Title: Teachers’ enactment of a co-designed mobilized science curricular innovation
Author(s): Ye Xiaoxuan, Wu Longkai and Looi Chee-Kit

This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.

Copyright 2014 by Natural Sciences and Science Education, National Institute of Education

Archived with permission from the copyright holder.
Enacting Co-Designed Innovative Curricular

Teachers' Enactments of a Co-Designed Mobilized Science Curricular Innovation

YE Xiaoxuan

WU Longkai

LOOI Chee-Kit

National Institute of Education, Nanyang Technological University, Singapore
Enacting Co-Designed Innovative Curricular

Abstract

To a large extent, how teachers enact innovative curriculum will determine the success or failure of the innovation. However, previous studies found that teachers sometimes implement the curriculum in a way which was not intended by the designer of the innovation. In the efforts of diffusing a mobilized science curricular innovation from one pilot school to five more schools in Singapore, a community of practitioners (COP), consisting of a champion teacher from the pilot school and the seeding teachers from the other five schools (one or two from each school), was formed. It engaged in a variety of activities including co-design of the curriculum for teacher capacity building, and diffusion and dissemination of the innovation. In this paper, we investigate how the teachers from different schools implemented the co-designed lessons using the dimensions of both structure and process. Data sources include videotaped classroom observations of focal teachers, audiotaped post-observation discussions within the COP, and interviews with focal teachers. We find that although the curriculum was designed collaboratively, teachers enacted it in somewhat differing ways. The teachers mainly followed 5E structures for activity design and flow, with differences in details of substantiation. Varied pedagogical orientations, and different levels of facilitation skills and use of technology, were identified. The differences were caused by their teaching and learning beliefs, previous teaching experiences, and the supports they received within their own school context. Implications are drawn for teacher professional development in the context of diffusion of innovation, as well as to the implementation of a mobilized inquiry-based curriculum.
Teachers’ Enactments of a Co-Designed Mobilized Science Curricular Innovation

Introduction

The critical role of the teacher in implementing innovative curriculum, particularly those adopting constructivist-orientated pedagogy, has been widely recognized by researchers and educators (McNeill & Krajcik, 2008; B. Reiser et al., 2001; Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010). Teachers’ understanding of the innovation, their interpretation of the design principles, and their perceptions toward the fits of the innovation into their own school context affect the adoption of the innovation (Mustafa & Al-Mothana, 2013). However, teachers were often positioned as passive receiver and simply an executor in the innovation implementation, with or without well-developed curriculum materials by the innovation developer or researchers, thus likely to lead to unsuccessful implementation of the curricular innovation. To address the issue, researchers in the learning sciences have explored a collaborative approach of co-designing the innovation (Roschelle & Penuel, 2006).

Through co-designing the innovation, the teachers obtained a deeper understanding of the innovation and increasingly took ownership to find a way to fit the innovation better in their own context. Working with several highly devoted pilot teachers, the innovation may gain success in improving students’ learning and teacher’s transformation in pedagogical practices. But when trying to sustain and scale-up the innovation, the questions that crop up are: how the innovation could be diffused to different teachers, within a school or even across schools. There is abundant literature about the development of technology-afforded innovations and their effectiveness in improving students’ learning, but less research has been reported that investigates teachers’ implementation and differences in enacting an innovation, especially in the context of diffusion of an innovation.
The mobilized seamless learning (MSL) innovation was first introduced to a school in 2008, and implemented in 2009 involving one teacher and a grade level 3 (P3) students. Because MSL demonstrated increased student achievement, the school scaled-up the rolled-out of the mobilized curriculum to all the eight P3 classes within the school in 2012, and all P3 and P4 classes in 2013. In the year of 2013, the school (in its role as a Centre of Excellence for IT in Education in the North Zone cluster of schools) decided to collaborate with other schools in the cluster to explore the scale up of the innovation, and in particular, the enactment of mobile curriculum from the context of one school to a group of five schools. The innovation was “seeded” in the five schools, and probably spread to even more schools. In this regard, we perceive the piloting school as seeding school, and the five schools as seeded schools. In the efforts of innovation diffusion, a community of practice (COP) was formed consisting of a mentor teacher from the seeding school, the teachers from the seeded schools, researchers from university, and officers from Ministry of Education (MOE). In order to help teachers to better understand the innovation, and to adopt the innovation to better fit their school contexts, various learning activities were provided across the diffusion process, including the co-design of a curriculum package. After a series of activities, the teachers all acquired a high degree of buy-in and perceived the innovation in a way that is congruent with the developers’ intentions (Ye, Wu, & Looi, 2014). In 2014, the five school teachers started to implement the co-designed curriculum. Previous research studies have found that when enacting an innovative curriculum, teachers were commonly found adapting the curriculum, but sometimes the adaptation, or the transformation demoted the goal of the innovation developer (Pintó, 2005). In our study, in order to achieve the ultimate objective of diffusing the innovation to a larger scale, the researchers applied the strategy of shifting more ownership to the teachers, rather than taking the lead in every activity initiation. So the

---

23 In Singapore, the school academic year starts from Jan and ends in November.
champion teacher from the pilot school, who has been teaching the innovative curriculum and working with the researchers for more than five years, takes lead in organizing the working sessions and interacting with teachers, while the researchers observe the process and provide necessary supports. Eventually, we hope to diffuse the innovation to more schools and cultivate more champion teachers through this “seeding-seeded” relationship, while the supports provided by the researchers fade away. In this scenario, it is especially important for us to understand how the teachers with different background implement the co-developed innovative curriculum in their own context, so as to further inform the provision of supports for the teachers (i.e., professional development or other ways of supports), and policies about scale-up to more schools. In this paper, we want to explore: (1) What are the commonalities observed across the five teachers’ implementations; and (2) What are the differences among the teachers’ implementations? By answering the two research questions, we also make efforts to find out how and why these commonalities and differences arise and draw implications on the provision of supports and the scale-up model.

Theoretical Background

The Mobilized Seamless Learning Innovation

The seamless learning model advocates that learning is distributed across different learning processes (emergent or planned) as well as across different spaces (in or out of class). Mobile devices are as mediating tools to facilitate the seamless integration of different types of learning processes. Students are assigned a smartphone with 24x7 access in order to mediate a variety of learning activities such as in-class small-group activities, field trips, data collection and geo-tagging in the neighborhood, home-based experiments involving parents, online information search and peer discussions, and digital student artifact creation, among others. To facilitate the mobilized seamless learning (MSL), MyDesk mobile learning
environment that runs on a Microsoft Windows Mobile operating system was developed (Looi et al., 2010) for teachers to create curriculum-based lessons which embed multiple media (i.e., text, graphical, animations) and applications (KWL for students' reflection, NotePad for data collection, Sketchbook for drawing, MapIT for constructing concept map). Students' assignments and artifacts can be easily accessed and evaluated by the teacher for immediate feedback and comments. The innovative curriculum also incorporate the 5E (Engagement-Exploration-Explanation-Elaboration-Evaluation) instructional model (Bybee, 2006), which has been pervasively employed in the instruction of science in Singapore schools. Teachers are encouraged to apply constructivist teaching approaches to ask questions, conduct mobile and non-mobile activities, interact with students and scaffold the students' learning (Zhang et al., 2010). Equipped with mobile devices, individual students may carry out the learning activities in their own pace and pursue their preferred learning paths. The MSL curriculum was proved to be effective in engaging students to learn science in personal, deep and engaging ways as well as developing students' positive attitudes towards mobile learning (Looi et al., 2011).

**Co-Designing the Innovative Curriculum**

The researchers have explored a collaborative approach called “co-design” to developing innovations that fit into real classroom context (Penuel, Roschelle, & Shechtman, 2007). Co-design was defined as a highly-facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype’s significance for addressing a concrete educational need (Roschelle & Penuel, 2006). In spite of various tensions revealed from the co-design process (Penuel et al., 2007; B. J. Reiser et al., 2000; Shrader et al., 2001), it was argued that the approach served as a form of PD and
enhance teacher’s understanding of innovations, improve their teaching practice (Wong et al., 2011) and at the same time result in teacher’s taking increasing ownership and dissemination of the innovation (Penuel et al., 2007).

The co-design of educational innovations often involves different stakeholders, such as teachers (practitioner), researchers or innovation developers, and national educational policy maker in some of the research in Singapore context (Wong et al., 2011; Ye, Zhang, & Chia, 2010). Although tensions existed among the different parties, regarding the competing agenda, different working norms, difficulties in developing common understanding, it is worthwhile to involve different parties to leverage their expertise in developing the end product. In order to sustain and scale up innovations in school context, researchers developed an approach of cultivating lead teachers to design and conduct professional development sessions for the new-coming teachers, based upon the theories of communities of discourse and practice (Lave & Wenger, 1991), and cognitive apprenticeship and scaffolding (Brown, Collins, & Duguid, 1989). In our study, in order to achieve the ultimate goal of researchers’ fading away and the schools’ taking ownership of the innovation, a community of practitioners were formed with the implementing teachers (both seeding and seeded schools teachers) in the center, and researchers/innovation developer and the MOE officers in the peripheral areas observing and providing supports. The champion teacher took the role as leader and mentor of the COP and drove the diffusion of the innovation to the seeded schools. In the co-design session, all the parties in the COP discussed about the design and possible difficulties might be encountered in the implementation.

*Teacher’s Enactment of Innovative Curriculum*

Along the process of implementing an innovative curriculum, different versions of curriculum might emerge, such as what is intended by the designers (intended curriculum),
what is actually implemented (enacted curriculum), and how what happens influences those involved (experienced curriculum) (Marsh, 2009). As teachers implement innovative curriculum units, they often adapt them so that their enactments are consistent with familiar classroom patterns (Pinto, 2005), which might align with or deviate from the innovation developers’ intentions. These types of phenomena were addressed in research studies as “fidelity of implementation” and “adaptive implementation”, and some researchers correlated fidelity with the efficacy and effectiveness of the innovation and found that higher fidelity lead to better outcome (O’Donnell, 2008). While setting up the criteria of fidelity, it was suggested that not only the structure, but also the process of enactment of the innovative curriculum, which might have even stronger relationship to the outcome/effectiveness of the innovation outcomes (Mowbray, Holter, Teague, & Bybee, 2003), should be included. The dimensions of examination are decided by the research questions and characteristics of the innovation. For example, to examine teachers’ adaptation of an inquiry-oriented science curriculum, researchers analyze the classroom video recordings and measure the adaptation from 1) how much time was spent on the unit (the innovation provides curriculum materials for the unit), 2) the level of completion of the activities, 3) whether the teachers had students actively experiencing the unit’s investigations first hand or presented them as whole-class demonstrations (Fogleman, McNeill, & Krajcik, 2011). A study conducted by (Ashley & Butts, 1970) considered teachers’ classroom behavior change as the degree of implementation and developed a classroom observation form to measure the behaviors. The form consisted of four categories that were related to teacher/student interactions and student behavior, related to teacher responses and action, related to specific personal teacher traits (self-control, enthusiasm for example), related to physical aspects of the classroom environment.

There were many factors influencing how teachers enacting the curriculum innovation. Morris and Hiebert (2011) attribute the variation in instruction in classrooms with
teachers implementing the same lesson plan in different ways to differences in the expertise of the teacher or differences in the context that prompt teachers to change the plans. The local context could be further unpacked to teachers’ teaching resources, training opportunities, teacher and student mobility, administration support, internet connectivity in the context of technology-afforded innovation and so on (Songer, Lee, & Kam, 2002). Researchers also found that teachers’ adaptations to innovations were influenced by their knowledge and beliefs about the subject they were teaching, their beliefs about their own identity and about teaching and learning, and the degree that the innovation was supported within their local contexts (Cronin - Jones, 1991; Pintó, 2005).

Roger (2003) contends that innovations that are more flexible can fit to a wider range of adopter’s conditions, and it explains why the more flexible the innovation is, the easier it spreads to larger scale. In our study, the key epistemological design commitments of the curricular innovation are: learning as drawing connections between ideas, and learning as connecting science to everyday lives, across multiple learning spaces (such as between formal and informal learning settings, individual and social settings, and learning in physical and digital realms). The curricular commitment is seamless learning, and inquiry-based facilitation and learning (Looi et al., 2014). When we co-developed the innovation with teachers, we focused on the essential ideas rather than rigidly constrain every aspect on what they must do. In line with the curricular commitment, we encouraged constructivist oriented pedagogy where teachers perform the role of facilitator rather than a teller, and science knowledge was constructed through collaboration and discussion, rich ways of linking classroom teaching and learning with learning outside the classroom, the classroom learning culture as a participative one rather than teacher-led one, and multiple modes of assessment (i.e., make use of students’ artifacts on the MyDesk platform).
Enacting Co-Designed Innovative Curricular

Research Design

The COP met fortnightly for about two hours to co-design the theme of “Diversity” in 2013. For each chapter within the theme, teachers went through the following process. As not all schools have the same scope and sequence of content, the teachers first standardized the scope, sequence and learning objectives for every topic. The standardization helps the community to implement the curricular in a similar pace so that they can have more meaningful sharing and reflection in the future. The teachers, then, decided the total periods for each chapter and discussed students’ common learning difficulties and misconceptions from their teaching experiences. One chapter often surrounds one focusing topic (i.e. living and non-living things, plants, animals, fungi and bacteria, materials) and the 5E model (Engage-Explore-Explain-Elaborate-Evaluate) was used by the community to design a learning cycle for one chapter. The teachers all contributed ideas and resources they have used for the activity, and appropriated those activities to fit in different stages. After going through all the five stages within 5E, the teachers individually volunteered to spell out the detailed lesson plans of specific lessons.

The MSL Curriculum

The seeded teachers started to implement the co-designed package in the beginning of the year of 2014. As the mobile devices were not ready until April and MyDesk was only used from August onwards, so only part of the co-designed topics were taught with the mobile devices. The topics taught in this year were under the theme of “Diversity”, and Figure 1 demonstrates a topic around the idea of “Exploring Materials”. The MSL curriculum also features the connection between learning in and out of classroom. For example, teachers may ask students to take photos of the shoes of their family members’ and annotate the materials used before the lessons, and in the classroom the students can share with the class.
about their observations and findings. Using KWL, students can reflect on what they have learnt and what they want to learn at home before or after the lessons, and teachers can select some of students’ inputs and address or discuss them in the class.

Figure 1. Overview of the activities incorporating 5E model for “Exploring Materials”

**Participants**

Twelve teachers from the five seeded schools were involved in the COP. In this study, we focus on the teachers who implemented the curriculum in the schools. We have five seeded schools, but due to schedule conflict, we only observed two lessons in one specific school, so in this paper we will only report the findings from the other four schools’ teachers. In the school D, two teachers co-taught lessons, so we have five teachers in this paper. The general information for the teachers can be found in Table 1. All names are pseudonyms. The last column of the table presented the teachers’ previous pedagogical practices which were provided by them in a survey.

Table 1. General information for the implementing teachers from four seeded schools
Enacting Co-Designed Innovative Curricular

<table>
<thead>
<tr>
<th>School</th>
<th>Name</th>
<th>Years of Teaching Experiences</th>
<th>Class Ability and Class Size</th>
<th>Previous Pedagogy Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Aaron</td>
<td>5</td>
<td>High ability (n=37)</td>
<td>somewhat teacher-centered</td>
</tr>
<tr>
<td>B</td>
<td>Julie</td>
<td>13</td>
<td>High ability (n=39)</td>
<td>somewhat teacher-centered</td>
</tr>
<tr>
<td>C</td>
<td>Clare</td>
<td>2</td>
<td>Mixed ability (n=42)</td>
<td>somewhat teacher-centered</td>
</tr>
<tr>
<td>D</td>
<td>Ava</td>
<td>6</td>
<td>Mixed ability (n=38)</td>
<td>somewhat student-centered</td>
</tr>
<tr>
<td>D</td>
<td>Ros</td>
<td>10</td>
<td>Mixed ability (n=38)</td>
<td>somewhat teacher-centered</td>
</tr>
</tbody>
</table>

We also have the mentor teacher Jane from the seeding school, who has been working on the project of MSL since the year of 2009. She has about six years of teaching experiences and now is the champion of the innovation within NCPS. She mentored teachers in her own school and now started to perform as a mentor for the five schools teachers.

*Data Collection*

The data of curriculum implementation was collected for the period of one term (about three months) covering the content of “Exploring Materials” under the theme of “Diversity”, and “Plant system” and “Body system” under the theme of “Systems”. The lesson observation team comprising Jane, researchers, and officers from the Ministry of Education who were interested in putting together the innovation package for scaling-up to even more schools in Singapore, visited the five schools once fortnightly. Every school visit comprised of one hour lesson observation and one hour of post-observation discussion with
the implementing teacher. The lessons were video-taped complemented with field notes taken during the lessons, and the discussions with the teachers were audio-taped with brief notes taken.

Findings

Although the curriculum package was co-designed by the COP, teachers adapted it in different ways to better fit in their school context that was related to but not limited to students’ learning abilities. In this section, we attempted to identify some commonalities and differences in the dimensions of both structure and process.

**5E to Structure the Activities with Differing Details**

The teachers are familiar with the 5E framework for lesson design but only some teachers used it for their lesson plan before the MSL curriculum. From our analysis, we found that teachers mostly followed the structures and sequences of the activities. Taking “Exploring Materials” for example, the teachers all started with a story to engage students and to introduce different types of materials. To further investigate the topic, the teachers designed experiments for students to explore the properties of different materials, after which, students’ acquired knowledge was applied to solve a design activity of boat making, and explained their choices of different materials for each part of a boat. Despite the similarities on the structure and flow, there were differences in the details of substantiation of each stage. For instance, in the “engage” stage, Ava created a story that a mouse family had to build a raft to escape from an island because of a volcano eruption, and she asked students to think about the materials that the daddy mouse needed to build the raft, and the material that the mummy mouse needed to pack the food in and so on. According to Ava, the Cinderella story (the original story telling designed for engagement) would “bored the students since they
were very familiar with it”, so she needed to “think very hard to draft a story that make them excited” (quotations from Ava in the post-observation discussion). Hence, she refined the “engage” activity with consideration of her students learning styles. So the students learnt the topic in an engaging and authentic scenario and applied their knowledge, not only scientific knowledge but also survival knowledge.

We also observed the differences in students’ autonomy in learning that was resulted from the teachers’ activity design, especially in the experiment. In the experiment of investigating a specific property of different materials, Julie distributed worksheets to students where steps of the experiment and the structures of reporting observations and findings were stated clearly; whereas Ava gave more freedom to students with regards to the design and execution after she elaborated the purposes and objectives of the experiments, and she walked around the classroom to ask scaffolding questions and guided students’ thinking. The difference in the level of students’ autonomy might result from teachers’ perceptions on students’ ability, since the students were in the P3 level and just started to learn science, so some teachers took more control during lessons because they were afraid students would not know what to do if they were given too much freedom.

In summary, we differentiate the levels in terms of the ways that teachers adapt the co-designed curriculum package as seen in Table 2. The teachers in our case did not reach the higher level due to limited exposure to the innovation but as when they become more familiar with the package, they would be able to do so.

<table>
<thead>
<tr>
<th>Level</th>
<th>Ways of Adaptation to the Curriculum Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Take more ownership in curriculum development and evolve the curriculum package by integrating other available innovative resources available.</td>
</tr>
</tbody>
</table>
Medium | Customize the curriculum package according to students’ learning ability, and schools’ resources.

Low  | Follow the original lesson plan without pondering the rationale of the design and internalizing the curriculum package for own use.

Varied Pedagogical Orientation and Facilitation Skills

It is the teacher’s pedagogy that substantiates the curriculum design or structure of the innovation. The curriculum was arranged as inquiry-oriented, but teachers might implement it not in a constructivist-oriented way. From our lesson observations, we tentatively categorized the teachers in different types. However, we believe that the pedagogical orientation could be changed through the process when more student-centered activities were experienced.

Ava, Julie and Ros had comparatively more teaching experiences, and we did find that they were inclined to apply more constructivist oriented pedagogical approaches. For example, we identified a similar characteristic in Ava and Julie in that when getting wrong answers from their students they probed their thinking through clarifying questions like “Why do you think so?” or “It’s interesting. Tell me why do you say so” rather than ignoring or directly correcting them. We also observed another valuable pedagogical strategy that Julie applied to foster students thinking: generating arguments. She questioned students a lot when getting into a concept and if she found there were two contrasting or different opinions got from students, she rephrased the contrasting viewpoints and asked the class to vote and argued about it. Ros highly emphasized the spirit and skills of inquiry, so she intended to explicitly address the inquiry thinking skills. For example, after students’ having learnt different parts of a plant she designed a paper experiment with objective of letting students realize each part was equally critical for the plant system to function properly. Students
worked in groups of four or five to solve the problem: whether the plant could survive without leaves/stems/roots. Before the experiment, Ros stated the research questions and reminded students to keep in mind of the aims of the experiment. In the worksheets, students were required to read through the whole process of the inquiry, and explicitly asked about whether the experiment design was a fair test. After that, students were provided the observations and asked to draw conclusions. It is worth mentioning that Ros highlighted the ideas of fair test and inquiry spirit to students for every experiment, either by demonstrations done by the teacher or the students.

Aaron and Clare had fewer years of teaching experiences, and we found that they were inclined to apply goal-driven oriented pedagogical approaches. In the first few lessons, we found that he tended to ask factual knowledge questions and “polling questions”. For example, he asked a lot of questions on the use of scientific terms, such as “long-lasting means what? What is the term for this property?” The “polling question” refers to the questions where he asked the class to vote for the two different answers obtained from two students, and if more students voted for the correct one, he proceeded to the next activity. At the same time, we found he seldom responded to the wrong answers from Socrative (©2014 Socrative.com), which is a tool embedding the use of real time questioning, instant result aggregation and visualization for students’ ideas sharing. This finding will be further discussed in the following part about use of technology. Clare has a class with mixed ability, so in her class, she spent quite an amount of time to let students spell the term and correct their spelling. At the same time, she also saved time to “drill” students about the answering skills for open ended questions, which were required by the exam papers. In her lesson, she tended to give much more guidance and provided varied thinking routines to students considering their learning ability. So from the observation, we identified her as applying more goal-oriented pedagogical approaches.
Use of Technology for Different Purposes at Different Levels

Use of the mobile devices with 24/7 access to internet is another critical feature of the MSL. The teachers haven't used MyDesk platform by the time we analyzed the data, so in this paper we only discussed use of other applications supported by the mobile device and internet access.

From analysis of the lessons, we found that the most frequently used technology-afforded activities included: students using Google to search information; Socrative for teachers posing questions and the class responded; teachers running videos for demonstration and explaining concepts. When integrating technology into lesson designs, it is not the frequency of using certain tools, but how the activity was designed (i.e., what is the task, how teachers feedback to students’ artifact, what is the follow-up activity) that really matters. In this part, we proposed different levels of ways of teachers’ integration of technology in lessons (see Table 3), and identified the instances of using technology for the four classes into different levels, as seen in Figure 2. As long as the activity involved the use of the mobile devices, we considered it as one instance. So even the same app/tool was used in the same lesson but for different content, we considered it as two instances.

Table 3. Different levels of integration of technology in lessons enactment

<table>
<thead>
<tr>
<th>Technology</th>
<th>Google for information searching</th>
<th>Socrative as formative assessment</th>
<th>Video playing for demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>The task involves students in lower cognitive level activities like</td>
<td>The questions require only factual knowledge; the teacher only selects right answers without</td>
<td>The video serves purposes of information delivery, but the teacher doesn’t cautiously</td>
</tr>
</tbody>
</table>

1969
| Level 2 | The task involves students in activities like interpreting, comparing, and summarizing; teacher follow-up and foster meaningful discussion on the search result. | The question requires students explaining, or applying knowledge and the teacher synthesizes students' responses and correcting students' wrong answers. | The video was engaging and informative, and the teacher uses it to reinforce students' understanding. |
| Level 3 | The task involves critiquing and creating. The teacher facilitates students to collaborate and argument in the search activity | The question requires students explaining, or applying knowledge and the teacher synthesizes students' responses and identified valuable teaching points from students' misconceptions for | The video was engaging and informative, and the teacher develops a lesson from the content covered in the video. |
As we can observe from Figure 2, Aaron, Ava and Ros used technology more frequently. Clare paced the syllabus much faster than the other three schools, so the lessons we were able to observe were mostly the review of content knowledge, and it explained the quantity of the technology integration in lessons. According to our conversations with Clare, we found that besides the three ways analyzed, she also used Edmodo (https://www.edmodo.com/) for students to work in groups to discuss and collaborate. For Julie, she was not willing to start to use the mobile devices until the MyDesk was ready, so there was little use of technology observed. Besides the three ways, Ava and Ros also asked students to use their mobile devices to collect data (picture taking or video recording). The data collected was usually shared within the class for further discussion.
Enacting Co-Designed Innovative Curricular

We observed improvements in Aaron's use of technology as lessons moved on. In the first few lessons, the design of technology use was not targeted and ill organized or followed-up. But we observed better designs, i.e., more meaningful questions set in Socrative, and more feedback was given to students' answers. Same patterns were evidenced in Ava and Ros' class. Not only the frequency, but also the quality and variety of use of technology was observed. For instance, in one lesson of Ros, she improvised some questions on Socrative when she found most of the students seemed confused and thus she wanted to get students to make their thinking visible. Ava also explored other platforms for more varied use of the mobile devices, for example she had tried Lionit (http://en.linoit.com/) for simultaneous collaboration and ideas sharing.

Discussion and Conclusion

Examining the enactment of the co-designed curriculum, we found that teachers enacted the innovation in differing ways. We reported the commonalities and differences in the three dimensions: their adaptations of the co-designed curriculum, their pedagogical practices, and the use of technology. We found that while following the main structure and flow of the curriculum package, they adapted and detailed the curriculum in different ways. In instantiating the lesson package, teachers applied pedagogical approaches, and we identified teachers having different pedagogical orientations. Some teachers were more skillful on questioning and facilitating, while others were learning to improve their strategies to probe students' deeper conceptual understanding. When integrating the technology into lessons, teachers designed tasks and conducted differently. Despite of the differences, we witnessed the progress in some teachers, and understood their challenges. In the paper, we not only described the differences, but also proposed the progressions that teachers might
develop across the process of implementation with regards to adapting the curriculum and use of technology.

From ongoing conversations with teachers and our observations of their lessons, we identified some factors that influenced their practices and determined the differences: teachers’ content knowledge or their confidence in their content knowledge; teachers’ beliefs in teaching and learning, as well as their beliefs in technology for learning; teachers’ perceptions in students’ learning ability; systematic supports from the school leadership. Aaron was very dedicated and held positive attitudes towards the innovation, however, he was not very confident about his science knowledge, so in the lesson he might choose not to probe deeper for understanding of certain concepts. Initially his teaching was quite goal-driven, and he would only acknowledged the correct answers, but later we found he also appreciated some wrong answers from students and tried to probe their thinking by asking why, so we thought he might change a little bit on belief in learning. We also found teacher’s beliefs in use of technology in learning made a difference in their implementations. Jessie had 13 years of teaching experiences and most of the classes she taught were higher level, so she was quite conscious about the learning objectives she must achieve, so she paced the class to achieve the goals smoothly. When teaching the class, we found she was quite willing to interacting with students and probe students’ thinking, so we deemed her strategies as more constructivist oriented. However, she was not willing to use the mobile devices till MyDesk was ready because according to her experiences the technology would introduce too many technical problems, which was similar to most of the teachers in Singapore. Nevertheless, we had compelling examples from the other school of Ava and Ros. Initially the use of mobile device did introduce some technical issues, but as the lessons went on, we found students were quite comfortable using the mobile devices and could trouble-shoot the problems skillfully. The teachers were also very skillful and confident using the technology. The
difference between Julie, Ava and Ros was not only due to their personal beliefs in use of technology, but also to the systemic supports from their schools. In Ava and Ros’ school, the principal was very supportive and sent the whole level science teachers to the deeding school for learning of the MSL and the teachers went back school forming a within-school community for implementation reflection and lesson design. Each lesson was peer observed and supported, at the same time they had a teaching assistant attending to the technical issues faced up in the classroom. Contrast to the strong supports in Ava’s and Ros’ school, some teachers in our study received quite limited supports from the leadership and within-school peers. Besides these factors, we also found teachers’ perceptions of students’ learning ability played a role in explaining teachers’ pedagogical approaches. In Clare’s class, she saw students as middle ability so she “controlled” the openness of the lessons and provided a lot of guidance comparing to other teachers.

As mentioned above, we saw positive changes from some teachers, and this was partially attributed to the impact of the structures of professional development opportunities that the COP provided. We met once fortnightly to co-design the lessons, and reflected on the difficulties encountered in the curriculum enactment. Jane shared with the teachers about her experiences of not only success but also frustrations and challenges. We also had valuable discussions after teacher’s lessons during lesson observation days. The teachers had opportunities to have feedback from observers with diverse expertise and solved the problems encountered in teaching in time. The discussion also served as a platform for reflection, which was critical for improvement in teaching. The COP also conducted occasional workshop or professional development sessions on specific topics, such as questioning for teaching and learning, and integration of technology for MSL.
Enacting Co-Designed Innovative Curricular

The work reported in this paper has some limitations as we have not analysed data on the teachers’ use of the MyDesk platform. Future work would be done to further explore how teachers from different schools made use of the platform.
Enacting Co-Designed Innovative Curricular

References


1976


