Supporting Teacher Learning for Pedagogical Innovation through Collaborative Co-Design: Issues and Challenges

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Abstract: This study reports on an in-depth analysis of two teachers' implementation of one collaboratively designed curriculum unit in the context of the school's participation in an e-learning initiative to integrate ICT use in the grade 5 General Studies curriculum. The analysis reveals significant differences in the actual implementation as well as in the students' learning outcomes achieved. While both teachers ventured beyond their comfort zone to provide more opportunities for student interactions and explorations, the enacted implementations reflect differences in the learning goals they targeted and their knowledge of practice. Visualizations of learning analytics did not trigger further exploration among teachers, though these reveal strong links between learning outcomes and the enacted curriculum. Findings raise questions about collaborative instructional design as a model for organizing teacher learning for pedagogical innovation, and the paper proposes design principles and further research to better facilitate innovation-focused professional development.

Introduction

There is much in the literature about the challenges to changing teachers' pedagogical practices, whether ICT is involved or not (Fullan, 2007; Hargreaves, 2000) The present study is concerned with promoting teacher adoption of more student-centered, inquiry-oriented pedagogies in their everyday practice, using ICT integration as a key leverage for pedagogical change. It is a design research conducted in the context of a government funded e-learning pilot project a school was awarded to carry out, and for which the research team was contracted by the school concerned to provide professional development and consultation service. A team design approach (Koehler, Mishra & Yahya, 2007) was adopted to foster the teachers' development of technological pedagogical content knowledge (TPACK, Koehler & Mishra, 2005) needed for the implementation as the teachers had been using rather traditional, teacher-centered delivery methods, and ICT use was primarily confined to teachers' use for whole class presentation purposes. In this design study, in line with the focus of the government pilot scheme to foster pedagogical transformation through e-learning implementation, the professional development focus was on learning design—the identification of learning goals and the design of appropriate teaching and learning activities that provide learning experiences conducive to student attainment of those goals (Goodyear, 2005). The knowledge and skills needed for the development of digital learning resources/online activities is not included in the professional development plan.

An important principle for design research is the need to be sensitive to the local context and to respect and nurture the agency of the teachers concerned. The teachers involved here were novices with regard to e-learning, and they did not have a clear understanding or expectation of the transformative potential of ICT. While the teachers were willing to take part in the pilot project, they were worried about their own technological competence and the workload involved. Hence the design principles adopted and the actual socio-technical design for teacher learning took account of the contextual constraints.

The focus of the present study is on identifying evidence of teacher learning throughout the design and enactment process of the technology-enabled, blended lessons in order to assess the effectiveness of the design principles for teacher learning adopted and how these could be improved. In this study, all five teachers were enacting the same curriculum unit design agreed upon after participating in a collaborative co-planning process. Given this scaffolded collaborative design process, would the teachers' implementation be largely the same, and how may they differ? What are the conditions, if any, for such teams to engage in sustained teacher learning and continuous improvement in professional practice? These are the research questions that this study addresses.

Literature Review and Conceptual Framework

Mishra and Koehler (2005) identify seven types of teacher knowledge for effective integration of ICT use in teaching and learning: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and technological pedagogical content knowledge (TPCK or TPACK). While there is no common agreement on the nature of TPCK as a theoretical construct, nor is there a commonly adopted set of measurement for TPCK (Voogt et al., 2012), there is general consent that the intersection and interaction between these three areas of knowledge and performance are important in the development of teacher competence to integrate ICT use in their teaching.

For teacher learning provisions to be effective, they have to be coherent and meaningful within the teachers' professional contexts. Koehler and Mishra (2005) reported significant advances in teachers' TPCK when they engage in the collaborative design of online courses. The design process provides participants with an authentic and engaging context to exercise their own creative agency, and the designed course materials become a reification (Stein & Coburn, 2008) that can mediate further learning through teachers' implementation practice. Design research (Brown 1992) has been found to be an appropriate model for supporting teacher learning as it can be designed to address three key challenges encountered in designs for teacher learning: the need to collaborate within the institutional context of the school, the need to trace and document individual as well as group level learning, and the need to provide an authentic context to link the teacher learning with their classroom practices (Cobb, Zhao & Dean, 2009). Design research is particularly suited when the teacher learning for technology integration aims to foster pedagogical change in the context of school reforms (Holland 2001). Penuel et al (2007) further found that the incorporation of lesson planning time and the provision of technical support were important for promoting implementation.

In the present study, the university-based research team was invited by the school to provide professional development support to help teachers integrate ICT use in their teaching of the school curriculum, and to conduct formative evaluation of the school's e-learning pilot implementation. Design-based research was adopted. Each cycle of learning is centered around the design and implementation of an e-learning curriculum unit. e-Learning in this context refers to the integration of online student learning activities to be completed individually or in groups within or outside of the timetabled class teaching time. To facilitate this mode of e-learning for novice teachers and learners, the researchers provide a Moodle-based learning management system (LMS) customized for young learners for the school to implement their blended learning curriculum units.

In designing the present study, the research team is guided by the following design principles:
1. The ultimate decisions on the design of the e-learning curriculum unit to be implemented rest with the school teachers to ensure its intelligibility, feasibility and acceptability to the culture and norms of the school (Fishman et al., 2000).
2. The teacher learning interactions should focus on the conceptual aspects of learning design (i.e., the selection and deployment of learning activities and associated online resources and tools for the targeted learning objectives) and skills in classroom implementation. To reduce the cognitive stress and workload for teachers, the installation of the designed learning activities and digital resources on the LMS are to be carried out by the research team.
3. Accessibility of technical support—hotline and email support for LMS operations.
4. Analyses of students' learning processes and outcomes will be used as a main form of feedback to scaffold teacher reflection on practice and further learning.

The Design Study

This design-based research was conducted in the form of a school-university partnership initiated by a primary school requesting school-based professional development and technology support for the implementation of the school's e-learning pilot project. The school was located in an area of relatively low SES and did not have a strong record of e-learning implementation. The predominant pedagogy was teacher-centered instruction, but both the principal and the teachers were keen to take advantage of the funding support provided to pilot schools to make advances in the pedagogical adoption of ICT. Each pilot project funding application had to identify the pedagogical focus, targeted outcomes and an implementation plan. This school identified the fostering of students' information literacy skills as recommended by the Education Bureau in Hong Kong (EDB 2005).

Grade 5 General Studies (GS) was selected by the school for e-learning implementation in the 2012-13 school year. All of the five in-service teachers teaching grade 5 GS in this school participated in the study. The collaborative design took an iterative process, led by the pilot project coordinating teacher, who was also one of the five grade 5 GS teachers. The teacher team selected the curriculum unit on *Fostering a Positive Attitude Towards Life* for e-learning implementation in the 2012-13 school year. Figure 1 is a graphic representation of the design study process undertaken, based on the design principles described above.

Based on design principle 1, the research team invited the teachers to provide an initial e-learning curriculum unit design they would like to implement based on their prior curriculum design. Three cycles of interaction took place between the coordinating teacher and the university team. During the first iteration, the researcher input focused on converting the essentially teacher directed curriculum plan to include inquiry-oriented individual and group-based student activities to foster student engagement, after which the coordinating teacher provided a revised unit plan. A second iteration of coordinating teacher-university researcher interaction took place that focused on providing ideas for further e-learning refinement. The coordinating teacher then submitted a finalized e-learning unit plan to the research team, who then implemented the e-learning component of the curriculum unit design into five separate but identical courserooms on the LMS, one for each of the five classes. A face-to-face team planning meeting involving all five GS teachers and the research team member then took place, during which the courseroom features and activities were introduced. The courseroom activities

were further refined after the meeting for actual deployment, based on the teachers' concerns and suggestions. The curriculum plan involved two double periods (each class period was 35 min) in the computer laboratory, and an optional single period for extension activities to be decided by the class teacher concerned.

The university-based researchers observed all the five teachers' classroom enactment of the final curriculum plan. The courseroom activities for all five classes were identical, which also served as a reification to mediate the implementation of the agreed curriculum plan. Videos were taken during the lesson observations. A student focus group interview and a teacher interview were conducted for each class right after the second double period. A short debriefing meeting was also held with all five teachers shortly after the completion of the curriculum unit. Three months after the completion of the teaching, a meeting was scheduled between a research team member and the teachers to review the graphic visualization of analyses of data from the LMS server that provide information about students' learning processes and outcomes for the five classes.
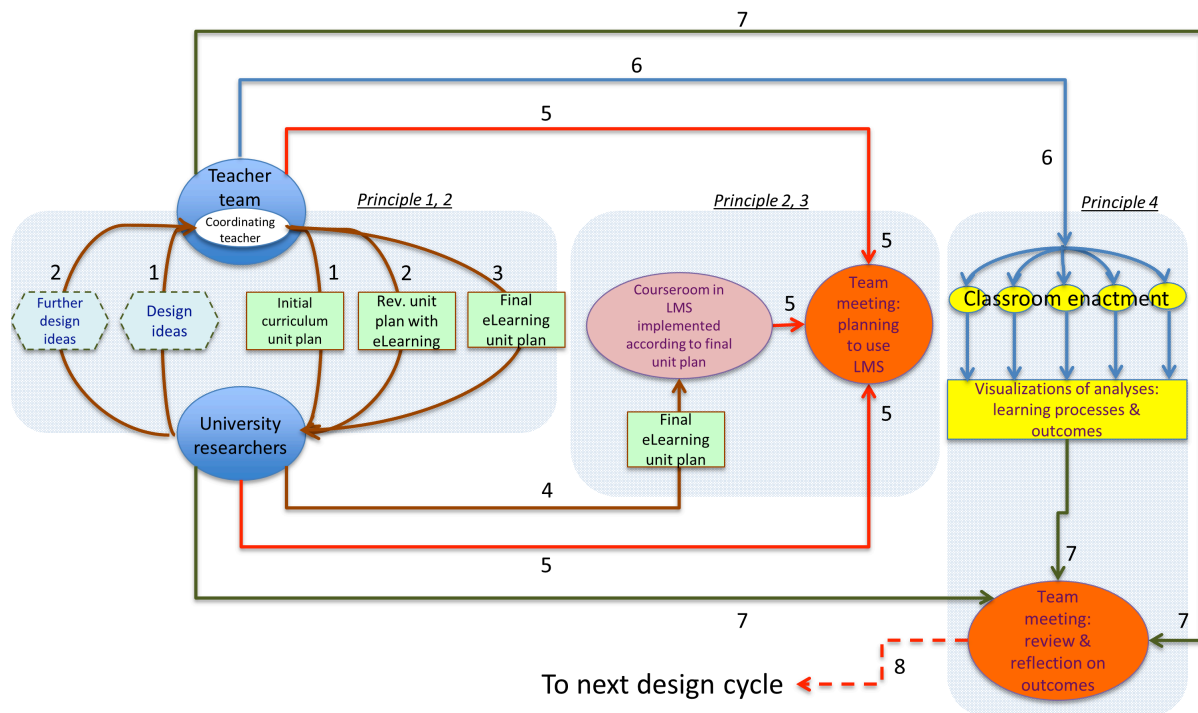

Figure 1. A graphical representation of the design research cycle implemented by the research team.

Design of the Curriculum Unit and Data Sources

The curriculum unit submitted by the teachers included a listing of the specific learning objectives for the unit, which remained unchanged throughout the study: I. set personal goals and develop an executable plan to achieve the goals, II. adopt a positive attitude towards stress and setbacks, and III. help others to adopt a positive attitude towards life. The basic learning design for the finalized curriculum unit was to use two contrasting cases, a hikikomori youth (1) and a "reborn hero"(2), to stimulate students' discussion and reflection, in order to foster in students a positive attitude towards difficulties and challenges in life. Table 1 presents the designed learning activities for the first of two 70 min. lessons in this curriculum unit. The plan clearly shows that the planned use of ICT was to support student sharing and exploration of ideas. Four types of digital tools are involved: a YouTube video for viewing by the whole class, an online discussion forum for students to post and share ideas, an online voting tool that provides an immediate summary of the class responses and a wiki for each group to review and consolidation what they have learnt. At the end of the second lesson, students were asked to share their thoughts and reflection on their learning experience using a blog in the LMS used in this course.

Analysis and Findings

In this section, we report on teachers' learning as reflection during each of the three phases of the design study process: the curriculum design phase, the enactment phase and review of learning analytics visualization of students' learning processes and outcomes.

Teacher Learning During the Design Phase

The design phase includes steps 1, 2, 3 and 5 of the design cycle in Figure 1. During steps 1 to 3, the research team interacts with the teachers through the coordinating teacher. Hence it is not possible to differentiate

learning at the individual level from the group level. The initial curriculum unit was based on the teaching plan used in the previous school year, which was strongly influenced by the textbook. The design focus was on including computer-based activities to provide opportunities to learn information literacy skills such as defining, accessing, managing, integrating, evaluating and communicating information. There were three major learning activities in the initial curriculum unit that focused on getting the students to develop their own personal goal: learning about the life cycle of the butterfly as an introduction to changes in one's life journey; identify a personal goal and to developing a personal plan for its achievement; and to develop a better understanding of various stages in one's life journey through studying the life events of a reborn hero. The e-learning activities included were mainly searching, selecting and presenting information connected with these tasks. The researcher input encouraged the teachers to focus on the social affective aspects of the targeted learning objectives and to include more sharing and group interactions among students. An example of a unit with a similar set curriculum objectives designed and implemented by teachers in a local secondary school was introduced to the coordinating teacher for reference. That example unit used two contrasting cases as a pedagogical anchor, a hikikomori youth and a reborn hero, and details of the design were publicly available from a webpage.

Table 1. Sequence of learning activities for the two 70 min lessons based on the teaching plan finalized by the coordinating teacher after the co-planning team meeting.

Sequence	Activity type	Description
Lesson 1		
1.1	Investigate	Students asked to investigate unhappiness by sharing with the whole class their unhappy moments, and discuss how they handle unhappiness.
1.2	Watch	Students watch a TV documentary (YouTube) on a hikikormori youth, Ar Yuen.
1.3	Discuss—online forum	Students share their feelings about the video, discuss why Ar Yuen isolated himself, whether and how Ar Yuen should connect with the outside world.
1.4	Investigate	Students vote online on the problem that troubles them most from a list: academic results, relations at school, relations with family, friends, money matters. Teacher review voting results in class, invite students to elaborate on the problems they experienced, and whether they had tried to isolate themselves under those circumstances.
1.5	Produce—online	Students work in groups of three on a wiki to describe: what problems trouble them most and how they solve those problems.
Lesson 2		
2.1	Discuss-whole class	Students asked to summarize the problems they encountered as reflected in group wiki entries.
2.2	Watch	Students watch a YouTube video on one "reborn" hero.
2.3	Discuss—online forum	Students to post their feelings about the reborn hero in the video.
2.4	Investigate & produce online	Students work in groups to search for further examples of reborn heroes online and select one to write about on their group wiki and reasons for their choice of hero.
2.5	Online peer assessment	Students peer assess other groups based on an online rubric and vote for the best group wiki.
Lesson 3—optional		
3	Reflection blog	Students post reflections on their learning in the unit using the LMS blog module.

The revised design submitted by the coordinating teacher was very close to the example design. The teachers decided to drop the activities related to the butterfly life cycle and the development of a personal goal and plan, and adopt the use of two contrasting cases as the design anchor. In the second round of interactions between the research and the teacher teams, the focus was on clarifying the intended function of the e-learning activities included and to reduce the number of different online activities within the same lesson to ensure that the plan was feasible. Hence, the finalized plan did not differ much from the plan previously submitted.

Step 5 in Figure 1 was the final step in the design and planning process. During this meeting the teachers were shown a sandbox courseroom on the LMS with the planned online activities set up for them to explore. During this meeting, the main concerns expressed by the teachers were how to navigate and manage the different activities, and whether the students would be able to handle the various online activities according to the plan. There was no discussion on the appropriateness of the overall pedagogical design. The teachers spent much time on mastering the technical skills of navigating and using the LMS, which was totally new to them. Towards the end of the meeting, several teachers expressed their lack of confidence in helping students to use

the e-portfolio system provided, Mahara, for their students to create their group report on a reborn hero in the second lesson. The research team then eliminated the need for students to work on two platforms (though linked through single sign-on), and created a group wiki in the LMS course room for the task.

To summarize, the teachers exhibited openness to trying out new pedagogical designs and technology tools, while still harboring much anxiety in the process. This is an important first step in teacher learning.

Teacher Learning During the Enactment Phase

As the curriculum design required all students to have access to an internet-connected computer during lessons, it was necessary to schedule the classes at times when the computer labs were available. In the end, the teachers decided that the best time was to conduct the classes during the post-examination period when teachers were able to flexibly schedule different activities. They booked both computer labs available in the school for two whole days and schedule the two double period lessons on the two days. This was very convenient for the research team as all lesson observation and interviews could be completed in two days. On the other hand, the teachers did not attempt to engage in peer lesson observation because of the tight time schedule, which in hindsight was an obstacle to more productive professional learning (to be further discussed in a later section).

All five teachers implemented the online activities according to the plan and were positive about the experience and outcomes in the post-observation interviews. The debriefing meetings with the teachers, whether individual or in groups, were rich and productive. While the implementation details and competences of the teachers differed, all were pleased with the ability of the students to complete the designed activities. Much of their initial fears and worries were allayed and most of the teachers found students' levels of engagement to be beyond their expectation. The most encouraging aspect of the teachers' conversation was its focus on matters that span both technology and pedagogy. For example:

> My concept of wiki was different from what I experience in this unit…. It is a learning approach…. Watching the YouTube video and working on wiki iteratively is very good.

> I could not imagine my students' response to be like this. I want to suggest .. modification .. For example, voting for the best [group] wiki [on reborn hero]. We should ask them to vote not only for the best group, but to give a score for each group. When asked whether we should ask students to do peer or self assessment earlier, I thought for a long time …. I have not seen peer- or self-assessment and I worried that the children would not be able to handle….

> It is difficult to get low achievers to collaborate … I find that their engagement in this activity to be much better than before. … online voting is a kind of guidance, encouraging them to do better. For example, one of the groups in the weak class was not putting in their best …. After the voting, the group was surprised that none in the class voted for them and asked why.

The teachers' talk exhibits a fluid and fluent integration of pedagogical ideas and concerns with the functionality and use of different online tools. The observation of their own students' engagmenet in the e-learning activities served as an important experiential grounding that connects/bridges the teachers' prior pedagogical skills and understanding with new technological tools and new pedagogical methods. The bridging was so successful in helping the teachers to make sense of the new tools and activities that they were able to suggest improvements to their enacted designs that would go beyond what they were initially prepared to "risk". Clearly, these teachers gained much in TPCK in their learning through design and enactment of those designs. What is also very encouraging was that the teachers were also aware of this venture as a productive professional learning experience, as so well articulated by one of the teachers in the post lesson interview:

> I did not plan for the children to come out and talk, but since there was time available … the [LMS] platform provide flexibility for teaching. You can think as you go along. You can never plan perfectly in advance … we need to accumulate experience. So I think this time we are not really teaching, but learning. We are learning how to use this [LMS] platform ….

It is clear from the above quote that the fear of not being able to navigate and manage activities on the new platform is replaced by confidence and sense of control, as communicated through the term "flexibility".

Variations in Teachers' Enactment of the E-Learning Plan

While all five teachers implemented the learning activities as planned, a detailed analysis of the classroom videos revealed subtle and important differences between them, which could be linked to differences in patterns of students' engagement and learning outcomes achievement as revealed through analyses of the online log data. Due to space limitations, two of the teachers' classroom interaction and orchestration are selected for

examination in this section as they represent different foci in their enactment. A brief summary of the activity sequence for the first double period lesson for Teachers A and C is presented in Table 2. Neither of these two teachers was the coordinating teacher.

Table 2 A summary of two teachers' implementation of the first lesson in the co-planned curriculum unit.

Sequence	Teacher A	Teacher C
1.1 Investigate	Did not perform this activity.	• Recapped a similar topic from last year • Asked for the meaning of "hidden" as in hikikomori • Ask for an adjective to describe Ar Yuen
1.2 Watch	Showed video.	Showed video.
1.3 Discuss	Ask whole class how the video described Ar Yuen, the meaning & attitudes of hikikomori. Strict regimented instruction to students: • 10 min to post own ideas • 3 min to *read others' posts* • 5 min to *discuss in group about notes read* • 8 min to *post group discussion results and respond to others*	• Checked students can login • Asked students to post responses to above questions on forum • Gave feedback on students' postings & refer to hikikomori as a social phenomenon • Guided students to post causes of hikikomori in terms of individual, family and social factors
1.4 Investigate	• Administered online voting on key difficulty • *Randomly chose 2 students to report how they voted*	• Administered online voting on key difficulty • Reviewed results and explained why academic results had highest votes • Contrasted Ar Yuen's attitude with students'
1.5 Produce	• Asked students how they solve own problems • 10 min for *group to discuss f-t-f their problems & solutio*n • Groups post results in wiki • Read some students' wiki entries to conclude	• Asked each group to discuss solutions to most concerned problem & post on wiki • Read out from wiki some of the students' solutions

N.B. Italicized texts indicate careful scaffolding of student interactions structures (individual, group and whole class) using face-to-face and online means. Underlined texts indicate conceptual scaffolds for student discussion and reflection.

Teacher A followed the plan very closely in the form of instructing students on the activities they need to go through. He did not attempt to provide a conceptual focus or guide the discussion. Teacher A followed the plan very closely in the form of instructing students on the activities they need to go through. He did not attempt to provide a conceptual focus or guide the discussion. On the other hand, he paid much attention to structuring of the discussions. In sequence 1.3, he gave time for the students to read others' postings, followed by a face-to-face group discussion, and then posting the group discussion outcomes as a response to the forum postings. Here the teacher modeled how online discussions is meant to be an interaction of ideas, and encouraged students to take each others' postings seriously. The italicized text in Table 2 highlights the instances Teacher A provided social-technical structuring of the discussions, which demonstrated his TPCK fluency in relation to facilitating student discussions.

Teacher C demonstrated a strong conceptual focus on her learning design enactment. She was the only teacher who started the unit with recapping for the students a similar topic in last year's curriculum, and to guide students to discuss the causes of hikikomori from individual, family and social perspectives; both of these moves were not mentioned in the curriculum plan. She also ensured that all students were able to login to the online learning platform before she gave instructions for the first discussion forum. The instances where she provided a conceptual scaffold for the students are underlined in Table 2.

Variations in Students' Learning Outcomes

Some preliminary analysis of the students' online discussion and reflection blog data reveal interesting differences in the learning outcomes for the different classes. Figure 2 presents an analysis of the quality of the forum postings from the different classes using an argumentation-based framework.

The quality of forum postings are often analyzed based on the quality of argument presented. As the children involved in this study were only grade 5 children and were not used to online discussion as a learning activity, explanations were not further categorized. The analysis presented in Figure 2 shows that class C has the highest number and percentage of high quality postings (i.e. explanation, personal judgement and suggestions). It is not clear whether this outcome is a consequence of the cognitive scaffolding provided by the teacher as Class C also happens to be the high achievers at this grade level. Another measure of quality of forum

discussions is the level interactivity among participants. Figure 3 is the Social Network Analysis (SNA) display for the two classes. The class C SNA result is a typical star shape indicative of students' postings serving primarily as responses to the teacher's posting. There was not real discussion or exploration of ideas among students. On the other hand, the class A SNA display is a well connected network showing much interaction among the students.
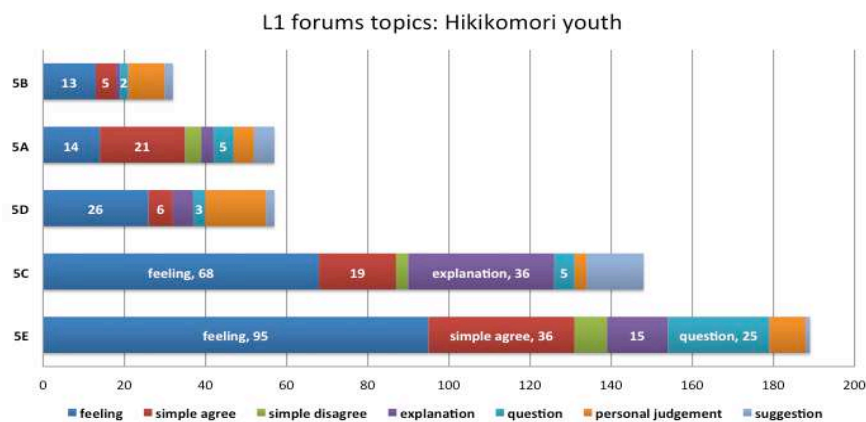

Figure 2. Analysis of the nature of the forum posts contributed by the five classes of students in lesson 1.
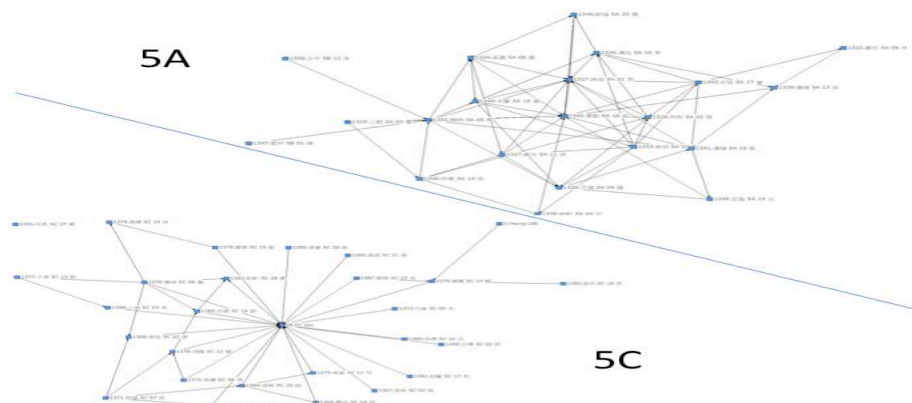

Figure 3. Social Network Analysis results for the discussion forum writing interactions for classes A and C.

A further analysis was conducted to categorize the level of reflection of the students' end of unit blog posts: 1) a simple listing of ideas learnt, 2) include positive suggestions on handling difficult situations, and 3) connect personal experience in the reflection. Contrary to results presented in Figure 2, class A students' levels of reflection in their posting (1:13:6) was much higher than those from class B students (10:5:1).

Variations in Students' Learning Outcomes

Three months after the curriculum unit enactment, the research team had an opportunity to present the above findings to the teachers, hoping that they will find these outcomes intriguing and trigger another conversation that allows for further probing of the unit design and its enactment. Disappointingly, the teachers did not show much interest and the graphs were taken as rather academic artefacts. On reflection, the research team identified several reasons why this may be so: 1) the analyses shown were rather unfamiliar to the teachers and do not really carry meaning in terms of learning outcomes as the teachers understand them, even thought they are familiar to the learning sciences research community; 2) lack of recency to effectively trigger discussion due to the time lag between curriculum enactment and the presentation of the analyses outputs; and 3) the teachers did not have an opportunity to observe each others' lessons and were hence unaware of the differences in enactment. All three conditions limited greatly the opportunity for this design study to contribute to deeper teacher learning.

Conclusion

Results from this study indicate that collaborative design based on the design principles presented under the conceptual framework section is a non-threatening approach to support teacher learning for e-learning implementation. The collaborative design that emphasizes teacher agency and teachers as the ultimate decision-maker provides a safe environment for teacher learning. The actual enactment of the learning design and post-enactment reflection is crucial to effective learning. The present study demonstrates that teachers were able to

master the interactive aspects of TPCK through practice. On the other hand, the findings also reveal the inadequacies of the design principles in fostering progressive inquiry and learning through reflecting on the variations in teacher enactment and associated student outcomes. Curriculum enactment reveals an extra, more nuanced level of teacher knowledge that cannot be adequately reflected in reified design documents or curriculum artifacts, be they digital or otherwise. To leverage this extra level of teacher learning and becoming in and through practice requires three additional design principles: 1) promote assessment and learning analytic literacy so that teachers can interpret and make use of the tools and indicators developed in the learning sciences community for understanding and improving their students' learning; 2) artifacts and opportunities to support reflection on practice should be provided as soon as possible after enactment to ensure recency and impact; and 3) provide peer lesson observation opportunities to teachers to support a teacher learning discourse on knowledge in and through practice.

While design principles clearly matter, it is important to note that there are school and system level conditions that are necessary for these principles to be feasibly implemented. For example, peer observation of teaching would only be a rarity unless explicitly supported by school level policy. Assessment and data analytic literacy and the availability of automatic data analytic and visualization tools need system level investment and policy support to be realized.

Endnotes

(1) A Japanese term referring to reclusive adolescents or young adults who withdraw from social life, often seeking extreme degrees of isolation and confinement, from http://en.wikipedia.org/wiki/Hikikomori.
(2) A term that refers to those who is determined not to succumb and continue to lead a productive life even in the face of great atrocities. In this curriculum unit, the "reborn hero" is a radio broadcaster (DJ) who returned to his former job after undergoing surgery as treatment for tongue cancer.

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