Making Tacit Knowledge and Practices More Explicit for the Development of TPACK

Meng Yew Tee and Shuh Shing Lee

Introduction

A teacher draws on a considerable amount of knowledge about the teaching and learning of a subject matter (Shulman, 1986), and how technology can play a role in the educational process (Angeli & Valanides, 2009a; Mishra & Koehler, 2006). Educational technology scholars have come to define this knowledge base as technological, pedagogical, and content knowledge (TPACK). When a teacher draws from this knowledge base, he or she may have understandings about teaching and learning that are not easily visible, as it is embedded in many layers of life experiences. These understandings may lay tacit until a particular situation requires its use. Some of these understandings can be positive, but others can be negative (Torff, 1999). For example, a teacher may have grown up on a staple of "*chalk and talk*" method of teaching, and over time, experienced reasonable success with such a method. As technology becomes more available, the teacher may intuitively transition into a "*PowerPoint and talk*" method of teaching. However, the teacher may not be fully aware that existing technology can be used to improve learning in ways that were not quite possible before. Even worse, the teacher may only be using technologies, because they have been forced onto him, or because they were made available and relevant training was also provided. Eventually, the teacher becomes a mere consumer of knowledge about technological tools, rather than one who is capable of using technology in ways that can improve learning (Koehler & Mishra, 2005).

Teachers, like the above example portrays, need opportunities to change their mental models. More specifically, according to Bransford, Brown, Cocking, and National Research Council (2000), teachers need opportunities to explore their

M.Y. Tee (✉) • S.S. Lee
University of Malaya, Kuala Lumpur, Malaysia
e-mail: mytee22@yahoo.com; lshuhshing@yahoo.com

C. Angeli, N. Valanides (eds.), *Technological Pedagogical Content Knowledge*,
DOI 10.1007/978-1-4899-8080-9_14

prior conceptions that drive their practices and try things out in the classrooms and then receive feedback. In addition, they also need opportunities to develop the capacity to judge successful transfer of a given technique to the classroom and its effects on student learning.

In other words, there is a need to create ways and conditions for teachers to encourage their tacit knowledge and practice to bubble up to the top, subject these to evaluation and feedback, and make necessary amendments for another trial run. We argue for a course design based on this idea, and a research that is guided by the following questions: Will such a design help teachers develop TPACK? If it does, how did this design help develop teachers' TPACK? How did the activities make teachers' misunderstandings (and understandings) more visible, paving the way for the development of TPACK? The conceptual foundation and how it can be operationalized are discussed in the following sections.

Conceptual Foundation of a Course Design

To cultivate a more robust TPACK base, the basic idea is to design a course for teachers, where they can make their conceptions toward teaching and learning practices visible to a community, and who can then have feedback for continuous improvement. One of the key challenges relates to how to facilitate the emergence of tacit pre-understandings, so that it can be evaluated by a community, and then adjusted and applied by the teacher for the purposes of developing more robust tacit post-understandings. It is this tacit understanding trajectory that differentiates this study from other studies on the development of TPACK (Angeli & Valanides, 2009b; Hammond & Manfra, 2009; Niess, 2011; Pierson, 2008).

To address this challenge, a number of assumptions must be explicated. Technological pedagogical and content knowledge (TPACK)—much like the knowledge involved in managing an organization (Tee & Karney, 2010) or teaching a room full of 7-year olds (Torff, 1999)—can include a significant tacit dimension. Much of TPACK can remain tacit for three primary reasons: (1) The knowledge base is too vast—the complexity of understanding human learning is a good example of the vastness and subjectivity of this knowledge base; (2) The context in which the knowledge base is utilized is extremely diverse—too diverse to be completely specified in advance; and (3) the constant fluctuation of the interaction between the context and the knowledge base that is being applied— "*every student-teacher interaction can change the teacher's goals and choice of operators*" (Bruer, 1993, p. 32) and the dynamics of the entire learning context.

Based on the above assumptions, it is argued that the pedagogical design must contain two key ingredients. First, it must put knowledge as well as practice in the forefront of the learning experience, so that tacit understandings can come to light in discussion and in practice. Experience alone is not enough and it must be combined with reflections, both of individual and collaborative nature (Dewey, 1933; Posner, 2005; Vygotsky, 1978). Second, it must create conditions and stimulate cycles of learning that account for the vastness of the knowledge base, the diversity of contexts, and the fluctuating interaction between knowledge and context.

Problem-based learning (PBL) was chosen to meet the requirements of the first ingredient. PBL was chosen, because it is a learning approach that requires intense discussions, reflection, and application. It is triggered by real-world complex problems and can be solved through a combination of collaborative, iterative, and self-directed activities (Hmelo-Silver, 2004). In the context of this study, Bransford and Stein (2002) IDEAL model was used to guide the classroom planning and management process. The IDEAL problem-solving process consists of five primary components: identify problems and opportunities; define goals; explore possible strategies; anticipate outcomes and act; followed by, look back and learn.

The details to meet the requirements of the second ingredient were found in Nonaka's work. Some scholars have argued that tacit knowledge cannot be captured in order to be transferred to somebody else, so that it can be converted to explicit knowledge for future consumption (Buckingham Shum, 1998; Polanyi, 1967). Tsoukas (2003) argued that tacit knowledge cannot be "*captured*" or "*converted*," but asserted that it can be displayed or manifested in what we do. Nonaka and his colleagues (Nonaka & Nishiguchi, 2001; Nonaka & Takeuchi, 1995; Takeuchi & Nonaka, 2004) took a differing perspective, arguing that knowledge can be converted or captured in several ways: from tacit knowledge to tacit knowledge (through socialization); from tacit knowledge to explicit knowledge (through externalization); from explicit knowledge to explicit knowledge (through combination); and from explicit knowledge to tacit knowledge (through internalization). According to Nonaka and Konno (1998), these knowledge conversions must take place in a *ba*, a Japanese character that basically means an overall shared condition. This *ba* is designed to energize the knowledge sharing and cultivating activities, by providing enabling conditions of autonomy, fluctuation and creative chaos, redundancy, requisite variety, and trust and commitment.

In relation to the design of the course, the *ba* can be operationalized in a number of ways. Students are given the freedom to act with relative autonomy, so that they can motivate themselves to experiment and discover new knowledge. Significant fluctuation and creative chaos are expected to grow from the deconstruction and reconstruction of rich and ill-structured real-world complex problems, largely to allow for the breakdown of old, encrusted mental models and routine behaviors and to make way for new ones. Numerous information sources can be made available to the students that go beyond of what they are accustomed to in classroom settings. This kind of information redundancy is expected to force students to learn how to discriminate the most critical information from the less important information. This is further accentuated by the principle of requisite variety, which calls for internal diversity to match the variety and complexity of its external environment. In this regard, the rich and ill-structured real-world complex problem investigated by teachers becomes a critical part of the design milieu. After all, effectively integrating technologies in the classroom is in itself "*a complex and ill-structured problem involving the convoluted interaction of multiple factors, with few hard and fast rules that apply across contexts and cases*" (Koehler & Mishra, 2008, p. 10). And finally, a culture of trust and commitment—such as, honest, but respectful communications and constructive feedback—was emphasized and practiced whenever possible.

In this regard, creating a *ba* is essentially about creating a condition, where there is an unifying form and ethos to share, stimulate, create and utilize knowledge, punctuated by the necessary energy, quality, and medium to perform the individual knowledge conversions in ongoing and interacting spirals of socialization, externalization, combination, and internalization (Nonaka, Toyama, & Byosiere, 2001; Tee & Karney, 2010). The place of creating a *ba* can be physical, virtual, or mental, or a combination of these forms, involving a network of people with common goals and aspirations. This concept is related to the work of Lave and Wenger (1991), who argued that knowledge, particularly practical knowledge, is situated. Knowledge exists in a social as well as a physical environment and is difficult, if not impossible, to be separated from its context (Bereiter, 2002). In this regard, the situativity as well as the individual and group processes of knowledge cultivation must be allowed to emerge, so that it can be subject to feedback, improvement, and change. In other words, more robust forms of TPACK can be cultivated through a series of PBL, social interaction, personal reflection and insight, and through different forms of experiential learning, where one's actions, or communications, are recursively emphasized, as new layers of knowledge are conceived (Tee & Karney, 2010).

In the following sections, we will describe an example of a course that was designed and implemented based on the set of principles and ideas discussed earlier.

Operationalizing and Researching the Course Design

Course Background

The students were enrolled in a 14-week course as a core subject in a master's program in Instructional Technology, or as an elective, for several other graduate programs in the School of Education. The students in the course comprised of 24 in-service teachers, with their ages ranging from mid-20s to early 40s. They taught at elementary, secondary, and tertiary levels, in varying subjects, including language arts (English language, Malay language and Chinese language), social sciences (history and business), and mathematics. Twenty-two of the 24 participants were women. All of them have been teachers for at least 1 year, with an average of 8 years of experience. This chapter reports the broad-based statistical data for the entire class, and specific quantitative and qualitative data for one of the groups that had adequate empirical data in relation to the research objectives.

Operationalizing the Course Design

As mentioned earlier, a PBL approach together with the Nonaka's SECI framework was used. Learning activities were based on the five PBL phases (I, D, E, A, L) complemented by *ba*-like conditions that were created to stimulate socialization, externalization, combination, and internalization.

Since socialization has to do with open as well as relatively unstructured dialogue and sharing, the instructor facilitated open-ended in-class discussions in every session and encouraged self-directed asynchronous online discussions. For example, students were asked to share stories from their everyday classroom experiences. The overall ethos tended to be less formal and low-stake in order to create conditions for facilitating the sharing of feelings, emotions, experiences, and mental models.

Externalization has to do with sharing to meet specific requirements, such as, negotiation and articulation of agreement of common terms, concepts, meanings, and ways of doing things. The sharing can be in the form of dialogue, writings, actions, or prototypes. The overall ethos is more formal than socialization (but not to the level of combination), with the stakes increasing (i.e., more concerned with do-ability). In the context of this course, activities to stimulate externalization included individual-written reflections and focused group discussions, as the participants prepared to propose a solution or implement their plan.

Combination has to do with synthesizing emerging knowledge bases to meet a specific need, in a way that is easily shareable with different audiences. In this regard, the students were asked to design and act on the best solution possible, tell their story in a way that was suitable for public consumption (i.e., group-based writing of a chapter for a wiki-based book), as well as to carry out their oral presentations in the presence of guests (e.g., teachers from other institutions).

Internalization has to do with engaging in action and reflection. As such, students in this course were asked to not only propose the best solution possible, but also to carry out what was proposed. They were also asked to reflect before, during, and after these activities, either orally or in writing.

The design of the course was operationalized roughly into four chronological segments. The first 4-week segment intended to give students time to provide context and meaning to the problems they were facing in their real-life teaching practice, with the initial discussions taking place in a Moodle-based discussion board, and later transitioning to a face-to-face setting. The problems had to be directly related to teaching and learning (as opposed to policy, management issues, or technical problems). The problems had to be complex, as opposed to being too simplistic (for example, the LCD projector in my classroom is unreliable). The problem preferably had to be common, or similar, to what two other people were also facing. The students worked in teams based on the specific problems they chose to own and work on.

The second 4-week segment was for the teams to consider different solutions, propose, and select a solution. The third 4-week segment was for each group to implement the selected solution in a pilot or full-blown situation, and subject it to further evaluation. The fourth and final 2-week segment was for students to present and discuss the process and outcome of the entire learning cycle.

Throughout the semester, approximately two of the 3-hour class sessions were used to share findings and suggest and justify ways forward. The remaining time was mostly devoted for collaborative meetings. The latter proved important as students found it difficult to find common times to meet outside the scheduled class

time, due to professional and personal obligations. Each group was required to write a chapter in an electronic book (e-book) project, using Wikispaces to document their on-going experience during the course. The wikis were accessible to all members of the class, but edits could only be made by respective members of each group. In addition, they were also requested to write, every 4 weeks, a two- to three-page reflection paper about what they have learnt during the process.

Five articles—including two articles on TPACK (Koehler & Mishra, 2005; Mishra & Koehler, 2006)—and two videos (including the "Did you know?" video made by Fisch & McLeod, 2009) were selected for focused discussions. Mini lectures and reflections by the instructor were given on an as-needed basis (Hmelo-Silver, Duncan, & Chinn, 2007), and the longest one—which occurred only once during mid-semester—went for approximately 45 min, while the shorter ones—which occurred throughout the semester—had a duration of about 3 or 4 minutes. Mini lectures were triggered by common and critical questions asked by different individuals or groups in the class. The instructor responded directly to the questions, or facilitated a discussion, that eventually led to a conclusion.

Researching the Course Design and Implementation

This study was carried out using an action research design (McNiff & Whitehead, 2002). This method is ideal to research how a course design can address a real life problem, in this case the development of TPACK.

The first author of this chapter was a participant observer, functioning as the course designer, the instructor, as well as the researcher. As with a typical action research process, four steps were taken: plan, act, observe, and reflect. The planning step was discussed earlier. In the subsequent steps, the design was carried out, while observations and reflections were done during and after the implementation. Five types of data were collected, namely: self-progress survey; learning reflections from the participants; progressing draft and final version of the writings and discussions in the wiki-based e-book; documents, records, and artifacts that reflect the overall design of the course; and the instructor's reflections. The self-progress survey initially developed by Schmidt et al. (2009) was utilized to gain an indicator of the participants' own beliefs about their abilities to teach with technology, as a result of the experience of going through the course. The results from the survey, administered at the beginning of the course, were compared with the results at the end of the course.

The remaining sources of qualitative data were coded and analyzed. Salient incidences were first identified. These incidences primarily had the following characteristics: description, discussion, and evaluation of past, present, and future practices of teaching and learning. Then, further analysis of all the data sources was done to identify the activities and conditions that led to the salient incidences, iteratively comparing with the conceptual framework discussed earlier, as well as to identify gaps, or details, not represented by the framework. Isolated incidences without

triangulated descriptions of triggering activities and conditions were put aside in order to focus on "*complete*" incidences that allowed for fuller narrative to emerge. In this study, credibility was addressed with four techniques: triangulation, prolonged engagement, persistent observation, and referential adequacy. The use of triangulation was particularly important to detect tacit aspects of TPACK. In terms of referential adequacy, all analyzed data were captured and documented in its original form. In addition, the data were coded by two coders (both authors). Problematic cases were handled carefully until consensus was reached.

Results and Discussion

This segment begins with reporting the results of students' evaluation of their own progress, based on a paper-and-pencil survey they filled out at the end of the course. An analysis and discussion of the qualitative results is presented thereafter. In this regard, the discussion revolves around one of the more successful groups that presented more salient data in relation to the research questions. The group is called Beemer and consists of five members (with pseudonyms of B1, B2, B3, B4, and B5). Their age ranged from 25 to 34, with an average teaching experience of almost 5 years. B1, B2, and B3 were language teachers, while B4 and B5 were in mathematics and instructional technology, respectively. The problem they identified revolved around B1's Year 9 students, who were struggling with learning Bahasa Malaysia, or BM (Malay Language). This happened to be the national language, but many of B1's students did not seem very interested in learning it.

Overall and Group Self-Progress Survey

The overall indicators—based on repeated measures *t*-tests—for the whole class showed that the teachers believed that their TPACK had improved, with a statistically significant mean difference of 1.09 ($p < 0.003$, $N = 24$) and a large effect size of 1.75 (as reported in Tee & Lee, 2011). The other sub-components that were measured also improved significantly (numbers in parenthesis indicate mean difference): TK (0.27), PK (0.62), CK (0.31), TCK (1.00), TPK (1.39), and PCK (0.63). The results for the Beemer group—as presented in Table 1—showed similar trends.

Similar to the measures for the whole class, Group Beemer's mean difference for technological knowledge (TK, group = 0.33 and class = 0.27) score was also the lowest compared to the other dimensions. Based on the qualitative data, there may be two possible explanations. First, the explicit awareness about their indirect learning of technology in itself may have been low. Second, the course was designed to emphasize how technology can be used more effectively in relation to the intended learning outcomes (content knowledge), pedagogical practices of the teacher (pedagogical knowledge), and how students were responding to the culmination of these

Table 1 Summary statistics of teachers' beliefs in using technology for teaching: Group Beemer versus whole class comparisons

	Group Beemer's mean at the START of semester	Group Beemer's mean at the END of semester	Group Beemer's mean difference	Whole class mean difference
TK	3.25	3.58	0.33	0.27[a]
PK	3.22	3.81	0.59	0.62[a]
CK	2.58	3.00	0.42	0.31[a]
TCK	2.50	3.25	0.75	1.00[a]
TPK	3.15	4.10	0.95	1.39[a]
PCK	2.50	3.00	0.50	0.63[a]
TPCK	2.58	3.75	1.17	1.09[a]

[a]Statistical significant difference, $p < 0.003$, $N = 24$

components in the classroom. As a result, some teachers learned to repurpose technologies that they already knew how to use. For example, B3 said that she was a regular technology user and had taken more than five technology courses, and thus was already quite comfortable with technology, but have yet to learn how to use technology effectively in the classroom.

Students' understanding of the relationships between technology and content (TCK), the relationship between technology and pedagogy (TPK), and the relationship between technology, pedagogy, and content (TPACK) improved over time. Most notably, Group Beemer's mean difference of 1.17 was higher than the mean difference of the whole class, which was found to be 1.09, providing a strong indication that the teachers in Group Beemer believed that their TPACK improved. The questions that remain are: how did the design of the course help develop teachers' TPACK? How did the activities make teachers' misunderstandings (and understandings) more visible, paving the way for the development of TPACK?

Socialization Leading to Re-evaluation of One's Teaching

Active socialization exchanges allow for relatively open sharing of feelings, emotions, experiences, and mental models, creating opportunities for the development of trust and rapport (Nonaka et al., 2001; Tee & Karney, 2010). Some very clear indicators of these kinds of exchanges were apparent in Group Beemer early in the semester.

In the first 4 weeks of the course—as the teachers talked about the problems they were facing in their classrooms—B1 expressed her heart-felt frustration in teaching her students. She said that she felt like giving up and was on the verge of tears, when she explained the different teaching approaches that she had attempted with little success ("*Actually, I almost gave up on teaching the class… The students are very weak in BM*," [translated] B1 said in exasperation). Her students were not engaged,

showing little or no interest in learning the language. The moment was so intensely disheartening that weeks later, one of the group members—B2—wrote about B1:

> I still remember the face of B1 when she started talking about her case, she looked so hopeless that I felt we had to think hard and give her good and refreshing ideas.

Here, we also realized how sharing of feelings can begin to energize the socialization and externalization process. Somewhat out of desperation, B1 went back to the drawing boards. She began to re-evaluate her own teaching and the way she related with her students. She wrote about this in her reflections:

> When the group studied my case, I found many weaknesses in my teaching and learning approach. It also affected my students' interest in learning. From the discussions, I realized that I was far behind with no improvement, and always holding on to the "chalk and talk" method.... While discussing my problem, I also realized that I needed to take my students' background into consideration. (Translated)

Here, a number of pre-understandings were beginning to bubble up to the top, allowing them to be subjected to evaluation and feedback. For B1, at this point, there was a realization that didactic methods might not always work, and a recognition that perhaps her choice of pedagogy was dependent on how the students responded. The other members of the group also began re-evaluating the role of the teacher. B3, for example, reflected about ceasing the tendency to blame the students and instead to consider different ways to help improve students' understanding. B2 reflected about being challenged by the authentic situation they were facing as a group, and the need to figure out a way to make meaningful learning for the students:

> What to do then? It seems we always have to go back and recheck and ask ourselves: is this going to help my students? Is this (the) right approach to take? How will this work with my students? At the end, it is about making learning meaningful for them.

By the fifth week, after a series of investigations chronicled through videos and descriptions in the eBook, B1 reflected about her inability to reach out and motivate her students to fully engage in the learning process, but was thankful for a supportive group ethos. Still, the problem continued to pose a significant challenge. As B3 wrote, here we see again tacit pre-understandings emerging in the forefront allowing for remediation:

> Finding the root problems of B1's case was not easy, because there were several factors to be considered, but, at the end, we realized that the most significant factors for our root cause were: how lack of… (basic proficiency and) vocabulary prevented the students from learning, and how their attitudes toward (the subject) was careless, since (it was) not meaningful to them.

The two researchers reflected that these candid evaluations were quite unique to this group, especially at the early stages of the semester. By contrast, the other groups in the class were mired for a longer period of time in a "*blame the students*" mental model—or what Biggs (1999) referred to as *Level 1 approach of teaching*. At this level, according to Biggs (1999), the teacher still has strong feelings that this is just the way the students are—they either could learn, or could not learn. Group Beemer's mental model, however, moved quickly to Level 2, where the focus was on "*what the teacher does*" (Biggs, 1999). Two key factors probably contributed to

this—B1 was desperate for change, and her group members responded in a candid but supportive way. In this climate consistent with the intended design of the course, they were galvanized to make their tacit pre-understandings visible, and thus, open up opportunities for remediation, and, in the process, deconstruct and reconstruct the problem as well as their existing mental models, while they deliberated on the predicament they were facing. In this regard, the socialization *ba* also seemed to be taking shape quite well, as this was evident from their willingness to share their experiences and feelings even from potentially vulnerable situations.

Externalization of Goals and Synthesis of Emerging Ideas

Externalization has to do with articulation, negotiation, and development of common terms, concepts, ways of doing things, and meanings (Nonaka et al., 2001; Tee & Karney, 2010). The members of the group were motivated to solve the problem they were facing, but now they had to figure out a way they were going to approach the nitty-gritty task of problem solving. They used the TPACK framework from their readings, and with the urging of the instructor, to make sense of the source of the problem. For instance, this is what B1 wrote in her reflection paper:

> I found out that TPACK is very important in each case. This framework helps each group to investigate their case according to the content—are the learning objectives being met and is it suitable for the students? Were the pedagogies used appropriate for the students? How deep is the teacher's knowledge for that particular subject and what about students' prior knowledge? And, ultimately can we identify suitable technologies to teach the subject (translated)?

As their exploration for possible solution progressed, a more nuanced understanding began to emerge, as they began to recognize the importance of deconstructing their pedagogical practice and options (PK), followed by how technology can support the learning needs, as can be seen in B4's reflections:

> Actually, in our case we are trying to use the TPACK framework with more emphasis on PK. For instance, we use different strategies for teaching… (different from) those strategies that were used by the teacher previously. We tried to use technology to change the students' attitude (towards acquiring a second language)…

As they visited B1's class to observe and collect data, the group began to recognize that B1's students were mostly uninterested in learning the subject matter. The group's priority began to focus on increasing motivation and relevance. First, the group recommended a change from a chalk-and-talk approach to a more active and practical language laboratory setting. Secondly, B2 and B4 went into B1's class as guest speakers to talk and share thoughts about the benefits of bilingualism. The group also tried other means to motivate the students:

> We utilized a ticket and rewards system for the students. Changing the learning environment by taking the student to the language laboratory, where all the chairs and tables are arranged according to different groups… The outcome was very good.—B1

B1 students' positive response to the different approaches reinforced the need for change. It sent a clear message that the right kinds of change can lead to more positive consequences. It was at this point when the group seemed to be more hopeful in their outlook.

Soon, four more lesson plans were developed to help students achieve the intended learning outcomes. It was this phase where the process of combination or synthesis was the most active as the group began attempting to systematically organize and prepare to apply their solutions that were derived from diverse knowledge bases. The following is an account from the group's e-Book entry of what began to transpire with one of the lesson plans:

> B3 told us about comics as a possible solution… (citing a paper by Ujiie & Krashen). According to the authors, comic book reading is associated with reading for pleasure for the children. Knowing that students don't feel so inspired to learn BM … It will be a good idea to use comics to engage them in reading and writing. Using http://www.makebeliefscomix.com/Comix/, or a similar website, students will be able to create their own comics using BM.... After they finish their comic, they can either print or email to others their comic (strip).

This signalled a more purposeful use of technology. They drew from Krashen's work to use comics to re-engage their students. Instead of giving comic strips to their students, they asked them to create strips in the Malay Language, meant to be shared with their classmates. The researchers noted that this shift to focus on learning outcomes is consistent with what Biggs (1999) refers to as "*what the student does*" approach of teaching, or *Level 3*, where the focus is on using teaching-learning activities to help students attain desired depth of understanding. In other words, the focus is on what students learn. This is a significant mental model change, and also signalling again an emerging knowledge base that is consistent with TPACK.

Internalization in Action and Reflection

Internalization occurs through a series of action and reflection, with the support of the other key processes—socialization, externalization, and combination—and vice versa, usually involving an ongoing culmination and refinement of one's knowledge (Tee & Karney, 2010). In other words, none of these processes is sufficient alone and all must be present to feed off each other (Nonaka et al., 2001). The members of Group Beemer engaged in these processes, as they dealt with a common problem, analyzed the problem situation, discussed possible solutions and eventually acted on an agreed upon decision, and prepared themselves to respond to what transpired.

In the early weeks of the course, the overall ethos was quite bleak. B2, for example, wrote: "*None of us in the team were excited nor hopeful for B1's students, when we first started…*" But a sense of hope grew from the collaborative work. As B1 wrote that when she shared new teaching problems with her group members,

it gave her a "*new energy to improve her teaching*." This "*new energy*" clearly reflects the importance of a galvanizing *ba* that occurs in effective socialization and externalization. Later, in her final reflection, B1 wrote:

> At first starting this e-book project (on wiki), I wasn't sure it would change my students' attitude towards BM, however, there have clearly been changes after we used ICT in the teaching and learning process. They are more active in class and they are more earnest in doing the task given to them (translated).

In the following closing narrative, take particular note of the series of social interaction, personal reflections and insights, and through different forms of experiential learning, where a variety of tacit pre-understandings emerged in actions and communication, thus allowing for remediation activities and creating new layers of more robust knowledge. B1, for example, began to be inspired in terms of attitude and the development of new ideas. B2's observations captured these changes in B1:

> I noticed that by sharing her case with the class and with our team, B1 didn't feel so hopeless as before, and I started noticing she was gaining a sense of hope again. The following week, I kept observing B1's attitude towards her case and how she was gaining her lost confidence, and getting full of new ideas and energy to implement them.

B1, who had rarely used technology for her teaching in the past, began implementing new ideas that emerged from her group discussions as well as from class discussions:

> From dealing with each of our case problems, I think it helped create greater awareness of one's own teaching and learning weaknesses and ways to overcome them. For example, the use of online games in Mathematics used by Iza (from another group in the class), indirectly attracted the interests of students who were weak in the subject.

B1 also wrote that she would share the various new ideas with her colleagues at work. Clearly, the learning was not limited to B1. For example, B3 expressed a more robust TPACK in her reflections:

> Sometimes, we will get excited about a new tool that we have seen and our first reaction is… that is the solution to our problems, and then when we think more critically, we realize that may be it is not.

B2, in her final reflection, wrote this:

> At the beginning, we were not very clear about the use of technology, basically because we were thinking that technology by itself was an excellent tool to use in teaching, but, as the class progressed, we realized that we had to focus first on the analysis of our situation and choose the right technology only after doing the whole analysis of the teaching and learning scenario.

A more nuanced TPACK also emerged in B2's reflections:

> By learning from the other groups as well, we realized that may be some technological tools that worked well with a group of students may not work the same way with others, and that is why it is important to work using the framework to not get lost in the process, by the sense of novelty of new and attractive technologies.

Learning Through PBL and SECI

The SECI-based PBL process has created ways and conditions for the teachers' tacit knowledge and practice to bubble up to the top, and thus allowing for evaluation and feedback, followed by improvements for another trial run. It opened up opportunities for the in-service teachers to re-evaluate their teaching practices, to rethink the nature of the subject that they were teaching, and how technology might play a role to support the learning of the subject matter. For example, the teachers began to realize that technology in itself is not likely to improve ineffective teaching practices.

Much of the class was designed with the intention to create a helpful environment for the purpose of stimulating SECI. Socialization and externalization were largely manifested in the form of class discussions, occasional online discussions, and out-of-class group discussions. Both externalization and combination can be seen in the wiki-based e-book project and higher-stake presentations at the end of the course. Internalization was stimulated in the implementation and reflections in class, and in the reflections they were writing for the course. About two thirds of the scheduled class time was used to encourage students to present where they were at, and more importantly, justify their diagnosis of the situation, as well as justify their way forward. The overall milieu—as the accounts presented above suggest—enabled conditions of autonomy, fluctuation and creative chaos, redundancy, requisite variety, and trust and commitment.

This study provides some important guidance on designing a course for the development of TPACK. However, to be able to further extrapolate, similar studies need to be done in different types of classes involving different demographics. In addition, more explicit data are needed to track the importance of the *ba* qualities to the knowledge cultivation process. Pedagogically, in a broader class context, one of the more serious issues was that at least five of the 24 individuals took on minimalistic or passive roles during collaborative work. Further iterations of these kinds of studies are required to better understand why this occurred, and how it can be remedied.

Conclusion

This chapter argues that the PBL approach guided by the SECI model (Nonaka et al., 2001; Tee & Karney, 2010) can help in-service teachers cultivate technological pedagogical content knowledge. Within this design, the teachers were given opportunities to make explicit their prior conceptions that drive their practices, re-evaluate them within a supportive community, and to try new things out in the classroom and then receive feedback again for continuous improvements. In all, various different technologies were learned throughout the course, including wikis, blogs, videos, and picture editing tools, as well as online games. Several tools, such as

PowerPoint (as students' storytelling tool) and camera video phones (to record students' creative works to post online for their friends and parents to view), were repurposed to stimulate learning.

Most importantly, the in-service teachers demonstrated a more nuanced and tacit understanding of the complex interplay between the three basic components of knowledge—content, pedagogy, and technology. They demonstrated in their implementation of solutions that they understood the need to use a combination of pedagogical methods and technologies that give the students the best opportunities to achieve the intended learning outcomes.

Acknowledgments The authors would like to thank the participants for making this study possible. This work was funded in part by the University of Malaya Research Grant.

References

Angeli, C., & Valanides, N. (2009a). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*, 154–168.

Angeli, C., & Valanides, N. (2009b). *Examining epistemological and methodological issues of the conceptualizations, development and assessment of ICT-TPACK: Advancing Technological Pedagogical Content Knowledge (TPCK)—Part I. Teachers*. Paper presented at the meeting of the American Educational Research Association (AERA) Annual Conference, San Diego, CA.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Erlbaum.

Biggs, J. (1999). *Teaching for quality learning at university*. Buckingham, England: Open University Press.

Bransford, J., Brown, A. L., Cocking, R. R., & National Research Council. (2000). *How people learn: Brain, mind, experience, and school* (Expandedth ed.). Washington, DC: National Academy Press.

Bransford, J. D., & Stein, B. S. (2002). *Ideal problem solver* (2nd ed.). New York: W.H. Freeman.

Bruer, J. (1993). *Schools for thought: A science of learning in the classroom*. Cambridge, MA: MIT Press.

Buckingham Shum, S. (1998). Negotiating the construction of organisational memories. In U. M. Borghoff & R. Pareschi (Eds.), *Information technology for knowledge management* (pp. 55–78). Berlin: Springer (Reprinted from: *Journal of Universal Computer Science, 53* (58), 1997, 1899–1928).

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Boston: D.C. Heath.

Fisch, K., & McLeod, S. (2009). Did you know? 2.0 [Online presentation]. Retrieved February 1, 2009, from http://shifthappens.wikispaces.com

Hammond, T. C., & Manfra, M. M. (2009). Giving, prompting, making: Aligning technology and pedagogy within TPACK for social studies instruction. *Contemporary Issues in Technology and Teacher Education [Online serial], 9*(2). Retrieved from http://www.citejournal.org/vol9/iss2/socialstudies/article1.cfm.

Hmelo-Silver, C. (2004). Problem-based learning: What and how do students learn. *Educational Psychology Review, 16*(3), 235–266.

Hmelo-Silver, C., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller and Clark (2006). *Educational Psychologist, 42*(2), 99–107.

Koehler, M. J., & Mishra, P. (2005). Teachers learning technology by design. *Journal of Computing in Teacher Education, 21*(3), 94–102.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Eds.), *Handbook of technological pedagogical content knowledge for educators* (pp. 3–30). New York: Routledge.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

McNiff, J., & Whitehead, J. (2002). *Action research: Principles and practice* (2nd ed.). London: Routledge.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44*(3), 299–317.

Nonaka, I., & Konno, N. (1998). The concept of "ba": Building a foundation for knowledge creation. *California Management Review, 40*, 15.

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge emergence: Social, technical, and evolutionary dimensions of knowledge creation*. Oxford, England: Oxford University Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Nonaka, I., Toyama, R., & Byosiere, P. (2001). A theory of organizational knowledge creation: Understanding the dynamic process of creating knowledge. In M. Dierkes, A. Berthoin Antal, J. Child, & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 491–517). Oxford, England: Oxford University Press.

Pierson, M. E. (2008). Teacher candidates reflect together on their own development of TPCK: Edited teaching videos as data for inquiry. In K. McFerrin et al. (Eds.), *Proceedings of the society for information technology and teacher education international conference* (pp. 5305–5309). Chesapeake, VA: Association for the Advancement of Computing in Education.

Polanyi, M. (1967). *The tacit dimension*. London: Routledge & K. Paul.

Posner, G. J. (2005). *Field experience: A guide to reflective teaching* (6th ed.). Boston: Pearson.

Schmidt, D., Baran, E., Thompson, A., Koehler, M. J., Mishra, P., & Shin, T. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123–149.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–31.

Takeuchi, H., & Nonaka, I. (2004). *Hitotsubashi on knowledge management*. Singapore: Wiley (Asia).

Tee, M. Y., & Karney, D. (2010). Sharing and cultivating tacit knowledge in an online learning environment. *International Journal of Computer-Supported Collaborative Learning, 5*(4), 385–413.

Tee, M. Y., & Lee, S. S. (2011). From socialisation to internalisation: Cultivating technological pedagogical content knowledge through problem-based learning. *Australasian Journal of Educational Technology, 27*(1), 89–104.

Torff, B. (1999). Tacit knowledge in teaching: Folk pedagogy and teacher education. In R. J. Sternberg & J. A. Horvath (Eds.), *Tacit knowledge in professional practice* (pp. 195–214). Mahwah, NJ: Lawrence Erlbaum.

Tsoukas, H. (2003). Do we really understand tacit knowledge? In M. Easterby-Smith & M. A. Lyles (Eds.), *The Blackwell handbook of organizational learning and knowledge management*. Malden, MA: Blackwell [Electronic source: http://is.lse.ac.uk/Events/ESRCseminars/tsoukas.pdf].

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.