a group of 3 pupils, 30 points each for a group of 4 pupils; i.e., the more complex the character is, the higher the points each pupil is earned). In addition, the teacher may opportunistically gather the pupils to discuss about the pupil-formed characters, stimulate their thinking and provide them appropriate hints for subsequent game time. At the end of a 15-minute game round, the groups are disbanded. The pupils then proceeds to the next round where the system assigns new character components to them.

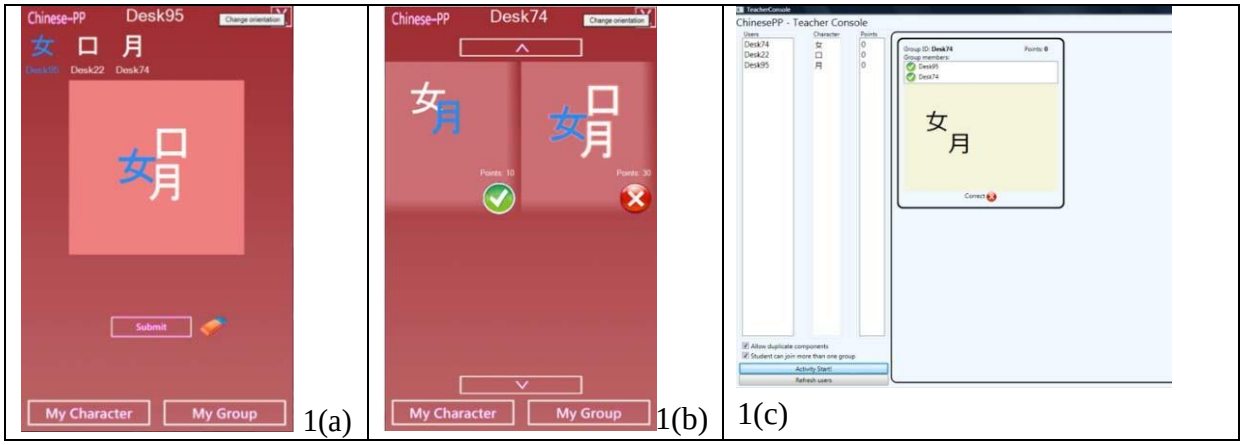

Figure 1. The user interface design of Chinese-PP

In order to systematically posit the research findings, we coined several terms according to the different roles that the pupils played during the activity process. In the game community, a pupil who actively invites others to form groups is known as "Inviter". A pupil who was reactively passive to accept an invite was known as an "Invitee". Pupils are also classified according to their habits of forming characters either in a guessing, risk-taking manner (known as "Guess" pupils) or through a cautiously, ascertaining manner (known as "Non-guess" pupils). "Guess" pupils are inclined to try their luck in using components to form characters and sending out invites 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 in character formation, for instance, the use of phonogram rule. On the contrary, "Non-Guess" pupils prefer to retrieve and recall the characters they had previously learned when forming the characters, or seek consultation from their teacher or peers before sending out an invite.

3.2 Research Method

We adopted the design-based research (DBR) method (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Collins, Joseph, & Bielaczyc, 2004) and underwent two cycles of DBR. The first DBR cycle focused on the design, experiment, review and improvement of the game rules and system (Wong, Boticki, Sun, & Looi, 2011). This paper covers the second cycle of DBR where a full-fledged empirical study of the improved system was conducted.

In the pre and post-test, pupils 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 pupils, by adopting one of the relevant dimensions of the ILS learning style questionnaire, namely, "sensing/intuitive" learning styles. Each dimension consists of 11 questionnaire questions to determine which learning style the pupil belonged to.

In addition, we conducted interviews with six pupils after the intervention in order to gain insights on the mindsets of pupils with various learning styles in exhibiting their game behaviors. The pupils were selected based on the maximum variation strategy, which were comprised of HA, MA and LA pupils with sensing or intuitive learning style. Both the quantitative and the qualitative 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) Was there any significant difference between the game scores and learning effectiveness of the pupils with different learning styles?
(2) What were the learning behaviors (inviter or invitee, guessing or non-guessing) displayed by the pupils with different learning styles in different bands (HA, MA or LA groups)?
(3) What were the frequencies of the pupils playing inviter or invitee roles with different learning styles throughout all the game sessions?

4. Findings

4.1 Analysis on the Learning Effectiveness

Chinese-PP emphasizes the development of pupils' orthographic awareness of the Chinese characters through social negotiation, stimulation of higher-order thinking, and timely and appropriate feedback from the teacher. In the early game rounds, the pupils habitually sought help from the teacher when they could not form characters. After several game rounds, they gradually transformed from passive to active learners (increased interactions and instances of invites); and their response time were reduced.

A paired samples t-test on the pre- and post-tests scores of the 31 target pupils 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 pupils went through the Chinese-PP game.

However, our main interest was lying on investigating the relationship between the roles played by pupils of different learning styles and the learning effectiveness. As such, we performed a two-way ANCOVA by using the pre-test scores as a covariate, game behaviors (active inviter/passive invitee/both) and learning styles (Intuitive/Sensing) as independent variables, while the game scores were a dependent variable. After verifying that the assumption of homogeneity of regression was not violated with F=1.046 (p>.05), the game scores of the six groups of pupils were analyzed with the two-way ANCOVA, as shown in Table 1.

Table 1. Between-subject effects in the two-way ANCOVA Analysis of game scores

Resource Learning	SS	df	MS	*F*	p
styles (Sensing/Intuitive) Game	47734.398	1	47734.398	*7.208**	.013
behaviors	2877.594	2	1438.797	*0.217*	.806
Learning Styles*Game Behaviors	25362.731	1	25362.731	*3.830*	.062

* $p<.05$

According to the above analysis, no significant effect was observed for the interaction between independent variables (F=3.830, p>.05) on the pupils' game scores. Thus, it is sensible to investigate the main effects of dependent variables, which is shown in Table 2. It is found that the game scores (mean=180.77, SD=76.10) of the sensing-style pupils were higher than the those (mean=101.67; SD=86.72) of the intuitive-style pupils ($F=5.541^{*}$, p<.05). However, no significant difference was found among the main effects of pupils with different game behaviors (F = 0.024, p >.05). The mean game scores of the pupils who predominantly played the active-inviter role, who predominantly played the passive-invitee role, and who were balanced in both the active-inviter and passive-invitee roles are 148.46 (SD=105.58), 124.00 (SD= 85.92) and 130.00 (SD= 40.00) respectively.

Table 2. main effect of different learning-style pupils' game scores

Resource	N	Mean	SD	Adjusted Mean	F	Pairwise comparisons
Intuitive	18	101.67	86.72	98.64	5.541*	Sensing>Intuitive
Sensing	13	180.77	76.10	173.73		

* $p < .05$

Nevertheless, the game scoring is designed in the way that pupils who form a group to compose a legitimate character will receive the same score. Henceforth, it is difficult to gauge the learning effectiveness of the pupils of different learning styles and/or different game behaviors/roles based merely on their individual game scores. In turn, another two-way ANCOVA was conducted by using the pre-test scores of learning achievement as a covariate, game behaviors (active inviter/passive invitee/both) and learning styles (Intuitive/Sensing) as independent variables, while the post-test scores of learning achievement were a dependent variable. After verifying that the assumption of homogeneity of regression was not violated with F=0.482 (p>.05), the post-test scores of the six groups were analyzed with the two-way ANCOVA, as shown in Table 3.

Table 3. Between-subject effects in two-way ANCOVA Analysis of the post-test

Resource	SS	df	MS	*F*	p
Learning styles (Sensing/Intuitive)	10.840	1	10.840	*0.673*	.421
Game behaviors	20.758	2	10.379	*0.645*	.535
Learning Styles*Game Behaviors	78.128	1	78.128	*4.852**	.039

* *p*<.05

It is found that a significant effect was observed for the interaction between two independent variables (*F=4.852**, *p*<.05) on the pupils' learning achievements, implying that simple main effects of each independent variables need to be further conducted, which is shown in Table 4.

Table 4. Simple main effect in two way-ANCOVA of the post-test

Resource		N	Mean	SD	Adjusted Mean	F	Pairwise comparisons
Intuitive	Active (inviter)	5	13.00	4.123	12.89	4.594*	Balanced>Active
Learning	Passive (invitees)	10	12.00	5.121	12.24		Balanced>Passive
Style	Balanced	3	21.00	2.000	23.20		
Sensing	Active (inviter)	8	14.50	6.824	15.02	0.109	
Learning	Passive (invitees)	5	13.40	3.578	13.43		
Style	Both	0					

* *p* < .05

For the intuitive-style pupils, the learning effectiveness (mean= 21.00, SD=2.00) of the pupils with balanced game behaviors were significantly better than that of the active-inviter pupils (mean=13.00; SD=4.12) and the passive-invitee pupils (mean=12.00; SD=5.12) (*F=4.594**, *p*<.05). However, for the sensing-style pupils, there was no significant difference between the learning effectiveness of the pupils playing active-inviter role (mean=14.50; SD=6.82) or passive-invitee role (mean=13.40; SD=3.58) (F = 0.109, p >.05). Both cohorts of pupils performed similarly. Note that there is no sensing-style pupil exhibiting balanced behaviors during the games.

In short, based on the findings, pupils who performed a balanced frequency of inviters and invitees had achieved higher learning gains, particularly in the post-test. The post-test scores of the intuitive-style pupils with balanced roles were significantly better than intuitive-style pupils who predominantly played the active-inviter role (p=0.048) as well as those who predominantly played the passive-invitee role (p=0.034). However, among sensing-style pupils, there was no significant difference in the post-test scores between active-inviters and passive invitees.

4.2 Analysis of different learning styles and the roles played in the game

Next, we are keen to find out what roles (inviter or invitee) the HA, MA and LA bands of pupils played and the game strategies they deployed during the Chinese-PP game through analyzing the system logs. Figure 2 depicts the distribution of the pupils' learning styles and the roles they played among the three bands. The code on in each box indicates a specific cluster (S=sensing style; I=intuitive style; A=played active inviter role most of the time; P=played passive invitee role most of the time). For example, "SA" refers to a type of pupil with sensing learning style who predominantly played the inviter role. Three pupils who straddled between IA and IP are not shown in the Figure 2 because the times of playing the inviter roles were the same with the times of playing the invitee roles during playing the games. Among the three pupils, two of them were HA pupils while only one was MA pupil and no one was LA pupil.

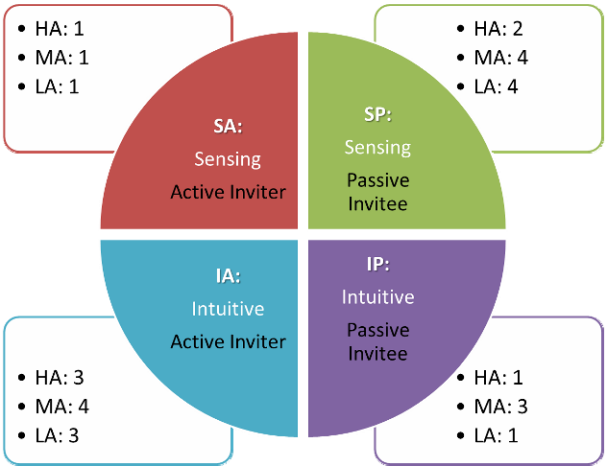

Figure 2. Distribution of roles played by pupils with different learning styles for all achievement groups

Among the pupils who frequently played the inviter role, the proportion of intuitive- to sensing-style pupils is approximately 3:1 (76.9% of the pupil are Intuitive); the proportions of HA, MA and LA pupils who were predominantly inviters are 61.5%, 30.8% and 7% respectively. The Intuitive-style pupils were creative and went along with their experience or feelings to play this game regardless of whether they were in the HA, MA or LA band. Only two LA pupils predominantly played the inviter role. Despite being LA pupils, they bravely shouldered the inviter role most of the time. We therefore infer that the Sensing/Intuitive dimension is most highly related to whether individual pupils predominantly played the inviter or the invitee role; while their prior knowledge is a secondary factor.

For the impact of the degree of prior knowledge on the pupils during the game, we discovered that most of the invitees were not from the HA band. Two HA pupil predominantly played the invitee role, belonged to the SP group. 66.67% of the invitees belonged to the Sensing style groups. Contrarily, most of invitees in the Chinese-PP game were made up of sensing-style pupils in MA and LA bands.

4.3 Analysis of pupil behaviors during the game process

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

Table 5 presents the number of invites sent according to the system logs. Note that sensing-style pupils played the invitee role in a significantly higher frequency as compared to intuitive-style pupils. There is no significant difference between sensing- and intuitive-style pupils when the pupils tend to be the active inviters.

Table 5. Analysis on roles played for two groups of pupils with different learning styles

Game role	Learning style	N	Mean of frequency	Standard deviation	*t*-test
Active Inviter active (A)	Sensing (S)	13	6.62	3.15	1.05
	Intuitive (T)	18	5.33	3.51	
Passive invitee (P)	Sensing (S)	13	11.54	4.74	2.72*
	Intuitive (T)	18	6.94	4.57	

Furthermore, by cross-checking the video recordings and the system logs, we discover frequent switches of inviter and invitee roles that the pupils played in the communities. A salient phenomenon is that with the flexible grouping approach, HA, MA and LA pupils were all engaged in searching for the right partner(s) to form the correct character in order to score points. Due to the fact that each pupil held

a different component, even the LA pupils were needed in the games, resulting in a natural way of collaboration to work towards the common personal goal of scoring high.

Next, a few typical pupil 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 pupil behaviors. In addition, we split the pupils into Guess and Non-guess categories in the following bases: (1) Whether the pupils preferred to guess during the Chinese-PP game, i.e., individual pupils' responses to the teacher's opportunistic questions during the game on whether they did recognize those Chinese characters or that they were formed; (2) pupils' self-reporting on their guess or non-guess behaviors through an additional item in the questionnaire.

Cases 1 & 2: A comparison of pupils ID 3 and ID 30

Case 1: Pupil ID 3 (HA / IA - intuitive; predominantly inviter type; non-guess)

Case 2: Pupil ID 30 (MA / IP –intuitive; predominantly invitee type; non-guess)

Pupil ID 3 who was "intuitive, inviter type and non-guessing" predominantly played the inviter role within Community 2 throughout the three game sessions. This is congruent with our general finding in the previous section that intuitive-style pupils were frequent inviters in the games. In addition, he exercised a non-guess behavior by always making sure that the character formed was indeed valid before sending it to the teacher's console. In many other occasions, he 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, he often introduced to his potential team members (perhaps in MA or LA band) the form, pronunciation and meaning of the character that he intended to form. Whenever necessary, he explained the general orthographic knowledge related to the Chinese character. This is the emergent peer guidance commonly found in the games that had perhaps elevated the ability and self-efficacy of the MA and LA pupils as a result.

Two other pupils with the same learning style as Pupil 3 in the HA band, pupil ID 10 and pupil ID 20 (both in Community 1), exhibited similar behaviors throughout the three game sessions.

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

Cases 3 & 4: A comparison of pupils ID 27 and ID 2

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

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

Pupil ID 27 in Community 1 was a pupil 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 three game sessions, she seemed to comprehend the rules of the game well and enjoyed the game. Her inviter-to-invitee record stood at 8:13. That is, while being categorized under the invitee-type, she braved herself in assuming the inviter role frequently. She was not afraid to commit mistakes and consequently learned from the feedback the teacher and her peers.

On the contrary, Pupil ID 2 of Community 1 exhibited a relatively inconsistent pattern. She was less active in the first game - only sent out one invite and was invited once. She played the invitee role throughout the second session. However, in the third session, she became very active by inviting different pupils and accepting invites from different peers. This was not only due to her faster actions, but more so of her courage to adopt the guessing approach. Initially, she perceived herself as one who had to heavily rely on her peers as she was from the LA band. However, in the final game, the number of times she invited others was the same as the occasions she played the invitee role (2 times each).

Another case with a similar pattern was seen in Pupil ID 22 (SA, MA) in Community 2. Both Cases 3 and 4 exemplify that during the games, MA and LA pupils were willing and dared to try.

5. Discussion

The findings presented in the previous section indicates that there were indeed a complex variety of factors that shaped the pupils' learning experiences during the Chinese-PP intervention. The flexible grouping approach stimulated the pupils of various learning styles and prior achievement levels to actively interact with peers after several rounds of games. Specifically, the sensing-style pupils played the invitee role more often than their intuitive-style peers. However, the learning outcomes of the sensing-style pupils were significantly better than intuitive-style pupils. As such, the pupils who played the invitee role did not necessarily achieve lower learning gains than pupils who played the inviter role. The Chinese-PP game promotes the premise of "learning from doing and learning from errors". Even if the characters cannot be formed with 100% accuracy (perhaps due to the guessing approach), the pupils may still advance their orthographic awareness due to the in-situ or post-reflection. The teacher should encourage the pupils in reflective discussions during the game rather than adopting a repressive attitude towards characters formed via the guessing approach. Every pupil should be given the opportunity to receive constructive comments from the teacher and their peers, which may include feedback on analyzing if certain wrong characters formed do fit specific orthographic rules of Chinese characters. Thus, the pupils would be able to construct and reinforce such higher-level knowledge for their further attempts in forming characters in the right directions.

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 pupil groupings, perhaps for easier classroom/learning management by the facilitators or more robust execution of collaboration scripts. Instead, Chinese-PP leverages more on emergent peer negotiation as a form of positive interdependence to keep the learning activities going. Each pupil 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), she 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 scores 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). Mapping this game characteristic to the social interdependence theory, we see this as an innovative means to promote positive interdependence and minimize negative interdependence.

6. Conclusion

This study concludes that the rapid and meaningful pupil interactions stimulated by the flexible grouping game design is the key factors of Chinese-PP to outstanding learning outcomes of pupils with respect to its learning goal of increasing orthographic awareness. The objective of the game is not to determine who have memorized more characters. It is meant for enhancing the general orthographic knowledge of Chinese characters through social learning and peer support. This is an inspiring form of intervention where learning is designed to bring about interactive support learning across peers, teachers and technology (Wong et al., 2011). In the future, we intend to collate the three 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 more thoroughly the unique nature of flexible grouping model. This will provide future reference to aid such application to the learning of other subject areas.

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