

Design for Scalability: From a Class Intervention to a Level Intervention

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STUDYING TEACHER ENACTMENT of an innovation helps us understand the process of effective spread of a curricular innovation to teachers who have differing levels of content readiness, pedagogical orientations, and different student profiles. Towards this, we explore how different teachers in the same grade level appropriated a common science curriculum enabled by mobile technologies in their classrooms. As curriculum designs are not self-sufficient by themselves, the enactments of the teachers differ in how they leverage on students' artifacts, how they integrate the technology into the class and in which way they interact with students in a mobile learning setting. We draw implications for the innovative curricula implementation and for teacher professional development of such innovations with the ultimate purpose of scaling and sustaining.

INTRODUCTION

The literature on curricular innovations is replete with reports of pilot studies and proofs-of-concepts. It is rare to see a project move through the various phases of research and implementation to a point where the innovation actually becomes an integral part of routine classroom practices (Dede, Honan & Peters, 2005; Penuel, Fishman, & Cheng, 2011; Sabelli, 2008; Schneider & McDonald, 2006). Successful research intervention projects usually involve a few highly motivated teachers, but sustaining the innovation and scaling it up requires the average teacher to assimilate the designed curriculum and pedagogy into their daily practices.

As adoption of a curriculum is not a one-to-one mapping of the designed curriculum to the classroom, teachers must always adapt

KEY IMPLICATIONS

- Teachers do adapt the curriculum for their own use based on their pedagogical orientations.
- Scaffolding supports can help teachers enact curricular innovations; these include differentiated materials and methods for different ability levels, video clips of teaching episodes, and teacher scaffolds.
- Form a community of practice to help teachers assimilate the innovation into their teaching practices.

the curriculum for their own use (Barab & Luehmann, 2003). Studying how teachers adopt and adapt an innovation in their own classrooms is critical to understanding how innovative curricula work in classrooms and the kinds of support teachers need (Puntambekar, Stylianou & Goldstein, 2007).

Collaborating with a primary school in Singapore, we developed a viable curricular innovation in Science by working with one teacher and one primary level class over a period of 2 academic school years. The innovation involved the transformation of the existing Science curriculum into an inquiry-based one which exploits the pedagogical possibilities of mobile technologies (Zhang et al., 2010). Because the curricular innovation demonstrated increased student achievement, the school has decided to scale-up the roll-out of the transformed curriculum to more classes in the coming years, thus, providing an opportunity to study an innovation as it is being scaled up.

RESEARCH DESIGN

In this research innovation cycle, we adopted a design-based research approach by first working with one teacher to co-design the curricular innovation and enact the lessons in one class over a period of 2 years. At the end of the 2 years, with the support of the school's leaders, we moved into the innovation cycle in which all 8 Primary 3 classes in the school were taught the new Science curriculum. There were 6 teachers for these 8 classes, which included the teacher in our initial study. In this paper, we examine the enactment of the curricular innovation by 4 of these 6 teachers, namely, Helen, Emily, Serena and Jodie. We observed how they contextualized the curriculum based on their beliefs and goals, their perceptions of the students' needs and ability levels, and their content and pedagogical knowledge. All the teachers, except Jodie, were new to the mobilized curriculum. Before the scale-up implementation, they had attended one-day workshops on the use of the suite of learning apps on the smartphones, and had familiarized themselves with the mobilized curriculum.

Creating a curriculum is an ongoing process, the product of which is a composite of what is intended (planned curriculum), what actually happens (enacted curriculum), and how what happens influences those involved (experienced curriculum) (Marsh,

2009). Marsh proposes that desirable educational experiences arise when the interaction of these three curricula is flexible and evolving; and, therefore, it is not about "best" practices or "most correct" answers to fundamental curriculum questions.

Building on Marsh, we propose our conceptual model for the study of teacher enactment (see Figure 1). The planned curricular innovation is co-designed by participating pioneer teachers and researchers. This is then enacted by the pioneer teachers, and later on at the scaling stage, by teachers new to the curricular innovation. The enacted curricula is what actually happens in the classroom, as it generates experiences and reflections in all those involved. Researchers as meso-level mediators interpret the experiences, processes and outcomes of the experienced curricular innovation, and work collaboratively and iteratively with teachers to refine and improve the planned curricula for more effective enactment and experiences in the next round of implementation.

KEY FINDINGS

Contextualizing the curriculum is ultimately a local phenomenon (Squire, MaKinster, Barnett, Luehmann, & Barab, 2003), and is the result of factors such as teacher's goals, teacher's pedagogical values, students' ability levels, students' needs, and other local constraints. In this study, each of the teachers received the same lesson plan, and they did a walk-through of the lesson plan during the Time Tabled Time (TTT). Though the same lesson plan design was presented to the 4 teachers, each of the teachers adapted the plan to focus on different aspects of the science learning that were congruent with their epistemological orientation and pedagogical beliefs, and based on what each believed was relevant to the ability level of their class. Through classroom observations and data analysis, we attempted to identify variations in the teachers' lesson implementation by describing their pedagogical orientations in the instruction (Voogt, 2010), their patterns of technology integration into teaching practices and their strategies of dealing with instructional events. Our analysis included identification of teachers' pedagogical orientations, their response to instructional events, and their behavioural response towards the learning goal, learning objectives, questions and process skills (Faikhamta, 2013).

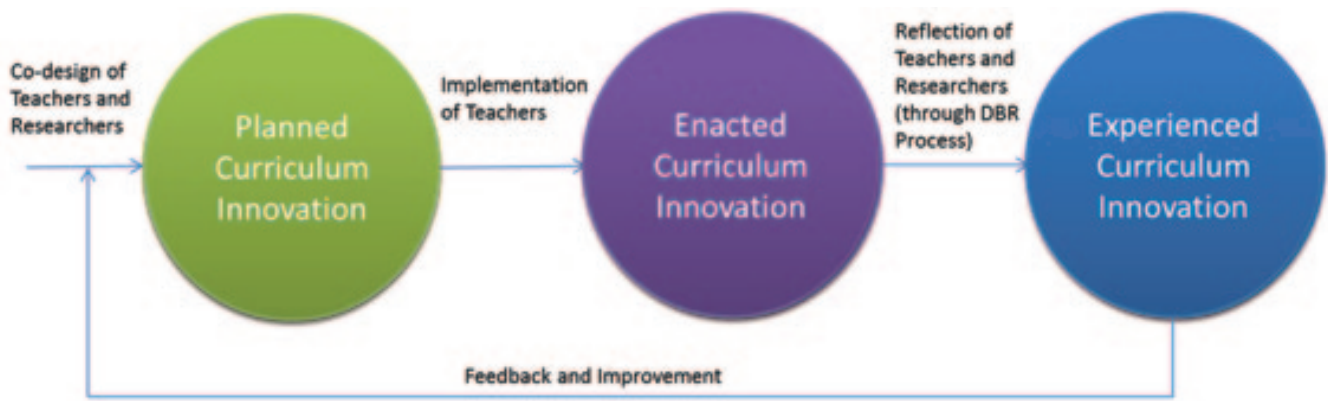


Figure 1. Conceptual Model of Enactment of Curricular Innovation.

Teacher Differences on Pedagogical Orientations

Teacher's belief has been identified as the most important influence on what they practise in the classroom (Carlson, 1994). In this innovative curriculum, teachers' pedagogical orientations, which are affected by their epistemological orientation and pedagogical beliefs, were identified and examined by comparing their performance during classroom instruction. This analysis provided a window into teachers' personal beliefs that influenced the enactment of the 5E mobilized curriculum and its impact on the students' responses. The results of this analysis led to recommendations for the pedagogical approaches of the 5E mobilized curriculum. From our observations, we noted that the 4 teachers displayed different pedagogical orientations. Four categories of pedagogical orientations were identified ultimately, and different inclinations towards traditional teaching methods (more teacher-guided instruction) and constructivist strategies (more student-centered instruction) were detected and analysed (Means & Oslon, 1997).

Use of Technology

The classroom observations revealed that with different pedagogical orientations, teachers' perceptions of technology integration in science instruction also varied. The major difference was reflected in their way of incorporating the technology into their classroom teaching. Table 1 presents the strategies they used to incorporate the technology or technology-related learning artefacts into their teaching of the materials in the 5E mobilized science curriculum. We categorized their strategies as either teacher-guided strategies (Bielefeldt, 2012) or student-centred strategies (Kerawalla, Petrou, & Scanlon, 2013), so as to study their technology deployment strategies in relation to their orientations on the integration of technology in the science curriculum.

Teacher-Student Interactions

To identify the differences among the 4 teachers' interaction with their students, we compared their performance and roles as mediators in the students' learning, because mediated learning involves teacher-student interaction. We identified the scaffolds the teacher provided to mediate students' learning, such as scripts, prompts, exploratory questions and challenging students' ideas (Weinberger & Fisher, 2006; Ge & Land, 2004; King, 2002). Below, in Figure 2, are the representations we mapped out to show the differences in teacher-student interactions in a particular lesson episode. The X-axis represents the major instructional events in the lesson and the Y-axis represents the level of teacher-student interaction (at the class level or individual student level). The different types of verbal interaction are represented by different shapes. The frequency of each type of interaction is indicated in the center of the shape.

Figure 2 shows up some significant differences in the pattern of teacher-student interactions among the 4 teachers. Teachers like Jodie and Serena, who used more constructivist strategies, provided more scaffolds for students and were more involved in students' activities in their classes. Teachers like Emily and Helen, who used more traditional strategies, spent more time on lecturing and were less involved in students' activities. Specifically, Jodie and Serena were more involved in students' work and tended to provide appropriate scripts and prompts for the students to find solutions by themselves. Thus, more questions were posed in their classes for investigating students' knowledge and identifying misconceptions.

The findings also revealed that teachers performed differently in asking exploratory questions, challenging students' ideas and offering immediate and appropriate scripts and prompts. These differences had an impact on the implementation of

Table 1. Teachers' strategies of the technology integration into the class.

Teachers	Ways of the use of technology	Teacher-guided	Student-centered
Helen	Monitoring the progress	√	
	Evaluation tool	√	
	Identifying misconceptions	√	
	Delivering key concepts(lecture)	√	
	Guiding discussion and thinking		√
Emily	Evaluation tool	√	
	Homework Assignment	√	
	Delivering correct answers	√	
Serena	Evaluation tool	√	
	Demonstration	√	
	Identifying misconceptions	√	
	Hands-on activities		√
	Reflection tool		√
	Guiding discussion and thinking		√
Jodie	Monitoring the progress	√	
	Evaluation tool	√	
	Identifying misconceptions	√	
	Conducting collaborative work		√
	Guiding students' discussion and thinking		√
	Reflection tool		√
	Comparison tool		√
	Supporting collaborative work		√

the mobilized curriculum. The findings consistently indicate that students benefit more when there are more student-centred activities and when more opportunities are provided for students to engage in inquiry and investigation. If teachers act as facilitator and mediator in students' learning, provide appropriate scaffolds to facilitate learning, and allow students to use smartphone tools to record their activities and data, the gap between designed lessons and enacted lessons could be eliminated.

IMPLICATIONS

A productive view of change management in transforming teaching practices includes the assumption that individuals who are attempting to implement changes will continually need clarification about the changes, and that people will only change if there is pressure to do so, a supportive environment, and opportunities to share experiences with others in similar situations (Fullan, 1992). As a result of working with teachers individually and as a team, a clearer understanding of what the mobilized curriculum means and how to enact it emerged for

the teachers, and in fact, for the researchers as well.

Working with the teachers, we decided to differentiate the lesson plan for different ability groups. For example, the entire level conducted experiments relating to the test of materials but the lesson procedures and instruction were differentiated for classes of different ability levels. Responding to observations garnered during the course of the research, the researchers re-defined and revised their roles to address the teachers' needs. They re-conceptualized their relationship and interactions with the teachers in order to better support the teachers in the enactment. The result of building better rapport with the teachers was that the researchers were invited by the teachers to give them individual critical feedback.

To assimilate the curriculum into the classroom culture (Squire et al., 2003), we addressed the challenges the teachers faced in delivering a new curricular innovation that builds new skills and competencies beyond what is usually assessed in the standardized assessments used in the school. Two methods were proposed to help the teachers. The first was to provide support to the teachers by giving personalized feedback after each lesson enactment, and to help them to adapt the lessons for different ability students. The second method was to conduct teacher sharing sessions, facilitated by the researchers at the weekly TTT meetings to discuss questioning skills, ways of providing scaffolds, and the use of technology. These skills were identified in the lesson enactments in which a particular skill had been modelled by a teacher or researcher, and examined in lesson study discussions using recorded classroom sessions. While the researchers provided the initial scaffolding, the plan was to build up the capacity of this group of Primary 3 Science teachers so that they would be able to sustain the innovation in the coming years after the fading out of the researchers from the scene.

In levelling up the capacity of the teachers, some new activities were planned. Arrangements were made for teachers to observe their peers conducting the lesson activities. There was a suggestion for each teacher to co-teach with another teacher, but was later abandoned because of time constraints and time tabling issues (for example, co-teaching was not possible

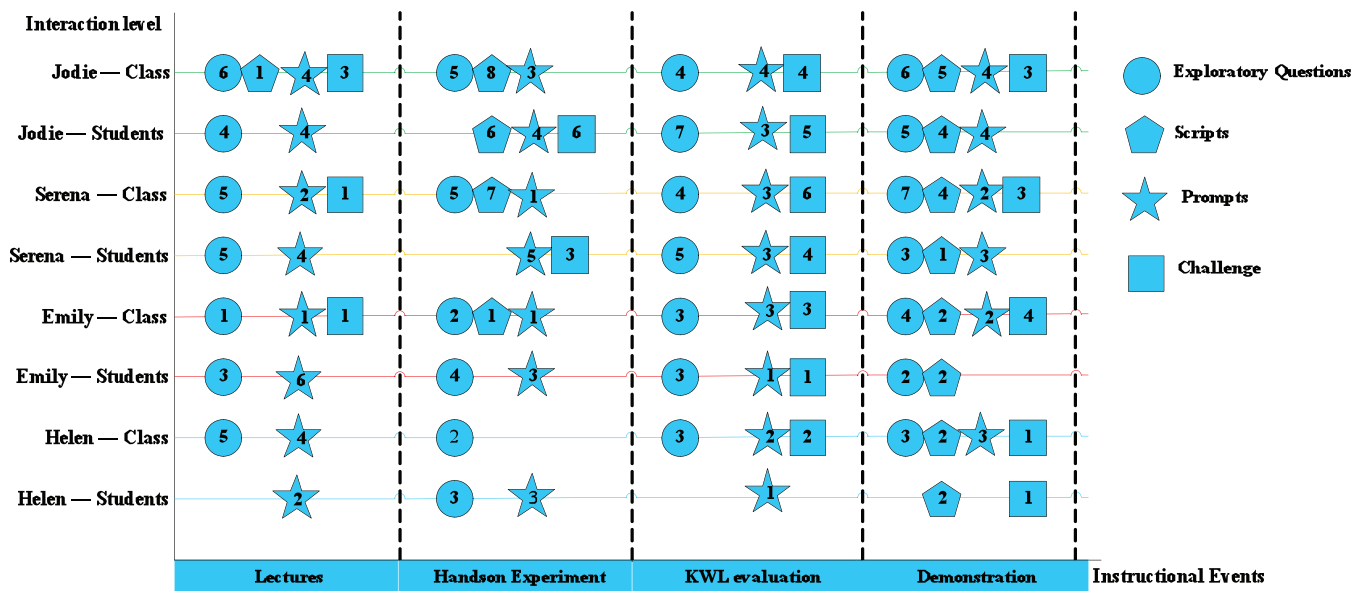


Figure 2. The representation of teacher-student interactions.

when the teachers were teaching different classes concurrently. In place of co-teaching, the researchers edited short video clips exhibiting good teaching and learning scenarios to be viewed by the teachers.

Another activity conducted at the TTT to improve the capacity of the teachers was a short session, led by a researcher, which simulates a classroom activity. During the session, the teachers acted the role of students and answered questions by the researcher. The purpose of the activity was to allow teachers to understand the activity from the students' learning perspectives and to demonstrate the type of questions that would lead students to construct understanding because they were not closed-ended questions. The student interest and work on using the smartphones for learning helped to drive the teacher's facilitation in the classroom.

Figure 3 (below) shows a refined model of the relationship between the planned, enacted and curricular innovations. From analysing the interactions involving the curriculum, the technology and the teacher-student exchanges in our design-

based research, we iterated and collaboratively developed with the teachers differentiated materials and methods for different ability levels, curriculum scaffolds (e.g., video clips of teaching episodes to guide teachers to more effective classroom discourse with personalized feedback) and teacher scaffolds (e.g., encouraging teachers to engage students in better classroom discourse with personalized feedback).

In conclusion, our analysis of the journey of the teachers' enactment of the designed technology-enabled curriculum helped us to explore the interplay between the scaling intention and plan, the technology-enabled curriculum, the teachers' pedagogical beliefs and habitual classroom practices, and the teachers' growth. In summary, this work is a contribution to a deeper understanding of the process of effective dissemination of a technology-enabled curricular innovation to teachers who have differing levels of content readiness, pedagogical styles, epistemological orientations, and who need to adapt instruction to student groups of different ability levels.

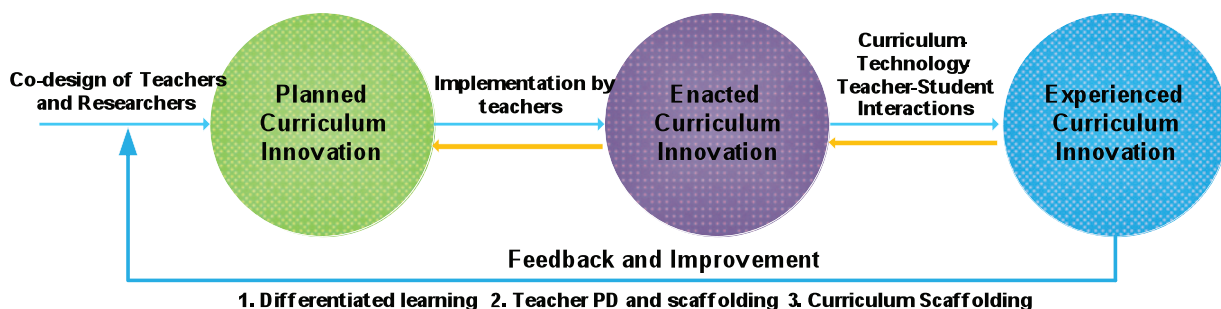


Figure 3. Conceptual model of enactment of curricular innovation.

The initial stage of scaling up a research-developed curriculum requires an intensive co-design process with the teachers. The process is iterative, dynamic and reflective. Key areas to focus on include the interactions in the curriculum-teacher-student relationship, consideration of the teachers' readiness, students' learning ability levels, and teachers' and students' motivation. The implementation research does not only produce a set of technology-embedded curriculum materials but, more importantly, surfaces the need to change the culture of teaching and learning, and to make explorative learning for teachers and students a habit of mind and a life-long goal. To help teachers assimilate the innovation into their teaching practices, forming a community of practice is pivotal. A community of practice provides support and development for the teachers in the absence of the researchers. It also ensures the transfer of ownership from researchers to teachers. With successful transfer of ownership, there will be continuity in innovation and more assured outcomes of the implementation and scaling process.

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