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Source	*19th International Conference on Computers in Education (ICCE 2011), Chiang Mai, Thailand, 28 November to 2 December 2011*
Published by	National Electronics and Computer Technology Center, Thailand

Citation: Wong, L-H., Looi, C-K., Boticki, I., & Sun, J. (2011). Improving the scaffolds of a mobile-assisted Chinese character forming game with the SCAPE framework. In T. Hirashima, G. Biswas, T. Supnithi & F. -Y. Yu (Eds.), *Proceedings of the 19th International Conference on Computers in Education*. Chiang Mai, Thailand: Asia-Pacific Society for Computers in Education.

T. Hirashima et al. (Eds.) (2011). Proceedings of the 19th International Conference on Computers in Education. Chiang Mai, Thailand: Asia-Pacific Society for Computers in Education

Improving the Scaffolds of a Mobile-assisted Chinese Character Forming Game with the SCAPE Framework

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Abstract: Appropriate design of collaborative learning activities for students using 1:1 handheld devices can lead to peer scaffolding, building up students' collaborative skills. Building on such prior studies in mCSCL (mobile Computer Supported Collaborative Learning), we derived Chinese-PP, a novel design of in-class mobile synchronous collaborative learning game on constructions of Chinese characters from components, with the unique characteristic of spontaneous small group formations. In this paper, we propose a framework, namely, "SCaffold Analysis and Provision Envisioning" (SCAPE) to guide us in examining and refining/revising the interplay among various forms of scaffolding in the learning model across various Design-Based Research (DBR) cycles of our study on Chinese-PP. We believe a generalized SCAPE framework has the potential to inform TEL research in a structure to embark on the iterative process of enacting and redesigning the socio-techno-pedagogical frameworks developed by individual research projects.

Keywords: SCAPE framework, Mobile Assisted Language Learning (MALL), mobile Computer Supported Collaborative Learning, Scaffolding, Design-based Research

1. Introduction

One-to-one (1:1) technology-enhanced learning (TEL) environments transform classroom dynamics as individual students can carry mobile devices with wireless affordances into the classrooms [1][2]. Nevertheless, the incorporation of the 1:1 infrastructure into the classroom may impose additional challenges on the teachers in trying to cope synergistically with content, pedagogy and technology. To go beyond the clinical stages of research and turn such designs into regular classroom modules, various aspects such as theoretical and curricular fit, pedagogical guidance, technological design and logistic support need to be addressed [3].

Appropriate design of collaborative learning activities for students using 1:1 handheld devices can lead to peer scaffolding, building up students' collaborative skills [4]. Building on such prior studies in mCSCL (mobile Computer Supported Collaborative Learning), we derived a novel design of in-class mobile synchronous collaborative learning game with the unique characteristic of spontaneous small group formations. We name our design as "Chinese-PP", where PP refers to 拼一拼 or "Pīn yì Pīn" in Chinese, which means "trial assembling". In the game, students follow or adapt the peer scaffolds imposed both by the teacher and by the computer system. In order to complete the learning tasks, they have to draw upon their social relationships with other students to negotiate and optimize the solutions.

In this paper, we propose a framework, namely, "SCaffold Analysis and Provision Envisioning" (SCAPE) to guide us in examining and refining (or revising) the interplay among various forms of scaffolding in the learning model across various Design-Based Research (DBR) cycles of our study on Chinese-PP. We adopt DBR to carry out an *iterative* process of designing, experimenting, reflection upon and redesigning the learning model and applications, and to

integrate design principles with technological affordances to render plausible solutions [5]. We will narrate one completed DBR cycle of our study to see how SCAPE has assisted us in accomplishing crucial revamps in the learning design. Rooted in DBR, a generalized SCAPE framework may inform TEL research in a methodology to embark on the iterative process of improving the socio-techno-pedagogical structures developed by individual studies.

2. Towards a 1:1 Solution for mCSCL Chinese Character Learning

The Chinese-PP study is an attempt to tackle the primary hurdle of learners of Chinese as a second language (L2) – the logographic nature of the Chinese script [6]. The Chinese scripts are a rule-based system – each Chinese character comprises of one or more components, spatially arranged with certain principles. The traditional way of teaching Chinese characters are either through strokes or through whole characters as an image by bypassing the components. Neither approach conforms to the principles of language acquisition theories such as comprehensible input [7], information processing [8] and connectionism [9]. The fact that a limited numbers of components can form a large number of characters leads us to argue that learning characters through combining their components in different positions is cognitively effective. It allows learners to nurture the ability of making educated guesses on unfamiliar characters.

Building on prior mCSCL work by Zurita and Nussbaum [10] and our previous explorational study on fractions addition mobile game [4], we designed the Chinese-PP character forming activity based on 1:1 TEL setting which would be conducted in multiple rounds. In Zurita and Nussbaum's work, students were assigned to fixed small groups before the beginning of the classroom activities. We adapted the activity design in which students have to negotiate with other students to form their own groups spontaneously with no fixed size. In each round, a set of Chinese components is assigned by the system server via 3G network to individual students' smartphones. Students form groups by composing appropriate characters out of the components and place them at the correct positions, thereby forming a valid Chinese character. For example, with the components 女, 口 and 月, students could place the components in the correct order to form the character 娟 ('graceful'). In addition, we encourage the students to form larger legitmate groups (groups of more than two) for composing more complex characters. Figure 1 features an architecture overview of the technological solution.

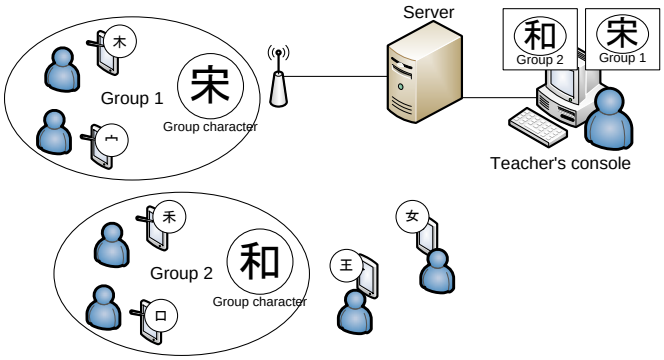

Figure 1: A broad architecture overview of the Chinese-PP system

Given the unique feature of flexible groupings in Chinese-PP, a significant game element is the reinforcement of global goals - no student to be left out. Hence, students ought to set aside their pursuance of local (individual) goals (i.e., to form a larger group) to help their peers. While some groups might have formed their characters, the others might have reached a dead-end situation. In such cases, students will need to think about other group configurations – that is, they need to integrate their thinking and collaborative skills together with their linguistic knowledge towards group goals. They might even come up with the solutions that require

disbanding of existing groups and form new groups with left-out peers. The act of balancing the local and global goals can be considered as the act of balancing competitions and collaborations.

3. The SCAPE Framework (SCaffold Analysis and Provision Envisioning)

We envisaged that the Chinese-PP activity would consist of three main scaffolding sources: technological, peer and the teacher. Technology provides scaffolding in the sense of both generic and domain-specific rules and logic (in the form of software features or affordances), while the teacher acts as facilitator and helps the students in dealing with impasses. Peer scaffolding is encouraged in order to increase student interaction and collaboration [4].

Adopting a DBR methodology, we propose a framework (Figure 2) for examining the potential roles of teacher, peer and technological scaffolding in CSCL. The essential idea is that through the school-based experiments, different forms of teacher and peer scaffolding may be emerged during the learning activities. The researchers, the teachers and even the students then propose new forms of scaffolding in retrospectively addressing the pitfalls that they encounter. They could subsequently identify those which can be fully or partially automated as technological scaffolding (arrows A in Figure 2), and distil those which should best remain in the form of teacher or peer scaffolding to become part of the teacher facilitation guide or student strategy guide (arrows B). Certain teacher scaffolds might be able to be replaced or assisted by the peer help (arrow C), thus relying on the social intelligence of the class.

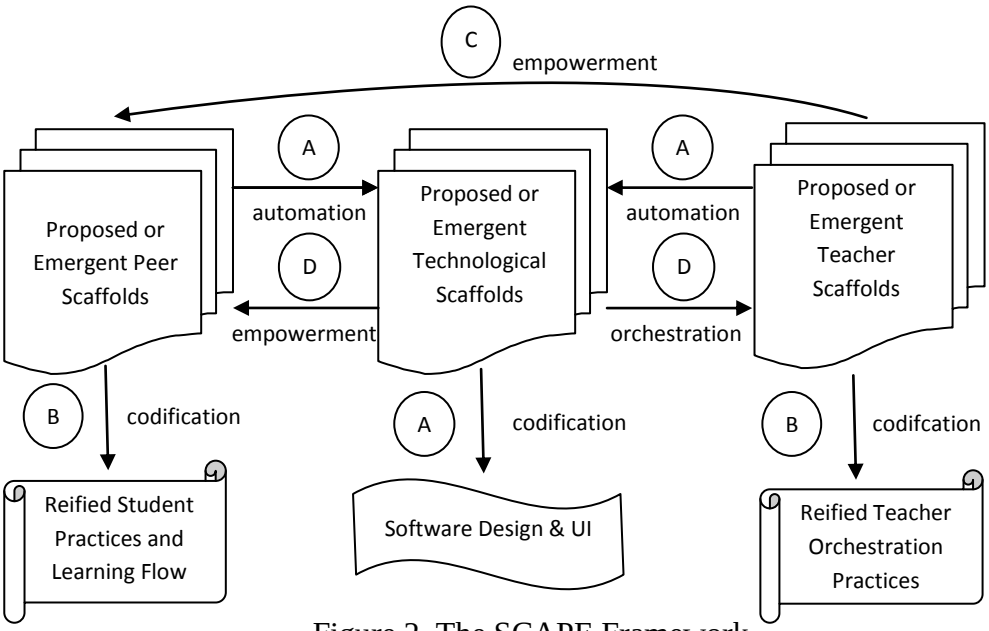

Figure 2. The SCAPE Framework

In addition, the scaffolding analysis can be extended to the identification of the critical success factors of learning environments and the assessment of the roles of the technological supports, i.e., if teachers and students can do better in providing certain scaffolds, then the role of the technology will need to be revised (arrows D). We name this framework "SCaffold Analysis and Provision Envisioning" (SCAPE), motivated by advocating an extensive and expansive land*scape* or view of learning design. Such a framework may guide us in redefining the roles of the teachers, the students and the technology to tackle various challenges and improve the students' learning experiences and outcomes. When good scaffolding leads to positive learning processes and outcomes, these can be reified by creating representations which can serve as best practices to help future learners and teachers.

4. Chinese-PP: Study Description

To carry out the study in our collaborating school, a primary school in Singapore, we have planned three DBR cycles that aims to advance from the base learning design towards an effective mCSCL practice informed by language acquisition theories (e.g., [7][8][9]). We will apply the SCAPE framework across all three cycles to continuously improve the design.

- **1st Cycle – Formative evaluation of the base learning design**: We focused on preliminary game rule design, development of technological solution and formative evaluations in these aspects. Two rounds of trial runs (two "micro-cycles" here after) were conducted with small groups of Primary 3-5 (9-11 year-old) students. Students were not coached in the domain knowledge or collaborative strategies. They just played the game with the prescribed rules so that we could identify emergent learning patterns, iron out logistic issues, and probe the students on their perceptions in the design. The findings in each round informed our refinement in the rules and the software, which were then tested in the subsequent round.
- **2nd Cycle – Pilot classroom lessons:** We will design a pedagogical framework to facilitate a series of learning and game playing sessions that foster students' learning growth over the time (roughly 8 sessions with 2-week intervals). The Chinese Language teacher in the Primary 3 experimental class will take the lead in designing and enacting individual lesson plans while the researchers will play a supporting role.
- **3rd Cycle – Implemented classroom lessons**: The school will take over the agency in scaling up the learning model to all its Primary 3 classes. We will provide support in teachers' professional development.

In the following sections, we will describe our trials, findings and refinements in the 1st cycle. Due to the space limit, we will not report our plans for the 2nd and 3rd cycles.

5. 1st Cycle: The Experiment and the Subsequent Improvement in its 1st micro-cycle

Within the 1st cycle, we conducted two micro-cycles of design, evaluation and re-design with Chinese-PP. The first micro-cycle involved two pilot runs during May and August 2010. This had resulted in a major revamp of the game logic and user interface design. The second micro-cycle which involved another two pilot runs during February and April 2011 respectively had prompted us in making relatively minor fine-tuning.

Prior to the first micro-cycle, we designed the game rules with the following principles: (1) Based on our previous experiences in the fraction addition games [4], we recommend up to 15 minutes for, and 15-20 participants to be involved in, each game round; (2) In preparing each game round, the teacher needs to identify a set of components according to the number of participating students and input them to the system – the choice of components should allow the construction of as many eligible characters as possible, and with at least one global solution (i.e. no student will be left out) available; (3) The game rules, scaffoldings and incentives should be designed in the way that students are encouraged to strive for balancing the local global goals.

We developed the Chinese-PP version 0.1 software (Figure 3). In the beginning of each game round, students choose appropriate components out of the "peers' components" screen (Figure 3b), thereby forming a group. Members of each group then discuss and choose one of the general Chinese character configurations to organise their components properly via templates (character configurations) supplied by the Chinese-PP application (arrows < and > in Figure 3a). The teacher's console is not only used for controlling the game rounds (e.g., assigning components, starting/ terminating a round, etc.) but is also projected on a screen to give students a global view of the game (i.e. which characters have already been formed).

In the first micro-cycle, we engaged 37 Primary 4 students in the trial runs. These were mixed ability students in Chinese Language. As such a game may also be carried out using cards with individual components being printed, we experimented on both the "phone mode" and "card mode" (with four rounds of each game) on two different days. We split them into two sub-groups of 18 and 17 members each and repeated the trials on both sub-groups. The card games

applied the same game rules as the phone games except without any ICT support, and the students needed to cluster together to manipulate their cards in trial composing characters. For the phone games, the students could invite potential group members and accept/reject invitations through the smartphone application. The teacher facilitated all the games by controlling the game pace, hinting the students on-the-fly concerning possible groupings, verifying students' groupings, and determining when to terminate a round.

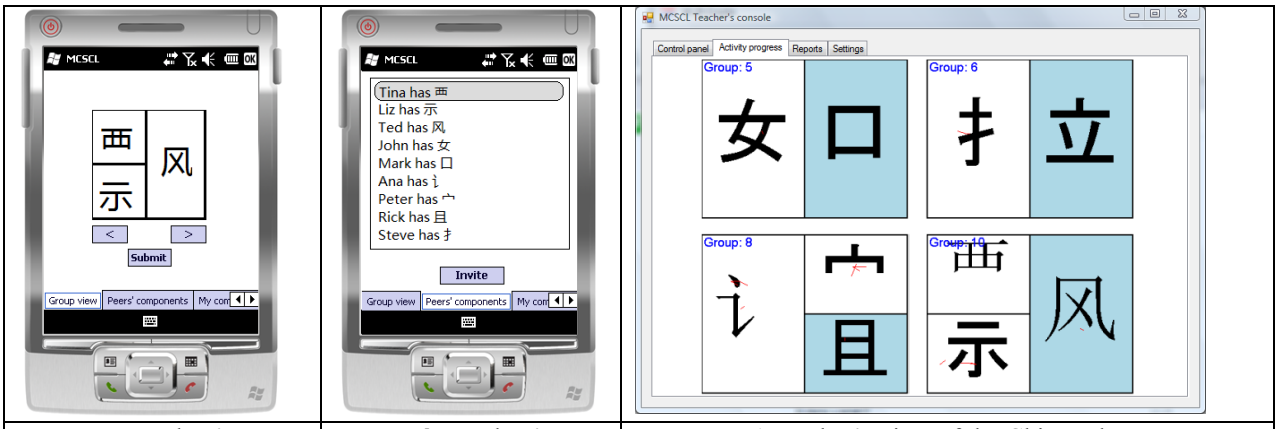

Figure 3a. Student's smartphone application displaying an assembled character.

Figure 3b. Student's smartphone application with Chinese language components.

Figure 3c. A teacher's view of the Chinese language learning activity. The screen shows the characters from four groups of students framed into a template.

Furthermore, we introduced a unique scoring scheme after the first pilot run in order to encourage the balancing of global and local goals. Students earned and accumulated scores by forming legitimate groups – 10 points for a 2-component character (same score to be awarded to each group member), 30 points for a 3-component character, and 50 points for a 4-component character. This was to encourage the students to form bigger groups so as to fulfil their local goals. However, in order to motivate the students to assist their left-out peers, each student who had formed a group and earned points will be penalized by 5 points times number of peers being left-out by the end of a game round, while the left-out students would not be penalized. Due to resource constraints, this functionality was not automated in Chinese-PP v0.1. Thus, in the second pilot run, we computed the 'live' scores manually, which was very time consuming.

All the games were video- and audio-recorded for analysis of students' game behaviors and collaborative patterns. The software logs of the students' interactions during the phone games were also used for triangulation. In addition, the focus group interviews that took place after each pilot run were conducted in order to reveal the students' perceptions in the games and the reasons behind their game playing and collaborative behaviors.

The students exhibited similar discussion patterns in all the card and phone game sessions. In each game round, students started exchanging ideas verbally about arranging the components. Most students first identified a classmate to discuss, and then switched to groups of three to four to discuss alternative possibilities. An initial set of groups was created in the process with a few left-out students still looking for groupings. If the left-out students could not form groups among themselves, they would seek peers' or the teacher's assistance in identifying other solutions. Some of the students who had already formed groups continued helping out their left-out peers by thinking of the possibilities of adding a group member or even breaking their own group.

Nevertheless, due to the nature of the domain (Chinese characters) and the UI design of Chinese-PP v0.1, most of the students had during the focus groups indicated their preference in playing the card game, as they could cluster together and physically manipulate their cards by trial placing them in different spatial configurations. This emergent strategy is what we loosely call "trial-and-error". Instead, during the phone games, the students had to study the "peers'

components" screen (Figure 3b), and mentally construct characters before deciding whom to invite to form a group. When playing the phone games, some students still approached each other physically to discuss, albeit unable to physically "trial construct" characters from their components. The UI design had been imposing additional cognitive burden to them.

Informed by the DBR methodology, we reflected on the game processes to decide on whether we should give up the phone mode and proceed to use the cards for our future study. Rather than judging it anecdotally, we let the domain-specific (language acquisition) theories inform and guide us in deciding whether we should accommodate or rectify the students' use of their emergent game strategy. A detailed account of our reflection process is given in [14]. In summary, our decision was to retain and improve the mCSCL solution. Guided by the SCAPE framework, we revised the learning and technological designs. For example, the students' trial-and-error strategy in the card mode has inspired us to re-design the smartphone UI to show "virtual cards" of individual components that can be dragged and dropped onto the working space to try assembling (***emergent peer scaffolding → technological scaffolding***; left arrow A in Figure 2). The tedious manual scoring tasks have been automated as well; individual students' scorings and their overall rankings are dynamically updated in the teacher's console (***proposed teacher scaffolding → technological scaffolding***; right arrow A in Figure 2).

With that, we redesigned the UI (Chinese-PP v1.0) which now has a client side layout consisting of the two main application pages (Figure 4a and 4b). On the main (first) page the student are able to see the available Chinese character components that are used to assemble a character (top page menu) and the central assembling canvas. The second main screen displays all formed groups containing a student's character (specially denoted with the blue colour). For each group the student is able to agree or disagree with the components' layout.

Figure 4c shows the redesigned teacher application with the user list, Chinese component list and the number of points on the left hand side and the assembled group representation area on the right hand side. Immediately after all students accept a suggested group (green arrow shown on a group representation screen), the teacher's application allows the teacher to verify the correctness of the assembled character. Only after the teacher has confirmed the correctness of a group's character, the points are assigned to its members.

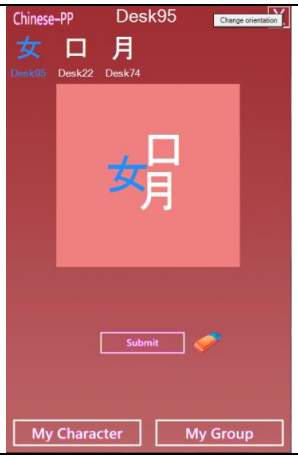

Figure 4a. The first client-side application page showing an assembled Chinese character.

Figure 4b. The second client – side application page showing all assembled groups.

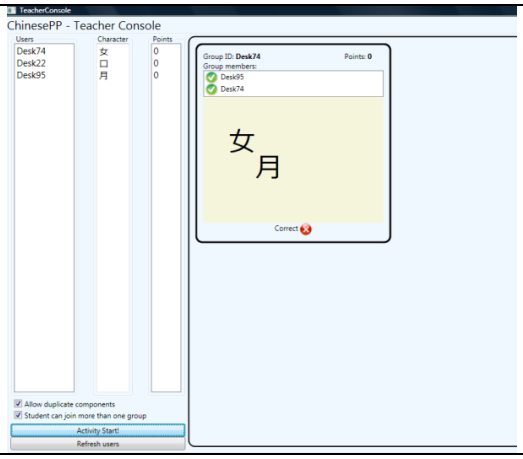

Figure 4c. Teacher's application showing all assembled and accepted by the students groups allowing teacher to verify the composed character correctness.

6. 1st cycle: The experiments in the second micro-cycle

We advanced to the second micro-cycle by inviting two groups of students to try out the revamped system. The first group comprises 15 out of the 37 students who were involved in the first micro-cycle's experiments (who had moved up to Primary 5). The second group comprises

of 16 Primary 3 students (which was not the experimental class of the 2nd cycle), also with mixed abilities in Chinese. We repeated the same experimental design as the first micro-cycle, except that the researchers no longer facilitated the game sessions and instead engaged the Chinese teacher of the future experimental class in our 2nd cycle of study to enact the activities. After the experiments, most of the students had indicated that they preferred the phone mode. The Primary 5 group who used to prefer the card mode in the last micro-cycle told us that the new UI had essentially resolved the 'problem' of inconvenient character composition process, with the additional advantage of letting them seeing all their peers' components on one screen – an affordance that the card mode cannot offer.

With the UI revamp, we observed one major difference in the students' game playing pattern as compared to the first micro-cycle. That is, at the beginning of each round, instead of going straight to peer interactions, they spent quite a while to drag, drop and assemble components into characters individually, as though they were attempting a one-player game. It was obviously the new UI that shaped the behavior. This is in principle not a drawback, as a system that allows children to work together as well as maintain the ability for individual exploration is an important advance in CSCL [12]. The interplays of individual exploration and group work were indeed observed in Zurita and Nussbaum's work [10].

What raised our concern was that some of the students just took their time to work individually and did not bother to advance to peer negotiations. We argue that a 'productive' game would consist of two (perhaps intertwining) phases: personal trial phase, and grouping and optimization phase. The first phase is inevitable and perhaps desirable, but it should not take too long. To reduce the potential problem, we plan to incorporate a timer to the teacher's console that will start counting down since a new game round commences, and alarm at 2 minutes later as a soft deadline for the personal trial phase (to remind the students to move on to checking whether they are also invited to join other groups, and begin peer negotiations). Furthermore, we will derive more collaborative strategies to train the students, or formalize good emergent strategies from specific students to train other students, with the aim of promoting peer scaffoldings. All these will be documented in students' guidebook (***proposed teacher scaffolding → teacher guidebook & student guidebook***; arrows B in Figure 2).

Another issue that we observed was pertaining to the teacher's facilitation of the game sessions. With the researchers' assistance in controlling the teacher's console and supporting the logistics, the teacher had been too obsorbed in interacting with the students, answering almost every single student question, and often giving away correct solutions. Hence, she often became the center of the attention when being surrounded by the students who were waiting for her quick answers instead of trying to resolve problems with their peers. Occasionally, we needed to remind her to return to the teacher's console to approve or reject students' submitted groupings. That wore her out in orchestrating the session.

The observation prompted us to reflect on the teacher's roles in the game. In the future, when such a learning model is translated into a school-based curriculum, researchers will not be around and individual teachers will be on their own. Our participating teacher's facilitation style will not work. We extracted all the student questions from the transcription of the games, and asked the teacher to categorize them and determine suitable strategies to deal with each type of questions, with the following intentions in mind: (1) to promote student thinking and collaborations, rather than spoonfeed them; (2) to reduce her burden in classroom orchestration and be able to smoothly switch between teacher-student interactions and the controlling of the teacher's console. For example, if a student assembles a character on the phone and asks for the teacher's verification without consulting the relevant peers, the teacher may advice the student to discuss with those potential group members (***teacher scaffolding → student scaffolding***; arrow C in Figure 2). All the derived strategies will be documented in teacher's guidebook for Chinese-PP (***teacher scaffolding → teacher guidebook***; left arrow B in Figure 2).

There were other minor improvements in the game rules and the system (Chinese-PP 1.1) according to the teacher/student feedback, thus concluding the 1st DBR cycle of the study.

7. Discussion and Conclusion

We have proposed Chinese-PP, a game-based learning approach to address the Chinese as L2 learners' need of enhancing their understanding in the structures of Chinese characters. Such a learning design is very different from the conventional instructional styles that typical teachers are well-versed in. We worked out complex game rules to meet the learning goals informed by theories of language acquisitions and collaborative learning. Yet the design and the use of technology may pose serious classroom orchestration challenges to the teachers should it be translated to regular classroom modules. Furthermore, individual teachers' diversified instructional or interactional (with their students) styles may play a crucial part in shaping (or constraining) students' learning and collaborative processes in Chinese-PP.

With the eventual aim of scaling up the learning model in the school, we adopted DBR and in turn derived the SCAPE framework to help us in systematically codifying and improving/transforming various types of proposed or emergent scaffoldings, and consequently redefining/redistributing the roles of the teachers, the students and the technology. Researchers of learning technology have a long tradition of pooling adequate resources and assuming the dominating roles in facilitating empirical studies based on their learning designs while teachers are virtually transformed into research assistants [13]. Therefore, whether such learning designs can become part of the regular curriculum is questionable – when individual teachers facilitate such classes on their own, they usually have much less resources, such as no technical assistant, at their disposal. In our study, we strive for tackling this issue by tweaking different factors and variables at different stages of the study with the aid of the SCAPE framework to gradually bring the Chinese-PP model closer to becoming a regular curriculum.

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