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# Unpacking the Researcher-Teacher Co-Design Process of a Seamless Language Learning Environment with the TPACK Framework

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**Abstract:** Integrating InfoComm Technology (ICT) into teaching and learning poses challenges for teachers, such as the lack of know-how, self-efficacy and time to design interventions. A possible solution is the design of sound Technology-Enhanced Learning (TEL) environments with relevant content and pedagogical tools to reduce teachers' design efforts. Technological pedagogical content knowledge (TPACK) could be used as a framework for understanding how teachers could integrate ICT into classrooms. Originally developed for informing teacher development, recent scholars called for 'repurposing' the framework to guide the design of TEL that encapsulate holistic TPACK knowledge. We therefore employed TPACK to design the TEL environment of 'MyCLOUD' to advance the use of mobile and cloud technologies for seamless Chinese Language learning. In this paper, we unpack how the distributed TPACK resources has contributed to the design of MyCLOUD. The analysis is accomplished through our coding and consolidation of 42 researcher-teacher meeting minutes throughout the developmental period where rounds of design-implementation-reflection- redesign process were jointly carried out by the participants. This is followed by a study of students' perceived usability of the platform. This study therefore demonstrates how the development of TEL can be attained by leveraging TPACK as a basis of technical design.

**Keywords:** Seamless Language Learning; Technological Pedagogical Content Knowledge (TPACK); Design analysis; Design-based Research; User Acceptance Test

## 1. Introduction

Integrating InfoComm Technology (ICT) into teaching and learning poses huge challenges for teachers, such as the lack of know-how, self-efficacy and time to design useful interventions (e.g., Laferrière, Hamel, & Searson, 2013). A possible solution is the design of sound Technology-Enhanced Learning (TEL) environments to reduce their design efforts. Well-designed TEL environments with relevant content and pedagogical tools in place would reduce the cognitive load and help shape and elevate their competencies in enacting ICT-mediated pedagogies.

Technological pedagogical content knowledge (TPACK) could be used as a guiding framework for understanding how teachers could integrate ICT into actual classrooms (Mishra & Koehler, 2006). The TPACK framework argues that effective technology integration for teaching specific content or subject matter requires understanding and negotiating the relationships between these three components: Technology, Pedagogy and Content. Many studies have adopted this framework to design teachers' professional development (TPD) activities, which have supported its efficacy for enhancing teacher competencies. Recent scholars (Chai, Koh, & Tsai, 2013) called for 'repurposing' the framework for informing the design of TEL environments that encapsulate holistic TPACK knowledge. To date, however, there has been only one such environment designed for the learning of software development by computer engineering undergraduates (Wu, Chen, Wang, & Su, 2008).

We therefore employed the TPACK framework to design a TEL environment to advance ICT integration for self-directed, collaborative and seamless Chinese learning. Code-named MyCLOUD (My Chinese Language ubiquitOUs learning Days), the design-based research (DBR) project is intended to develop a new mobile- and cloud computing-assisted language learning practice that encompasses multiple learning spaces. The iterative development of the MyCLOUD 1.0 learning environment, which

is comprised of a technological platform, classroom pedagogy and learning materials, took place from September 2010 to November 2012. It involved the participation of university researchers and primary school Chinese teachers in Singapore.

In this paper, we unpack how the various knowledge resources had contributed to the design of the TEL environment. The retrospective analysis is accomplished through our coding and consolidation of meeting minutes throughout the developmental period where rounds of design-enactment-reflection-redesign process were jointly carried out by the researchers and the teachers. This is followed by a study of students' perceived usability of the platform. This research therefore contributes to current development of TEL, which may be overly technology-centric, by using TPACK as a basis of system design. We argue that TPACK is essential in enhancing the ecological validity of the TEL environments.

## 2. Literature Review

### *2.1 TPACK*

The TPACK framework specifies three forms of knowledge: technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK), which are all needed in order to integrate ICT into classrooms. When these three forms of knowledge interact, technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPACK) are formed. TPK are knowledge about how to use different technologies in a pedagogically sound manner; TCK are forms of content representations that ICT can provide for specific form of CK, and PCK are the knowledge teachers possess to help bridge students' understanding of CK. TPACK are the syntheses of all aforementioned forms of knowledge for ICT integrated lessons (Cox & Graham, 2009). Teachers need to acquire or create such knowledge for sound integration to happen. Learning technologists can also draw from the research in TPACK when they develop technology to enhance learning. We therefore review relevant aspects of knowledge, including language learning (CK/PCK-related), seamless learning (PK/TPK-related), and the notion of 'learning hub' (TK/TCK-related). This is to path the way for the creation of the MyCLOUD environment.

### *2.2 The CK/PCK related consideration: Chinese language learning*

Classroom practice inevitably shapes learners' language learning practice and impact upon their language competencies. Contemporary language learning researchers (e.g., Liu, Goh, & Zhang, 2006; Tedick & Walker, 2009) have argued that that conventional language classrooms typically fall short in the following aspects:, (1) They are overly teacher and knowledge centric (2) De-contextualized; (3) Predominantly "presentation-practice-production" (PPP model); and (4) Disconnections between skills and knowledge,. Traditional language classrooms fail to practice autonomous learning by the learners and authentic social interactions beyond the classroom. Such practices are not conducive in developing learners' communicative skills and elevating/sustaining their learning motivation (Liu et al., 2006; Wong, Chai, & Aw, in-press).

The above shortfalls prompted the emergence of sociocultural and communicative approaches towards language learning (Lightbown & Spada, 2013), which view language learning as an active process where learners make meaning through activities that reflect real-world contexts (Widdowson, 2003). Social interaction is the context where language use and language learning co-occur (Min, 2006). Participation in social interactions is the goal and the means for language learning. These imply that language learning needs to depart from transmissionism and promote authentic and social learning.

### *2.3 The PK/TPK related demands of 21st century— seamless learning*

Seamless learning is one of the advanced learning approaches that can potentially address the needs of 21st century learners in dealing with the challenges posed by the era of exponential changes. Chan et al. (2006) advocate that the key of seamless learning is in leveraging 1:1 (one-or-more-device-per-student) setting to facilitate anytime anywhere learning. This fosters among learners the bridging of learning efforts across a variety of settings (e.g. formal/ informal learning, individual/social learning, and learning in physical/digital realms). Seamless learning has evolved from a technology- enabled mobile and

ubiquitous learning approach (e.g., Hwang, Tsai, & Yang, 2008) to a constructivist curriculum design or knowledge creation approach (Looi & Wong, 2013); and moved beyond situated learning where learning is no longer confined within a single 'situation' but reference to a learning culture (Milrad et al., 2013). Seamless learning pedagogy should therefore focus on long-term fostering of learners' disposition and skills in carrying out seamless learning, thus resulting in the emergence of a new learning community.

### *2.4 The TK/TCK related consideration: 'Learning Hub' with tools*

'Learning Hub' is a notion arisen from earlier research in seamless learning (Zhang et al., 2010). The mobile device carried by a learner on a 24x7 basis could integrates all the personal learning tools, resources and self-created artifacts at one place, thus serving as a learning hub. The learning hub can facilitate a learner in managing her/his own seamless learning journey. Suitable learning resources that the learner acquires along her/his ongoing learning journey to mediate the latest learning task could be stored, used and modified conveniently (Wong & Looi, 2011). Simply put, a 'learning hub' should be the nucleus of: (1) a suite of tools to support learning activities, and (2) the medium to document the learner artifacts. In addition, Wong (2012) argued that the fast-rising cloud computing technology offers personal 'learning hub' that need not be associated with any device. Instead, it may exist as a learner account that stores the learner's history on a cloud-based platform with a suite of learning tools.

The above review sums up current issues of language learning (CK/PCK) which mobile-related technologies complemented by cloud computing (TK/TCK) could be designed to support socio-centric constructivist pedagogy (PK/TPK). These considerations formed the grounds for MyCLOUD.

## 3. Research Context

MyCLOUD is a DBR study with the aim of developing a seamless Chinese Language learning environment for Singapore primary school students with Chinese as second language standard. The key idea is to facilitate a long-term seamless language learning practice that is blended into the formal curriculum to foster a cross-space ongoing learning process among the learners. The conceptualization and development of the MyCLOUD environment began in September 2010, which was subsequently piloted in three Primary 3 classes in the experimental school between August 2011 and November 2012.

We adopted DBR as the methodology, which considers the subject of study to be a complex system involving emergent properties that arise from the interaction of more variables than are initially known to researchers (Brown, 1992). Therefore, design-based researchers attempt to optimize the design in real-life settings and to observe how different variables and design elements interact (Barab & Squire, 2004). Hence, the design-enactment-reflection-refinement cycles are iteratively conducted with conjectures created and perhaps refuted, and new conjectures are developed in the next cycle and tested.

This paper reports the first DBR cycle of the MyCLOUD project from September 2010 to November 2012. During the cycle, the university researchers and 4 Chinese teachers formed a taskforce to progressively co-design, enact and refine the learning environment. The platform development was outsourced to a commercial software developer. The DBR cycle consisted of 2 phases:

Phase 1: Learning environment conceptualization and design (Sep 2010–Jun 2011). The taskforce met fortnightly to co-design the learning environment, with frequent participation from the software developer. Phase 1 ended with the launch of MyCLOUD 1.0 in July 2011.

Phase 2: Curriculum piloting and pedagogy refinement (Jul 2011–Nov 2012). The 16-month pilot study in three Primary 3 classes commenced and the fortnightly taskforce meetings continued. The researchers observed and analyzed the curriculum enactment and the students' learning progress for reflection and tweaking of the learning environment design.

In this paper, we unpack our reasoning and articulate the knowledge resources we work on to holistically design the MyCLOUD 1.0 learning environment as guided by the TPACK framework. This is followed by a study of students' perceived usability of the platform. This paper is therefore positioned as a design synthesis paper or design analysis paper on the learning environment; while the detailed analysis of student learning processes and outcomes are reported elsewhere (Aw, Quek, Wong, Zhang, & Li, in-press). The research questions that guide the writing of this paper are,

RQ1. How did the taskforce collectively create and improve MyCLOUD 1.0?

RQ2. What were the students' perceptions of usability, ease-of-use and acceptance of MyCLOUD 1.0?

To address RQ1, we qualitatively analyzed 42 written minutes of taskforce meetings to distil the important design decisions that led to the creation of MyCLOUD 1.0. Two researchers coded the documents independently in terms of TPACK-related decisions made (with Table 1 as the coding scheme). The coding traced the 7 categories of TPACK that were discussed during the meetings and the new forms of TPACK co-created by classifying them according to the categories. The two coders then compared the coded documents and discussed discrepancies (about 15% of the codes) until consensuses were reached. Adapted from the analytical scheme presented in Wu et al. (2008), the qualitative outcomes of the analysis is then consolidated in a two-dimensional matrix for each phase: 7 categories from TPACK versus 3 categories (new design ideas, emergent challenges and solutions).

Table 1: Coding Scheme of TPACK decisions.

| Construct | Example |
|---|---|
| Technological Knowledge (TK) | How to use the functions of mobile devices and MyCLOUD platform. |
| Pedagogical Knowledge (PK) | How to facilitate language learning through pedagogical strategies such as seamless learning. |
| Content Knowledge (CK) | How to use domain-specific content knowledge such as orthographic (word structure), phonic (pronunciation) and functional knowledge of Chinese language. |
| Pedagogical Content Knowledge (PCK) | How to enhance students' vocabulary knowledge through contextualized writing activities. |
| Technological Pedagogical Knowledge (TPK) | How to facilitate socio-constructivist learning through the social networking feature in the MyCLOUD platform. |
| Technological Content Knowledge (TCK) | How to construct linguistic knowledge through the use of Mictionary and other online dictionaries. |
| Technological Pedagogical Content Knowledge (TPACK) | How to carry out an ongoing, contextualized and collaborative language learning process by applying the MyCLOUD learning model. |

To answer RQ2, we administered a questionnaire to 259 students from the entire Primary 3 level in the experimental school who were enrolled in the scaled-up MyCLOUD curriculum in 2013. We adapted the survey instrument developed by Chen and Huang (2010), which is comprised of three factors: perceived usefulness, perceived easy to use, and system acceptance. The items were reviewed by the teachers before administering to ensure language suitability.

## 4. Design Synthesis

### *4.1 Phase 1 (learning environment conceptualization and design) (Sep 2010 – Jun 2011)*

The phase began in September 2010 with the teachers informing the researchers on existing Primary 3-4 curriculum, their classroom practices, and students' learning difficulties, i.e., the design considered teachers' CK, PK and PCK as essential inputs. The teachers acknowledged that they were practicing the PPP model; while the students' common learning difficulties include the lack of self-efficacy in learning the language and applying it in daily life due to limited vocabularies, English-style grammar, etc. An agreement was reached that MyCLOUD is not (merely) meant for enhancing the existing pedagogy. The intention was to foster a new language learning practice informed by the sociocultural perspective of SLA by leveraging all opportunities of language learning, applications and reflections within and beyond the class hours. The taskforce then spent 10 months to co-design and prototype the TEL environment, with the involvement of a software vendor in the aspect of ICT development. As the university could not support the development, the taskforce outsourced the technological development work. The limitation of such an approach was revealed in Phase 2 (see later). Tables 2 summarizes our qualitative analysis on the most important decisions made during the meetings held within Phase 1.

Informed by the notion of seamless learning, the SLA theories and the research team's previous study (Wong, Chin, Tan, & Liu, 2010), the researchers sketched a design framework which were then discussed within the taskforce. Teachers' comments were received and the framework was adapted (Figure 1). The framework can be seen as the initial TPACK designed by the taskforce, comprising of the intertwining dimensions of seamless and language learning. Within the seamless learning dimension, the Facilitated Seamless Learning (FSL) framework (Wong, 2013) is adopted as the basic learning process to guide the actual learning activities. FSL is represented as a cyclic, non-linear process that consists of the following four activity types (*CK1-1, PK1-1, PCK1-1* in Table 2):

(1) *In-class learning engagement*: These are teacher-facilitated activities in formal settings, to get students to begin the learning of new vocabularies and prepare them for activities (2) and (3).

Table 2: TPACK-informed analysis on the major decisions made in Phase 1

| ID | New design concept | Challenge | Solution |
|---|---|---|---|
| CK1-1 | Deep learning of Chinese vocabularies not only in their meanings and pronunciations but also the ability of applying them in appropriate contexts. | | |
| PK1-1 | Learning Chinese through self-directed, contextualized language applications and social interactions. The learning design is student-centric and the pedagogy is meant for nurturing such a habit-of-mind among the students. | | |
| TK1-1 | Employ mobile & cloud technologies to develop MyCLOUD. | | |
| PCK1-1 | Tap on student artifacts in in-class consolidation activities for students to carry out peer reviews. | | |
| TCK1-1 | Tap on online resources, e.g., e-dictionary & voice synthesis, to support content learning. | | |
| TCK1-2 | Develop Mictionary functions that afford students to self-manage vocabulary learning. | | |
| TPK1-1 | Build personalized space (Mictionary) and social space (MyCLOUDNet) to reduce student perception on MyCLOUD as a formal learning environment. | | |
| TPK1-2 | Adopt duo-platform model: MyCLOUD app for just-in-time learning tasks (e.g., artifact creation and social interactions) that is blended into daily life; and web version accessible from home computer for more complex tasks. | | |
| TPK1-3 | Build simple learning analytics on students' activeness, e.g., to display number of new vocabularies added to Mictionary, number of artifacts created, etc., over a period of time. | | |
| TPK1-4 | Implement classroom management module where teachers may enable or disable certain sets of tools on student devices at different time. This is to prevent or reduce the 1:1 classroom management issue where students might misuse the devices during lessons. | | |
| TPACK1-1 | The platform should facilitate easy, semi-automated bridging of multiple learning spaces: formal (My Textbook) and informal (Mictionary) spaces, individual (Mictionary) and social (MyCLOUDNet) spaces, etc. | | |
| TPACK1-2 | An existing classroom practice is that the teachers instruct the students to highlight unfamiliar words on the textbook. The "My Textbook" component of MyCLOUD should provide a similar affordance – students use the mouse to highlight salient vocabularies, right click to add them to Mictionary. | | |

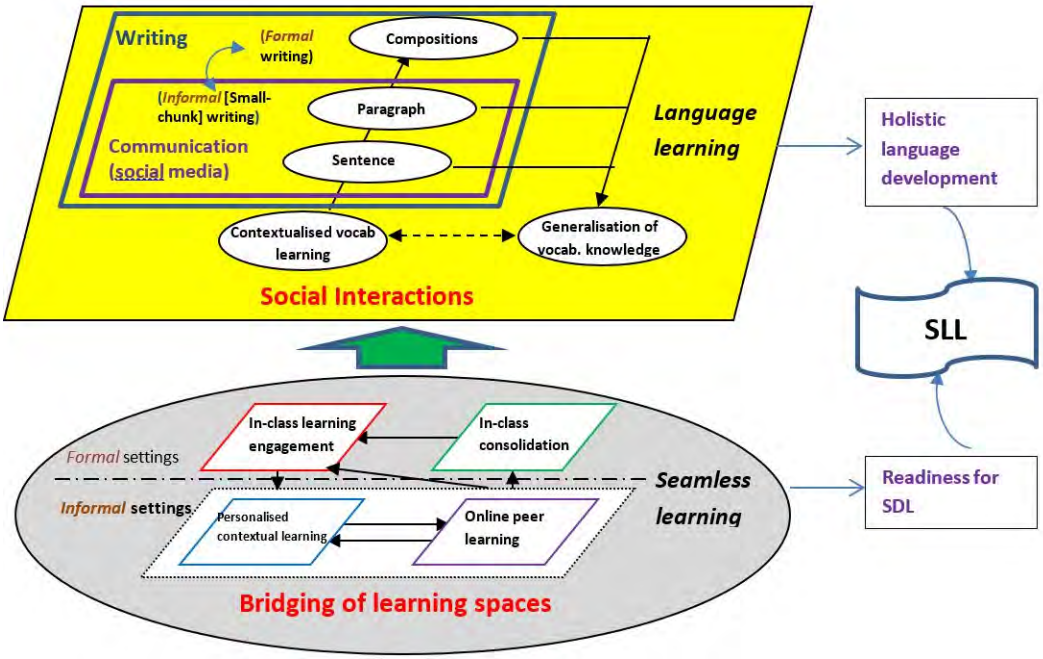


Figure 1. The learning design framework of MyCLOUD.

(2) *Personalized contextual learning*: Individual learners proactively observe, record, and reflect upon their daily encounters and apply their knowledge in their daily life. In MyCLOUD, the activities constitute of taking photos and making sentences pertaining to their daily encounters and posting such student artifacts onto MyCLOUD as social media.

(3) *Online peer learning*: In the online social space, learners carry out peer discussions mediated by their prior knowledge, resources, reflections and learner artifacts created during (1) and (2).

(4) *In-class consolidation*: Teachers facilitate and scaffold learners in in-class discussion and consolidation on teacher-supplied or learner-created artifacts during the entire FSL cycle.

Meanwhile, as depicted in the upper layer of language learning dimension, students individually create the digital language artifacts in the forms of sentences or paragraphs with or without photos to be uploaded. In the community, these artifacts are shared, reviewed and revised for deeper learning.

Informed by the framework, the taskforce and the software vendor proceeded to co-design MyCLOUD with the following main modules,

- **Mictionary**: Mictionary refers to 'Mobile dictionary'. In Mictionary, students record the vocabularies that they encounter in and out of class, and perform searches for meanings and exemplary uses. It serves as their personalized vocabulary learning e-portfolio where they are required to build most of the content on their own, such as adding the photo-sentence artifacts that utilize the vocabulary on the 'vocabulary page' or pooling relevant online resources *(TCK1-2)*.
- **My e-Textbook**: The digitized textbook passages are linked to a web-based text-to-speech service powered by Microsoft Bing for the platform to read them aloud. Students can highlight unfamiliar vocabularies and this will add the vocabularies to Mictionary *(TCK1-1, TPACK1-2)*.
- **MyCLOUDNet**: This is a social networking space for students to tweet or carry out photo-blogging (photo(s) + sentence(s), i.e., 'student artifacts'), and respond to others' artifacts. Students may (1) perform peer reviews to improve the accuracy and complexity (linguistically or contextually) of individual artifacts; or (2) be engaged in social interactions. Both types of responses are collectively known as 'replies' hereafter *(TPK1-1)*.
- **My Teaching Pal**: This is the classroom management module for the teachers to create lesson packages prior to the class, and manage the learning flow and enable all or selectively limit students' accesses to the features on MyCLOUD platform during the class. *(TPK1-4)*

In essence, My e-Textbook belongs to the formal learning space while MyCLOUDNet is an informal space. Mictionary bridges the two spaces by linking to My e-Textbook and MyCLOUDNet. If a student creates an artifact and add it to a vocabulary page in Mictionary (individual, formal-informal bridging space), the artifact will also be automatically duplicated to MyCLOUDNet (social, informal space). Two types of peer discussions could emerge – corrective/enriching feedback or social interactions on individual artifacts in MyCLOUDNet. Such discussions can be characterized as social meaning making which may trigger individual learners' reflections (*TPK1-1*, *TPACK1-1*).

The ICT architecture that we adopted to implement the MyCLOUD platform is the cloud-mobile model according to the revised 'learning hub' notion according to Wong (2012) (*TK1-1*). The platform is accessible by both a web-based interface and a mobile app. The former offers the full set of features while the latter provides a sub-set of functions for students to carry out quick learning tasks, such as creating student artifacts, online interactions and referencing to Mictionary, in their daily life.

In addition, we incorporated simple learning analytics features into the system, accessible by both the teachers and the students, such as reporting the frequencies of online activities of individual students and the whole class (e.g., new vocabularies added to Mictionary, artifact creations, online interactions, number of times each vocabulary is utilized by a student, etc.). This helped teachers to monitor student participation and adapt their interventions where necessary (*TPK1-3*).

The first working prototype of the MyCLOUD platform was implemented by the software vendor (see Figure 2 for the screen captures in the web version). Subsequently, a usability test was conducted by involving a group of Primary 3 students to use the tools and offer comments. The platform was then refined accordingly. The system was ready for deployment by July 2013.


Figure 2: Screen captures of the main components on the MyCLOUD platform (web version)

### *4.2 Phase 2 (curriculum piloting and pedagogy refinement) (Aug 2011 – Nov 2012)*

MyCLOUD 1.0 was launched in July 2011. 84 students in three Primary 3 classes were then involved in a 16-month school-based pilot study. Each of the students was assigned an Acer Iconia Tab W501 tablet for 24x7 access. Similar to Table 2, the major decisions made during Phase 2 is summarized in Table 3. There was a major shift of focus in the taskforce's design efforts – from conceptualizing a new intervention and transforming it to a learning environment in Phase 1 (i.e., more "Major design concepts" in Table 2), to developing concrete lesson plans and tackling the challenges emerged during the pilot study in Phase 2 (i.e., more "Emergent challenges" raised and addressed in Table 3).

Phase 2 was focused on the co-design of a basic lesson structure to guide future lesson designs (see *TPACK2-1* in Table 3). Nevertheless, the taskforce agreed that highly structured lesson plans may not be aligned with the spirit of constructivism and seamless learning. Instead, teachers and students should be encouraged to exercise flexibility. Consequently, the three teachers in the pilot study referenced the basic lesson plan structure, co-designed overarching learning activities for the chosen lesson units to be taught through MyCLOUD, and then individually adapted them to suit the profile and the progress of the students in their respective classes (i.e., 'differentiated learning').

Table 3: TPACK-informed analysis on the major decisions made in Phase 2

| ID | New design concept | Emergent challenge | Solution |
|---|---|---|---|
| PK2-1 | | How could we assess students' performance as they may not complete their assigned work? | Teachers strike a balance between student autonomy and teacher-directed activities. Moderately instill discipline as the students are very young. Enact formative assessment. |
| PK2-2 | | Students had been making superficial comments and corrections on peer artifacts on MyCLOUDNet. | Design scaffolds to nurture their peer critique and artifact re-writing skills, which should be enacted at the in-class consolidation sessions. |
| PCK2-1 | | Teachers' early emphasis on teaching new nouns that relatively lack contextual diversity in their usage were one of the reasons for students' creation of 'dull' artifacts. | Ensure greater form diversity in the choice of vocabularies to learn, i.e., nouns, verbs, adjectives, adverbs, conjunctions and idioms, etc. This may trigger students' creation of more contextually rich artifacts. |
| TPK2-1 | | Students should be able to revise their artifacts posted on MyCLOUDNet after peer feedback. The edit function was not available on MyCLOUD 1.0. | Encourage students to post their revised texts as new replies to the original artifacts. |
| TPK2-2 | | Many students find difficulties in expressing in Chinese or inputting Chinese text in the beginning, thus unmotivated to participate in the online activities. | Allow students to use English sparingly for replies in the first 1-2 months but artifact creation must be in Chinese. Inform them upfront that after the grace period, they should use pure Chinese for online activities. |
| TPACK2-1 | Develop a basic structure to guide the design of individual lesson plans: (1) Read textbook passage; (2) Add vocabularies from My e-Textbook to Mictionary; (3) Small-group artifact creation, and posting on MyCLOUDNet; (4) Reply to artifacts created by other groups on MyCLOUDNet; (5) Class-wide sharing of artifacts and discussion. | On Step (2), though teachers would pre-select vocabularies from the textbook passage for students to focus on and add to Mictionary, weaker students might find other vocabularies unfamiliar to them. | Encourage students to identify unfamiliar vocabularies beyond what the teachers have specified, and add them to Mictionary. |
| TPACK2-2 | Students may add vocabularies incidentally used in their artifacts posted on MyCLOUDNet to Mictionary. | | |
| TPACK2-3 | Design & enact learning processes that encompass the full FSL cycle and tap on specific events such as Chinese New Year in and mid-year school vacation. | | |
| TPACK2-4 | Design & enact mobile learning trails at Haw Par Villa and Asian Civilisations Museum to facilitate collaborative and authentic language learning. | | |
| TPACK2-5 | | Some students face difficulties in making sentences with newly-learned vocabularies at classroom lessons. | Teachers co-design the following learning process where students work in groups to (1) search online dictionary for the vocabulary; (2) pick a sample sentence using the vocabulary; (3) search for a photo depicting the sentence; (4) modify the sentence by referencing to other elements in the photo. |

Apart from classroom lessons, the taskforce also co-designed and integrated activities to reinforce students' authentic learning in daily life, i.e., to nurture their habit-of-mind in seamless learning. Two designs for these purposes are (1) Learning processes that encompass the full FSL cycle and tap on Chinese New Year and school vacation (*TPACK2-3*); (2) Out-of-school mobile learning trails to facilitate collaborative and contextualized language learning and applications (*TPACK2-4*).

Given the nature of DBR, ongoing refinements of the learning environment as triggered by emergent implementation challenges are inevitable. Thus, rapid (re-)prototyping of the platform was desired. However, the funding cycle prevented ongoing fine-tuning of MyCLOUD. This gave rise to the strategy as stated by a researcher, *"(In seeking for solutions to the emergent challenges,) we can hold TK as a constant for the time being, and seek for tweaking PK and CK variables."* Table 4 consolidates the proposed important enhancements on the forthcoming MyCLOUD 2.0 learning environment (in the 2nd DBR cycle) which emerged from the taskforce's tackling of challenges in Phase 2. The reporting of the 2nd DBR cycle is out of the scope of this paper as it has only started a few months before this paper is finalized (after we secured new development funding), with the MyCLOUD 2.0 platform still at its preliminary system design stage. We will report the implementation of and evaluation of the proposed enhancements in a future publication.

Table 4: Proposed enhancements in 2nd DBR cycle and MyCLOUD 2.0 platform

| Pedagogical/learning Design | |
|---|---|
| PCK3-1 | Develop systematic strategies to nurture students' habit-of-mind and skills in creating quality artifacts and being engaged in meaningful social interactions and peer reviews. |
| TPK3-1 | Derive effective principles or guidelines for teachers' presence in MyCLOUDNet communities, without overloading teachers. During the pilot study, teachers' involvement in student discussions were relatively ad-hoc. |
| TPACK3-1 | Employ flipped classroom-like strategy by asking students to learn and even apply certain vocabularies (e.g., to create artifacts) before the lesson. The artifacts could then be discussed in the classroom. |
| Technological Upgrades | |
| TCK3-1 | Advanced learning analytics to perform corpus analysis, social network analysis, etc. (To pick up what was left out in TPK1-3) |
| TPK3-2 | Insert a field under each student artifact on MyCLOUDNet to encourage the author to improve the text after peer discussion (not directly edit the original text) so that both versions of text are displayed to make the improvements explicit to all students. This is for facilitation of process-oriented writing (a TPK solution to TPK2-1) |
| TPK3-3 | Implement 'like' and 'badge' functions on the platform to boost student participation. (a TPK solution to PK2-1) |

## 5. User Evaluation

Throughout the study, the university researchers had been collecting various forms of data to continually evaluate the designed learning platform. The findings in students' learning processes and outcomes, and the participating teachers' development and perceptions on the learning environment are reported elsewhere (Aw et al., in-press; Wong, Chai, Aw, & King, in-press). In line with the aims of this paper, the results of the user acceptance survey are reported. As stated before, the 20-item, 5-point Likert-scale survey instrument developed by (Chen & Huang, 2010) was adopted and customized to the context of the MyCLOUD environment. The survey examines students' perception of usefulness (PU), perceived ease-of-use (PEU) and user acceptance (UA). The survey was administered to 259 students in the beginning of the 2nd DBR cycle. To test the construct validity of the survey, confirmatory factor analysis (CFA) was conducted. After removing 3 items with low factor loadings, CFA yielded satisfactory model fit indices ($\chi^2 = 250.57$, $\chi^2/df = 2.16$, $p < 0.001$, RMSEA = 0.067, CFI = 0.95, GFI=0.90) (Hair, Black, Babin, Anderson, & Tatham, 2010). Average variance extracted (AVE) and the composite reliability (CR) were computed to further examine the instrument and the results indicate that the instrument is valid and reliable. Table 5 below provides the means, standard deviation and factor loading, AVE and CR. The findings from the usability tests indicates that the primary 3 students perceive the MyCLOUD 1.0 environment as acceptable (UA=3.82), easy to use (PEU=3.92) and useful (PU=3.74), since all ratings are above the mid-point of 3. The general efficacy of the platform is thus supported.

## 6. Discussion and Conclusion

In this study, we developed and evaluated MyCLOUD, a learning environment for Primary school students' seamless Chinese Language learning. The researcher-teacher taskforce designed specific modules of applications that utilize technological affordances to support pedagogical strategies for seamless Chinese Language learning, based on their understanding of the students' current learning practices and shortcomings. Specifically, the taskforce drew upon their collective TPACK knowledge to

build the learning environment. Such a holistic consideration of learning environment design was well-manifested in a comment made by a researcher during a meeting (24 December 2010), *"We need to be wary whether this suite of applications will actually complement or distract students' learning. Although it may appear to be useful to have multiple tools on an integrated platform, the crux is what should be put inside. What we should introduce is a platform, not just a string of tools."*

Table 5: Mean, SD, Factor loadings, AVE and CR of the user acceptance test (n=259)

| Items | | Mean | SD | Factor loading |
|---|---|---|---|---|
| Factor 1: Perceived Usefulness (PU), AVE =0.59, CR =0.91 | | | | |
| PU1 | MyCLOUD is helpful to my learning. | 3.74 | 0.99 | 0.84 |
| PU2 | It's more efficient for me to learn Chinese in MyCLOUD. | | | 0.77 |
| PU3 | MyCLOUD can help me better understand Chinese vocabulary. | | | 0.81 |
| PU4 | The smartphone with MyCLOUD is good for learning. | | | 0.80 |
| PU5 | With MyCLOUD, I use Chinese more often than before. | | | 0.75 |
| PU6 | I learn good Chinese sentences and compositions from my classmates on MyCLOUD. | | | 0.60 |
| PU8 | I will continue to use MyCLOUD in Chinese learning in the future. | | | 0.80 |
| Factor 2: Perceived Ease of Use (PEU), AVE =0.52, CR=0.84 | | | | |
| PEU1 | MyCLOUD platform is easy to use. | 3.92 | 0.95 | 0.77 |
| PEU2 | MyCLOUD is a convenient platform for me to interact with my classmates. | | | 0.72 |
| PEU3 | It is easy to upload pictures to MyCLOUD platform. | | | 0.60 |
| PEU4 | It is easy to type in Chinese in MyCLOUD using smartphone. | | | 0.71 |
| PEU5 | I find it easy to do what I want to do in MyCLOUD, such as commenting on others' sentences. | | | 0.77 |
| Factor 3: User Acceptance (UA), AVE =0.52, CR =0.84 | | | | |
| UA1 | Learning Chinese using MyCLOUD is enjoyable. | 3.82 | 0.94 | 0.63 |
| UA2 | I like to make sentences in MyCLOUD. | | | 0.63 |
| UA3 | I like to interact with classmates in MyCLOUD. | | | 0.72 |
| UA4 | I like to post and share my interesting things in daily life in MyCLOUD. | | | 0.76 |
| UA5 | I enjoy reading the teachers' and peers' online comments for my work. | | | 0.83 |

Indeed, in the TEL field, many existing learning platforms were developed by pooling a variety of features without clear pedagogical considerations or design of learning flow to optimize the use of these functionalities. In designing MyCLOUD, we instead derived and mapped a variety of seamless language learning activities into the FSL framework to assist the students in establishing a coherent cross-space learning flow and experience. The three student-accessible modules of the platform were then designed to support the learning flow, particularly the bridging of formal (My e-Textbook) and informal (MyCLOUDNet) learning spaces (through Mictionary as the bridging module), individual (Mictionary) and social (MyCLOUDNet) learning spaces, and, learning amidst the interplay of physical and digital spaces during classroom lessons (using all three modules) and artifact creation tasks in authentic real-life settings (and subsequently posting on MyCLOUDNet and Mictionary).

Based on our qualitative analysis on the two-phased design process, whereas the entire design process was essentially underpinned by the researchers' TPK (by proposing the notion of mobile- and cloud-mediated seamless learning and sociocultural perspective of language learning to frame the design), the teachers' PCK that they established over the years of practice (students' learning preferences and difficulties, classroom dynamics and resource limitations, etc.) had been playing a crucial role in creating conducive conditions for a scalable and sustainable practice. Therefore, the eventual learning environment by the end of Phase 2 is a manifestation of newly created TPACK.

Thus, this paper contributes to the TEL literature not only in term of explicating the development of an innovative seamless language learning environment. It has demonstrated how the TPACK framework can be employed to guide the design of a holistic TEL environment that leverage distributed TPACK knowledge of researchers, practitioners and software developers. Through the collective design effort of the taskforce, an easy-to-use and useful platform that is well accepted by the 3rd graders was created. In terms of learning outcomes, we have also obtained some positive findings (Aw et al., in-press). Given these results, we would recommend TPACK as a common framework for researchers, teachers and software developers for the co-design of TEL environments. It is vital for TEL environments to be designed in consideration of pedagogy and content matters so that the system will possess higher ecological validity and therefore be useful in practice.

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