Implementing Mobile Learning Curricula in a Grade Level: Empirical Study of Learning Effectiveness at Scale

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Abstract

Developing and then scaling up an educational innovation so that it achieves on the dimensions of depth, sustainability, spread and change of ownership is a complex endeavor. In this paper, we present a study of one such innovation which has been developed through a design-based research process in a Singapore school. The innovation features a primary science curriculum integrating the 5E inquiry phases with the use of mobile technology. It has evolved through the various development phases to where the innovation is becoming an integral part of routine classroom practices. This paper reports some of the results of our scaling efforts, in particular, those relating to changes in classroom practices and the effectiveness brought by the curriculum innovation. Using qualitative data analysis methods, the study discusses the transformation of the classroom practices on teachers' pedagogical approaches, classroom culture, lesson plan design, linkages to informal learning, and parent involvement. Quantitative analysis of the performance of students in science assessments when compared between pre-scaling and scaling phases shows the efficacy of the innovation when scaled up to a whole grade level. Implications are drawn to inform future studies or work on factors for effective scaling up of technology-supported curricular innovations.

Keywords: scale-up, curricular innovation, science inquiry, classroom practices, yearly progression

Introduction

Nowadays, with technological advances in both hardware and software, the increasingly pervasive and ubiquitous nature of mobile technology has been recognized by many researchers and educators from the school perspective (Avraamidou, 2008; Mulholland et al., 2012). The literature cites research efforts devoted to developing mobile learning projects or curriculum which integrates mobile technology with appropriate pedagogy for supporting students' science learning in both formal and informal settings (Ahmed, & Parsons, 2013; Looi, Zhang, Chen, Seow, Chia, Norris & Soloway, 2011; Song, Wong & Looi, 2012). With mobile technology, science inquiry can be extended into more authentic contexts, such as field trips to a park, woodlands, and a museum, and other home-based activities. Such designs seek to establish connections between the acquisition of new knowledge in the classroom and the application of the knowledge outside of the classroom, and teachers' formative assessment can become more flexible and in-time (Merchant, 2012).

However, the research literature has also indicated that most studies of mobile learning are just pilot projects or proofs-of-concept that tended to focus on effectiveness studies, surveys and experiments or the designs of the mobile learning system (Wu et al., 2012). It is rarer to see a mobile learning project move through the various phases to where the innovation actually has become an integral part of routine classroom practices. There are also few studies that conceptualize sustainable learning with mobile technologies via immersion into the standard curriculum, especially in the domain of science education. There is a need to conduct longitudinal studies on tracing the learning effectiveness based on sustainable and longer-term interventions.

On the policy perspective, in the context of Singapore, the initiative of the government's third Masterplan (mp3) for ICT in Education (MoE, 2008) provides a policy imperative for schools to conduct sustainable curricular innovations for better use of the ICT in teaching practices. The emphasis is on integrating ICT into the curriculum through developing new pedagogy and assessment; for cultivating the competencies for the 21st century; for developing practice-based professional development models for teachers' better adaptation of the ICT-supported curriculum; and for improving the sharing of best practices and successful innovations. In this context, our work places a strong emphasis on how to integrate the mobile learning into the standard science curriculum and how to scale this curriculum into more grade levels and schools in Singapore. Moreover, educational researchers have pointed to the need to examine reform efforts systemically to understand the pathways and impediments to successful reform (Anderson & Helms, 2001). Thus, presenting the process and results of a curricular innovation can help unfurl the vivid map of the developmental trajectory of a curricular innovation, and provide evidence for the effectiveness of the curriculum implementation.

In our collaboration work with a primary school in Singapore over five years, we have developed such a viable curricular innovation model, namely a Mobilized 5E (Engagement → Exploration → Explanation → Elaboration → Evaluation) Science Curriculum (or M5ESC in short). The innovation involves the transformation of the existing national science curriculum into one with an inquiry-based orientation which leverages the affordances of mobile technologies (i.e. smartphones). It seeks to systematically and comprehensively integrate the mobile technologies into the national science curriculum at the primary level. In this paper, we describe this scale-up research of the curricular innovation, with a focus on the demonstration of its effectiveness when it is used in a routine and sustained manner, and deployed on at whole grade level.

This paper is organized as follows: we first discuss the literature for mobile learning in science education and for the scaling-up of evidence-based practices. We provide the contextual information of the M5ESC development and then narrate its scaling process. We next analyze data on changes in classroom practices as well as the perspectives of teachers who implemented M5ESC in their classes. For probing the effectiveness for students' science learning, we explore the students' performances based on the yearly comparison of their science test achievements from the years of scaling with the years of pre-scaling.

Literature Review

Mobile Learning in Science Education

With mobile technology, the science learning environment can be mobile and go with the students to the field site, to the laboratory and beyond (Martin & Ertzberger, 2013). The extension of the learning environment enables students to investigate more science phenomena in real life and to demonstrate principles and scientific knowledge in different contexts other than the laboratory (Shih, Chuang, & Hwang, 2010). Furthermore, the social networking opens up opportunities for students to do socially-mediated knowledge-building associated with learning science by doing science at anytime and anywhere. Science projects with the use of mobile technology have demonstrated the merits of mobile learning and its learning effectiveness for students (Pea & Maldonado, 2006).

Ahmed and Parsons' (2013) study focused on using a mobile learning system ThinknLearn for supporting students' abductive science inquiry in the process of exploration, examination, selection and explanation. Based on the results of a comparison of the experimental and control groups' performances, the findings suggested that with mobile learning, students improved in their skills on generating hypotheses and in developing critical thinking skills. In another study, a mobile plant learning system (MPLS) installed in PADs was used for supporting students outdoor investigation of plants through the ways of searching, creating and sharing the knowledge of plants. The study revealed that the MPLS helped students to acquire knowledge and stimulate their motivation and enthusiasm on engaging in outdoor mobile learning, as well as in social interaction and discussion about the course materials (Huang, Lin & Chang, 2010). In Ruchter, Bernhard and Geigers' study on the investigation of mobile computers in environmental education, the mobile tour system boosted student's learning about environmental literacy as well as their learning attitudes and motivation (Ruchter, Bernhard & Geiger, 2010). Song, Wong and Looi (2012) proposed a goal-based approach to design a mobilized curriculum to guide students' personalized inquiry learning in primary science. The approach has been verified with evidence that showed students' acquiring scientific knowledge and developing self-directed learning skills. These studies collectively point towards the particular role that mobile learning can play in science education, and that the combination of mobile learning system/apps and the appropriate pedagogical approaches (e.g. inquiry-based principles) could have special educational value for students' science learning related to their knowledge, skills, competences, and attitudes.

Scaling-up Evidence-based Practices

Fullan (2005) pointed out that understanding the change process is a big driver in the educational reform because such understanding of the change process is about establishing the conditions for continuous improvement in order to persist and overcome inevitable barriers to reform. The evidence-based practices serve the purpose of gathering evidences from a staged-based curriculum innovation to establishing the connection between consecutive stages. The evidence captured is especially beneficial to practitioners for understanding the change process of the curriculum reform and for assisting them to implement the innovation. Scaling-up evidence-based practices is the process in which researchers and practitioners initially co-design and implement innovations or interventions on a small scale, validate them, and then implement them more widely in broader contexts (Klinger, Boardman & McMaster, 2013).

Dunlap, Sugai, Lewis, Goodman and Horner (2009) delineate four phases of implementation when scaling up an evidence-based practice: (a) emergence, (b) demonstration of capacity, (c) elaboration, and (d) system adoption and sustainability. Emergence happens when the school leaders in consultation with the developers of the curriculum decided that it might actually be scalable. In the demonstration phase, researchers determine whether the practice is feasible and whether it has a significant effect on target outcomes. With the elaboration phase, the teachers implement the practice more broadly, drawing on the lessons learned during the demonstration phase and building on the capacity of the school leaders to implement the practice. In the final phase of system adoption and sustainability, the practices are integrated into the normal routines of the school so that they continue over time. These conceptual lenses pave the ways for our analysis of the scaling of the curricular innovation based on the evidence from the learning and teaching practices that resulted.

Context

M5ESC Development

We started first by working with a class of primary school students and a teacher over a period of two school years to develop M5ESC. Through a design-based research (DBR) approach (Penuel & Fishman, 2012), we first conducted several research cycles in the three-year research project entitled “Leveraging Mobile Technology for Sustainable Seamless Learning in Singapore School”. The project was framed in the broader context of constructing “seamless learning” environments to bridge different learning contexts (such as between formal and informal learning settings, individual and social settings, and learning in physical and digital realms), mediated by mobile devices in 1:1, 24x7 basis (Chan, et al., 2006; Wong & Looi, 2011). In the co-design process, researchers worked with teachers to revise and mobilize two years’ worth of the national science curriculum for Primary (Grade) 3 and 4 (or P3, P4, in short) by considering the opportunities afforded by ubiquitous access to mobile devices. Activities were designed which seeks to extend learning activities beyond the classroom. Students were each 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.

The basic rationale of the M5ESC that it is not feasible to equip students with all the skills and knowledge they need for lifelong learning solely through formal learning (or any other single learning space); henceforth, student learning should move beyond the acquisition of content knowledge to develop the capacity to learn seamlessly (Chen, Seow, So, Toh, & Looi, 2010). 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. The curricular commitment is seamless learning, and inquiry-based facilitation and learning. The technological commitments include: technology for construction, technology for communication, and technology for searching information anywhere anytime. The learning units in M5ESC are designed based on these design principles (Zhang, et al., 2010):

- Design student-centered learning activities (to promote engagement and self-directed learning)
- Make students' thinking process visualizable (so that they can be shared and subject to further refinement)
- Incorporate different learning modalities (to personalize learning)
- Design for holistic and authentic learning (make science learning meaningful)
- Facilitate social knowledge building (to promote collaborative learning)
- Ensure that the teacher plays the role of facilitator (to move away from didactic teaching)
- Provide an environment to integrate all learning activities (students have a hub to launch or continue their learning activities)
- Assess formatively (through the learning activities, students can receive feedback for their own ideas from peers or the teacher)
- Extend classroom learning activities beyond school hours and premises (to support the notion of seamless learning)

Concerning the curricular commitment, the Ministry of Education of Singapore has advocated teaching and learning science through inquiry and proposed the use of BSCS 5E Instructional Model in science learning (Bybee, 2002; CPDD, 2008). This 5Es model consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation. Each phase has a specific function and contributes to the teacher's coherent instruction and to the learners' formulation of a better understanding of scientific and technological knowledge, attitudes, and skills. The model frames a sequence and organization of programs, units, and lessons. Once internalized, it also can inform the many instantaneous decisions that science teachers must make in classroom situations. Figure 1 shows a lesson unit on the topic of “Exploring Materials” in P3 science curriculum. It is organized using the 5Es model and incorporates the use of the MyDesk learning system and other assisted tools.

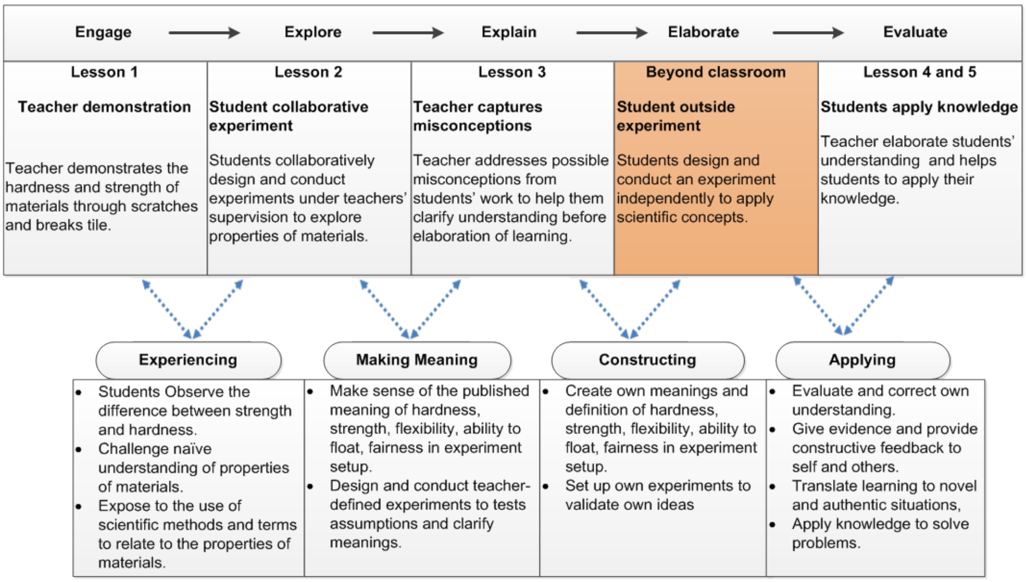


Figure 1. Lesson Design of M5ESC

The designed mobilized curriculum was developed with the use of software apps on the MyDesk that runs on a Microsoft Windows Mobile operating system. The MyDesk platform enables teachers to create differentiated lessons easily via its online learning management system, MyDesk Portal, and it enables students to easily personalize their learning experiences (Looi, et al., 2009). MyDesk supports teachers in creating complete, coordinated, curriculum-based lessons that employ multiple media and applications (e.g., text, graphical, spreadsheet, animations, and the like). It is an environment in which students engage in the specified learning activities and create various artefacts. MyDesk provides students following software tools with different educational value such as:

- iKWL: a self-reflection tool supporting students’ reflecting upon on learning process and conceptual changes through responding questions (i.e. what do I already **K**now? what do I **W**ant to know? What have I **L**earned?) to allow students to learn in a self-regulated way.
- SketchBook: an animation/drawing and picture annotating tool to assist students’ establishing connections between knowledge learned in the classroom and knowledge applied outside the classroom.
- MapIt: a concept map tool that allows students to develop conceptual understanding through creating, sharing, and exploring concept maps.
- Blurb: a question setup tool which facilitates the teacher to set up specific questions to ask students to give short opinions or feedback on their inquiry activities or their understanding of knowledge.

During the research over the first two years, learning efficacy has been demonstrated in a chosen experimental class of students over the two years. Now that the innovation is adopted by all the science teachers in the same grade level (P3 and P4) in our pilot school, we are interested in establishing how the classroom teaching practices are sustained, what the teacher perspectives of their curriculum implementation are, and what the learning efficacies of these cohorts of students compared with those of previous years are. In the study, we look at data collected on the transformations of classroom practices, on the summative assessments of science, and on an interview of teachers' perspective of changes in classroom after implementing M5ESC.

Scaling of M5ESC

The development and scaling of M5ESC went through two stages: Pre-scaling phase (year of 2010[1] and 2011) and scaling phase (year of 2012 and 2013). In 2009, we worked with one experimental class in P3 (n=44) taught by Jodie who had six-year teaching experience in science for implementing mobile curriculum to replace the traditional curriculum. In 2010, we continued our research by working with this same class who had by then moved up to P4. Particularly, our design was not just integrated as a project or activity in the class, but as a curriculum contained all topics in P3 science and harmonized with the science syllabus, classroom realities (student needs, student–teacher relationships, school culture, and textbooks) (Ertmer, Ottenbieit-Leftwich, Sadik, Sendurur & Sendurur, 2012), and followed the same class schedule and assessment schemes as the rest of the classes. Clearly changes have occurred in the experimental class and the teacher involved with evidences from research analysis (Looi, et al., 2011; Zhang, et al., 2010) during the two years of intervention[2], and from interviews with the stakeholders (school leaders and teachers). We saw a shift in the teacher's attitudes and behaviours towards science teaching, from a style that saw her pre-occupied with just covering the curriculum to one that allows her to watch over and facilitate students' work on the inquiry activities on their handhelds. With the mobilized lessons, we observed students engaging in science learning in personal and engaged ways (Sha, Looi, Chen, Seow & Wong, 2012). They demonstrated their understanding of science phenomenon in multimodal ways and did self-directed learning by doing online search, exploring on questions and discussing the learning artifacts related to the curriculum topics in both classroom and out of classroom. They engaged in instructional activities that involved their parents, such as in our mobilized lesson for the body

[1] The school academic year starts from January and end in November of the year; thus it is straightforward to refer to the school year by the calendar year.

[2] During the curriculum implementation, PD sessions in the form of regular meetings were conducted for improving teacher's understanding of and skills in implementing M5ESC, as well as for transforming pedagogical beliefs on the use of mobile technology. Meanwhile, the researchers sat in the classes and observed the teaching practices and learning activities so as to explore the gap between the desired curriculum and the enacted curriculum.

systems. This lied in contrast to the more “traditional” way of learning, in which students learned science from the didactic instruction of the teacher or from the textbook (Andrew, 2007). Our analysis of the science examination scores especially showed that amongst the six mixed-ability classes in P3 in the school, the experimental class performed better than other classes as measured by traditional assessments in the science subject (Looi, et al., 2011). This result was a very worthwhile contribution to the field, as much research work on mobile learning focus only on units of at most a few weeks duration or they were add-on activities to some existing curriculum (Ng & Nicholas, 2013).

When the curricular innovation using mobile devices has been co-developed and studied in the context of one class, and the empirical evaluation of the mobilized curriculum has shown its potential for learning effectiveness, the school leaders decided that it was a worthwhile innovation and, in consultation with the researchers and collaborators, would like to scale up the innovation. Once designed, the curriculum can be enacted by science teachers, and it is important for the teachers to understand the design principles and pedagogy behind a mobilized curriculum for inquiry learning and how to implement in the way to harness the best learning outcomes for students. In the academic years of 2012 and 2013, all teachers of P3 participated in the PD workshops and regular PD meetings for elaborating and implementing the curriculum. Researchers provided extensive support in both the PD and teaching practices, seeking to maximize the educational value of M5ESC through collecting and then analyzing multiple data from the classroom sessions. During scaling phase, students from eight P3 classes were expected to benefit from the M5ESC. To support this spread to all teachers and all classes in P3, the scale-up comprised these multiple dimensions of enablement which have been frequently discussed in the literature on curriculum reform or scaling (Davis, 2003; Fullan, 2002; Guzman & Nussbaum, 2009; Talbert, 2009)

- School leadership
- Teacher readiness
- Teacher facilitation skills
- Student readiness (e.g. hardware and software training of the mobile device, inquiry learning)
- Technology infrastructure (e.g. WiFi and 3G Connectivity; availability of mobile devices in 1:1, 24x7 basis)

Different kinds of transformations could happen with a curricular innovation. In the context of M5ESC, the transformations mainly centered on the pedagogy, curriculum, technology integration, students’ learning patterns, parent attitudes, teachers’ attitudes, beliefs and capacities, and classroom culture. We have reported our findings on some of these transformations arising from the implementation of M5ESC (Looi, Wong, So, Seow, Toh, Y, Chen& Soloway, 2009; Looi, Sun, Seow & Chia, 2014; Norris, Soloway, Tan & Looi, 2013). In this paper, we will provide fresh data on students’ learning outcomes and the analyses of classroom practices with the M5ESC implementation to assess the effectiveness of the curricular innovation when it is scaled up to a whole grade level. The yearly comparison of learning outcomes will be used for exploring students' progression in science learning, thereby demonstrating the value of M5ESC at scale.

Data Collection and Data Analysis

In this project, the data collection for the curriculum implementation was conducted during the whole school year. The data sources included the teachers' and students' performances in the classroom, teachers' PD sessions, and students' work in and out of classroom. To observe teachers' pedagogical orientation on the science instruction, the lessons which related to hand-on activities, experiments, mobile learning activities and any activities regarding to the learning artefacts constructed by smartphones were recorded and analyzed in each teacher's class. Three researchers conducted the classroom observations which included observing the teacher's and students' performance (e.g. questioning, interaction, and scaffolding) in the key instructional events. Two static cameras were set up in the front of and at the back of the classroom, and one mobile camera was used to capture the teacher-students interaction and target group activities. Audios were put at each group table for further capturing students' peer discussion. Using field notes, the sequence of key instructional events and main activities were recorded. With classroom observation sheets, the researchers noted how the teacher enacted lessons related to key instructional events, in particular, how the teacher facilitated the class activities following students' work on the smartphones, and how they interacted during the group activities. Meanwhile, several surveys and interviews were conducted during different scaling stages. Student tests scores of Semestral Assessment 1 (SA1) taken at the end of the first semester, and Semestral Assessment 2 (SA2) taken at the end of the second semester were selected and analyzed for revealing students' progression in conceptual understanding. The tests had been validated by researchers and experienced teachers, each question in SA1 had been measured as having consistent item difficulty as SA2. The total score of the tests was 100 with the SA1/SA2 tests comprising two components with 60 marks for MCQ (Multi-Choice Questions) (2 marks for each item) and 40 marks for OE (Open-Ended Questions) (2 marks for each item).

Both qualitative and quantitative data analysis methods were used. Data referring to classroom practices were retrieved, transcribed and analyzed for examining the changes of teachers' pedagogical approach, the design of lesson plan, the use of assessments methods, the deployment of the mobile learning in a formal or informal context, the classroom culture and the involvement levels of parents during the pre-scaling phase or scaling phase. These dimensions were frequently discussed for exploring the classroom practices in other relevant studies (Brand & Moore, 2011; Donlence, 2003; Diaconu, Radigan, Suskavcevic & Nichol, 2012). To obtain further insight into teachers' ideas and thoughts behind their M5ESC implementation, the interview transcripts of five science teachers from the same grade level (i.e. P3) were analyzed for examining their perspectives and experiences in implementing M5ESC.

To explore students' progression in conceptual understanding impacted by M5ESC enactment, we conducted a comparative analysis of P3 test scores during four consecutive years (i.e. 2010, 2011, 2012, and 2013) for evaluating the learning effectiveness on students' development in science concepts in more quantitative ways[3]. 2010 and 2011 are the pre-scaling phase in which the P3 classes had science lessons taught in their traditional way. 2012 and 2013 are the scaling phases in which the teachers in all the P3 classes taught using the mobilized curriculum. The yearly comparison of differences of SA1 and SA2 would provide us a more objective account of the different performance gains that different groups of students had achieved in different years. And the comparison was expected to provide more evidence for supporting our research hypothesis that students would benefit more in reasoning and conceptual understanding with the use of M5ESC. Each year, these students at the P3 level were divided into eight classes (3A, 3B, 3C, 3D, 3E, 3F, 3G and 3H). The eight classes were further divided by teachers into three levels of ability, named as HA (High Achievement), MA (Mixed Achievement) and LA (Low Achievement) based on their prior achievements at the P1/P2 level. In the data analysis, we firstly present and describe the overall performance gains and HA-MA-LA effects in 2012 and 2013 respectively. Then we compare the overall performance gains and HA-MA-LA effects of scaling phase with those of the pre-scaling phase, 2010 and 2011. Finally, we summarize the key findings from the quantitative analysis.

[3] These two examinations are meant to provide summative assessment of students' achievement of understanding in science, and the results are used by the school as key indicators to evaluate students' progress over the year in Singapore.

Findings

Comparison of Classroom Practices

Table 1 shows a comparison of the classroom practices from the perspectives of the classroom teaching approach, design of lesson plans, use of assessment methods, linkages of classroom learning to informal learning, classroom learning culture, and parental support and attitudes. We use the P3 science topic of classification to discuss and present our findings. In Table 1, the first column shows the previous classroom practices before the M5ESC was enacted by all the classes (i.e. before it was scaled-up[4]). The column for 2012 shows the classroom practices during the first year of scale-up to the grade level[5]. The column for 2013 is the second year of scale-up with M5ESC further refined based in the experiences and findings from the 2012 scale-up.

M5ESC is about learning activities for students to probe, state, create and discuss their own understanding of science concepts using the MyDesk apps and its' assisting tools on the smartphones. It is also about students holding the smartphone as a learning hub from which they can initiate or continue learning activities anywhere even outside of the classroom. A substantial transformation is thus that students took more ownership of the learning with technology by recording or doing learning activities through the use of the smartphones. The teacher becomes a facilitator of learning in the classroom characterized by classroom discussion of the science ideas and students experiences. The students are more generative in their science ideas. This is evident in their attempts to fill in the OE questions with possible explanations albeit the answers may be incorrect. Thus, in M5ESC classroom, teachers are encouraged to use more constructivist pedagogical approaches to pose questions, scaffold students, and interact with students, as well as conduct more student-centered inquiry-based activities (Holt-Reynolds, 2000). To customize more appropriate M5ESC lessons based on school culture, teachers are suggested to be more open to redesign the lesson plan based on characters and levels of their classroom with the use of differentiated instructional approach (Tomlinson, 2001). They are proposed to integrate more formative assessment methods for evaluating students' performance in the inquiry process rather than emphasize the results of term-based tests. Gradually, teachers will have more understandings of connecting science learning in classroom and outside classroom, and could monitor and assess learning artefacts created outside classroom for supporting students' conceptual understanding and skills development. Moreover, parents are also encouraged to involve more in the outside learning activities and assist in monitoring the work progress.

Positively, changes have been emerged after long-term intervention of M5ESC. In the initial stage of pre-scaling phase (the year of 2010), the teacher followed the traditional teaching approaches

[4] One experimental class in the grade level was involved in the research as P3 in 2009 and as P4 in 2010, but for the other classes, science was taught in the manner described in the first column.

[5] It was a year in transition as teething problems emerged during the teachers' enactment of M5ESC, and the teachers and researchers deliberated and worked collaboratively together to fine-tune M5ESC, adopt or revise new strategies to better support the enactment. Hence the column for 2013 is different from 2012.

on the lectures, technology use, experiments and other hands-on activities. She mostly guided the classroom activities and monitor and assess students' work. As we found that teacher-guided pedagogical orientations were common in the lectures, the instruction of experiments and hands-on activities, and the ways of conducting other activities (e.g. checking and providing the fixed answers for students' completion of worksheets and work books; cookbook pattern of instructing experiments; few types of scaffolding for elaborating students' knowledge) (Ertmer, et al., 2001). Thus, few students-centered activities appeared in her classrooms, and students were rarely received opportunities of doing activities and discussing their experience within group members. After one-year intervention, the teacher performed more skillfully on conducting experiments and discussion activities using some constructivist pedagogical approaches. She asked more questions when she introduced a concept or science phenomena; she increased the use of smartphone in the classroom and extended the ways of technology integration on evaluation and reflection of learning artefacts; she would like to ask students to conduct several discussion work on assessing their learning artefacts done by MyDesk, and interacted more for providing knowledge of the procedures and knowledge on seeking for the solutions. Positive and encouraged results received during the later stage of pre-scaling phase as we mentioned in the section of "scaling process of M5ESC".

Supported by PD sessions and regular meetings, teachers developed more teaching strategies based on the constructivist pedagogical orientation in the 2012 and 2013 scaling phases, especially in the year of 2013, teachers valued more students' knowledge construction through peer discussion and peer assessment, and they interacted more frequently with students with purposes on detecting their understandings and guiding the knowledge construction (Orlando, 2013). Moreover, teachers conducted more discussion and sharing activities about students' learning artefacts done at outside the classroom. This stimulated students' self-directed learning using mobile phone beyond the classroom (Wong, 2013).

Simultaneously, the design methods of lesson plans were changed from copying teacher guide book directly to co-designing school-based lesson plans, which indicated that teachers involved more in the lesson plan design to adapt the M5ESC and respond more appropriately to the ideas that students raise during instruction (Sherin & Drake, 2009). With the deeply practicing M5ESC, they processed strong willingness to elaborate their teaching strategies based on their teaching practice and students' needs. For example, M5ESC was first designed for a MA class[6]. The lesson plans for two years of science curricula for P3 and P4 were amongst the outcomes of the first research phrase. During the scaling phase, these lesson plans were discussed and revised arising from discussions in teachers' regular meetings[7]. One realization that emerged as teachers of one grade level started to

[6] The students were divided into different levels (low ability (LA), mixed ability (MA) and high ability (HA) classes) according to their scores at the end of P2.

[7] In the M5ESC project, different parties including educators, teachers, and researchers were sitting together to revise the lesson design, share teacher's experience and research findings, and discuss the contradiction between the designed lessons plan and the enacted lessons. The discussion and sharing sessions were conducted as regular meetings per week.

teach the curriculum to different ability students was the need for differentiated instruction. The teacher faced challenges in managing learning in a diverse classroom using the same set of lesson plan and resources (Tomlinson, 2000). And on the other side, differentiated instruction focuses on teaching strategies that give diverse students multiple options for taking in and processing information, making sense of ideas, and expressing learning. The use of technology tools could provide students with different levels of interaction with software, conduct inquiry activities and create learning artefacts (Smith & Throne, 2007). Consequently, M5ESC should be differentiated to challenge HA and MA students accordingly to their abilities. For example, HA students were required to construct and synthesise knowledge with higher level scaffolds. The HA, MA and LA used the same learning activities but required to produce different levels of same learning outcomes. Teacher efforts on the implementation of differentiated instruction could be detected in the classrooms at the later stage of scaling phase.

With the improvement on the skills of designing mobile learning activities for informal contexts in the scaling phase (e.g. home, zoo, botany, etc), teachers designed more students-centered mobile activities to relate students' understanding with real life experience and to improve understanding through applying the knowledge in daily life, and with the result of teachers' increasing the use of mobile technology in classroom and out of classroom. Consequently, students became more interesting in the learning activities and would like to share their ideas and knowledge with their classmates; students in 2012 and 2013 participated more actively in the learning activities compared to the students in 2010 and 2011, which lead to the changes of the culture of classroom learning. In the scaling phases, the term-based tests scores were not the only assessment instrument, students' performance in doing activities and the artefacts done by MyDesk had been selected another indicators for teachers' evaluating students' improvement and progression. For example, in the topic of "Exploring Materials", students were required to complete a series of tasks including constructing a concept map in MapIT for materials classification after they explored the experiments of materials and their properties, and writing their reflections on what they had learned in KWL, and connecting and applying their understanding in daily life through posting a pic of product and pointing out its materials and properties. It was found that more than 50% of the students posted their learning artefacts with different understanding levels. We illustrated three SketchBook artefacts constructed by students (Figure 2). And a considerable proportion of artefacts reflected that a number of students attained high understanding levels. The identification of the different levels of learning artefacts served for the teacher to monitor students' progress and provided in-time feedback for students to elaborate their understanding, as well as promote students to review and reflect on their learning process.

Figure 2. Students' Learning Artefacts in MyDesk

When they received positive results, the parents became involved more and aware of what their children were learning, they were willingness to assist their children's outside work and interacted teachers with feedback and suggestion.

Table 1. Classroom Practices on Classification in P3 Science

Items	**Pre-scaling phase**		**Scaling phase**	
	Years 2010	**Year 2011**	**Year 2012**	**Year 2013**
Teaching Approach	Traditional pedagogical orientation • Lecture: introduction-explanation • Experiments: "cookbook" pattern • Technology use: resource • Discussion activities: answers of worksheets and workbooks • Limited teacher-student interaction: answers, procedures	Somewhat constructivist pedagogical orientation • Lecture: questions-explanation-summary • Experiments: collaboration, sharing, and discussion • Technology use: resources, evaluation tool, reflection tool • Discussion activities: answers of worksheets and workbooks, learning artefacts • Teacher-students interaction: answers, procedures, knowledge	Constructivist pedagogical orientation • Lecture: questions, provide scaffolds, seek explanation, provide summary • Experiments: inquiry-based approach • Technology use: resources, evaluation tool, refection tool, comparison tool • Discussion activities: answers of worksheets and workbooks, learning artefacts, reflection, understandings, learning experience • Teacher-students interaction: procedures, knowledge, skills	Constructivist pedagogical orientation • Lecture: questions, provide scaffolds, seek explanation, provide summary • Experiments: inquiry-based approach • Technology use: resources, resources, evaluation tool, refection tool, comparison tool, sharing tool • Discussion activities: answers of worksheets and workbooks, learning artefacts, reflection, understandings, learning experience • Peer critique and activities: learning artefacts, understandings • Teacher-students interaction: procedures, knowledge, skills appropriate scaffoldings on knowledge building
Lesson Plan	Teacher guide book • Teacher followed publisher's teacher's guide.	Revised teacher-guide book • Teacher and researcher revised publisher's teacher guide • Teacher and researchers co-designed school-based lesson plan	School-based lesson plan • Teachers implemented and enacted the school-based lesson plan in their classrooms • Teachers-researchers co-designed differentiated instruction content • Teachers-researchers co-design school-based worksheets	School-based lesson plan • Teachers elaborated and implemented the school-based lesson plan in their classrooms • Teachers implemented differentiated instruction in their own class • Teachers implemented the school-based worksheet
Assessment methods	Traditional assessment • Worksheet and workbook • Term-based Tests	More formative assessments • Worksheets and workbook • MyDesk learning artefacts	Formative and summative assessments • Worksheets and workbook • MyDesk learning artefacts	Formative and summative assessments • School-based worksheets and workbooks

		• Performance in group work • Term-based tests	• Performance in experiments • Performance in group work • Term-based tests	• MyDesk learning artefacts • Performance in experiments • Performance in group work • Performance in activities beyond classroom • Term-based tests
Linkages to informal learning	Classroom Learning	Informal learning • Home-based activities	Informal learning • Field trips: Zoo • Home-based activities	Informal learning • Field trips: Zoo • Home-based activities • Supermarket visiting
Classroom Learning Culture	Teacher directed classroom • Teacher directed the doing of worksheets and activities. • Teacher directed the experiments and hands-on activities • Teacher assessed students' work	Transforming to participatory • Teacher directed the doing of worksheets and activities • Teacher assigned discussion and sharing work to students in experiments and hands-on activities • Teachers asked students to do peer assessments of learning artefacts.	Participatory • Students participated in the experiments and hands-on activities • Students discussed their learning artefacts and shared the learning experience out of classroom • Students shared their ideas and knowledge in group work	Participatory • Students participated in the experiments and hands-on activities • Students discussed their learning artefacts and shared the learning experience out of classroom • Students shared their ideas and knowledge in group work and peer assessment of ideas and artefacts
Parents	No involvement in outside activities	Some involvement in outside activities	Involvement of mobile activities outside of classroom	Involvement of mobile activities outside of classroom

Teachers’ perspectives of M5ESC

Five teachers, namely, Tom, Alice, Jemmy, Caroline and Jude, were interviewed at the end of academic year 2013 for about their changes after long-term practicing M5ESC. The questions posed to them were: “If you think back, over the course of the year, what is the one thing that you feel is different about how you are teaching? How are you teaching that is different?”

At the beginning of the M5ESC implementation, as Tom had low confidence in enacting the curriculum, he relied mostly on the textbook and teaching resources for preparing the lessons, and did not have a deep understanding of the principles of the M5ESC. After joining the group meetings and doing the lessons, he developed more confidence in implementing the curriculum. He noted the changes in students that resulted from the autonomy given to them in doing their hands-on activities and their participation in peer discussion and sharing of their learning experiences. He found that students become more engaged in the discussion and sharing work:

“Now I have more confidence to conduct the activities from M5ESC. When I saw my students were actively discussing their work and sharing their ideas with their partner, I understood the value of student-centred activities. I attempt to conduct more activities based on the co-designed lesson plans to develop students’ skills in collaboration and communication. And I’m amazed that there are kids that will conduct experiments or doing activities at home even though they were the weaker lot and their parents were also quite supportive. Most students could post their work done out of classroom, and they shared their process with their classmates and peer assessment of each other’s work, they enjoyed the learning process and seemed to be more engaged in the mobile learning activities compared to the paperwork activities. ”

Previously, Alice felt that the lack of her ability of doing technology integration was the obstacle for implementing mobile learning activities in the class. But later, she was able to apply technology in more activities with different cognition levels into the class (Starkey, 2011). During these activities, she valued students’ participation and contribution to their own inquiry activities. For example, in the lesson of “Exploring Materials”, the students developed deeper understanding of the properties and value of the materials and objects in their daily lives after they engaged in a series of activities using Sketchbook in MyDesk: looking for the products → taking the pictures → describing the constituent materials → pointing out the values and properties of the materials.

“But what I like about the phone is that the alternative platform allows children who may be reluctant to do the written work part … they at least have an alternative tool to get them to draw, to record, to crate and to generate their own work. The use of smartphone opens up my ideas on the technology use in more learning activities with different learning objectives. For example, I can teach students’ skills on data collection using camera and audio recorders in the smartphone; and I can ask students to practicing their reflective thinking skills using the KWL app, and assist students to develop systematic thinking skills through using MapIT app. These did not happen in my previous classroom.”

Jemmy shared that his students now spent more time on learning from books, and as they pursued understanding through interacting with teacher and their classmates, they become more open to peers' experiences for better understanding. These changes emerged after he implemented M5ESC for around one year. The same changes were found in their ways of seeking for answers that they would rather do peer discussion with their partners and not directly approach the teacher. Jemmy felt that he now paid more attention on how to scaffold students' peer discussion while knowing more about students' prior knowledge and providing appropriate scripts or prompts for them to find the solutions.

"I guess I am using more inquiry-based teaching in class. I am more conscientious with using the inquiry-based teaching in class. I probe more -- usually when my children do not give the answer, I will just tell them the answer, like 'hey this is it'. But now is like I probe a little more, I ask more questions and I get them to think more. Interestingly, students were not eager to get the answers from me but discussed with their partners until they reached the same answers."

Caroline felt the major change was her ways of assessment in science. Her previous focus was on students' answers in worksheets and workbooks; she emphasized more on students' SA1 and SA1 scores. She had gradually balanced her focus on the formative and summative assessments after intervention. She thought students' responses to KWL, learning artefacts constructed by SketchBook and MapIT provided valuable information on what levels and how the students were learning. More importantly, assisted by mobile technology, she could access students' work anytime and anywhere. Students benefited from her in-time feedback and assessment, especially for the low ability students who may require more assistance from her.

"Previously my science teaching is more like a paper kind of evaluation, even when we have science process skills (a worksheet), we have alternative assessments, having hands on that kind of thing …. We don't have time to see what the student is thinking. But right now with the smartphone, especially when I use applications like SketchBook and MapIT, I am able to give more opportunities for children to explain their thinking, to express their thinking, although we do not have the time to evaluate their answers, but it gives me a very fast perspective of general understanding of the kid."

Jude thought previously she had been playing the same role in the front of classroom, namely, lecturing to the class; she acted more roles in the class now. She became more mobile and flexible for facilitating students' group work and providing scaffolds when students required for assistances. In most occasions, she performed as a collaborator for joining students' collaborative or sharing work, and meantime monitored students' progress and provided in-time feedback for their problems. She felt although she became more busy while implementing M5ESC but students benefited more from her scaffoldings.

"The difference is in the way I conduct my lessons because now I used to ask questions where I want a certain kind of answer from the pupils but now I let them answer freely according to how they think they want to answer it and I'll adapt from there. By adapting from there, I mean I don't say

that their answers are wrong and try to steer them towards my answer but instead I joined their discussion and get them to rethink about whether what they have answered is the correct way of answering. Then they themselves discussed with one another and guide them to correct each other on the misconceptions and so on"

Students' Yearly Progress in Conceptual Understanding

For the year of 2010, 2011, 2012 and 2013, there were 1196 students in total; 295 students in 2010, 297 students in 2011, 299 students in 2012, and 305 Students in 2013. Table 2 shows the distribution of P3 students in HA-MA-LA.

Table 2. Distribution of Students

Ability levels	2010	2011	2012	2013	Sum
HA	121	132	128	128	509
MA	142	111	119	114	486
LA	32	54	52	63	201
Sum	295	297	299	305	1196

Through data analysis of yearly SA1 and SA2 scores attained by these students, the impact of M5ESC on students' conceptual understanding was gradually increased year by year.

Overall Performance Gains and HA-MA-LA Effects of Year 2012

Year 2012 was the first year in which the whole P3 level implemented M5ESC. To compare the overall performance gains, a one-sample t-test (Table 3) was conducted. The result showed that the whole P3 cohort has made a significant increase of 7.69% from SA1 to SA2 in terms of total scores ($t = 6.584$, $p < .05$). It was prominent to note that such a progress is mainly attributed to their gains in 27.04% increase of OE scores ($t = 11.845$, $p < .05$) since they experienced a slight (not significant) decrease in MCQ scores. This indicated that in 2012, most students developed deeper understanding and reasoning skills through reasoning about the scientific phenomena and through the teacher providing the principles or relevant knowledge for clarifying the understanding of the students.

Table 3. SA1/SA2 HA-MA-LA Gains of Year 2012

	MCQ Gains	**OE Gains**	**Total Gains**
All classes	0.49% t=.406	**27.04%*** t=11.845	7.69%* t=6.584
HA classes	-5.04% t=-5.987	**11.71%*** t=7.798	5.04% t=.535
MA classes	0.91% t=.595	**29.55% *** t=8.835	8.62% * t=6.047
LA classes	13.16%* t=2.487	**60.30%*** t=7.071	**23.49%*** t=4.809

*: Statistically Significant

Table 3 also shows the performance gains from SA1 and SA2 on the MCQ, OE and total scores respectively in the HA, MA and LA groups of Year 2012. Specifically, comparing to other groups, the LA group achieved the highest MCQ gains at 13.16% (t =2.487, $p < .05$), the highest OE gains at 60.30% (t = 7.071, $p < .05$) and the highest total gains at 23.49% (t = 4.809, $p < .05$). Additionally, the HA group achieved significant OE gains at 11.71% (t = 7.798, $p < .05$) and the MA group achieved significant OE gains at 29.55% (t = 8.835, $p < .05$).

In summary, from the SA1 to SA2 comparison of year 2012, we learnt that the whole 2012 cohort has achieved significant gains in total and OE scores. The improvement in OE scores was the major reason for the improvement of the total score in all levels. In particular, the MA and LA cohorts experienced more SA1/SA2 gains compared with the HA cohort, especially with respect to gains in OE scores.

Overall Performance Gains and HA-MA-LA Effects of Year 2013

Year 2013 was the second year for the whole P3 level to implement M5ESC. The one sample t-test showed that the whole eight classes have made a significant increase from SA1 to SA2 in terms of total scores (t = 13.626, $p < .05$). Such a progress was attributed to their learning gains in terms of both OE scores (t = 16.514, $p < .05$) and MCQ scores (t = 5.978, $p < .05$).

The P3 cohort of Year 2013, also consisting with HA, MA and LA classes, achieved gains for each ability group (Table 4). Our analysis showed that most of the HA-MA-LA classes have had a significant increase from SA1 to SA2 in terms of MCQ scores, OE scores and total scores, except that the LA classes has not achieved significant increase in the MCQ gains.

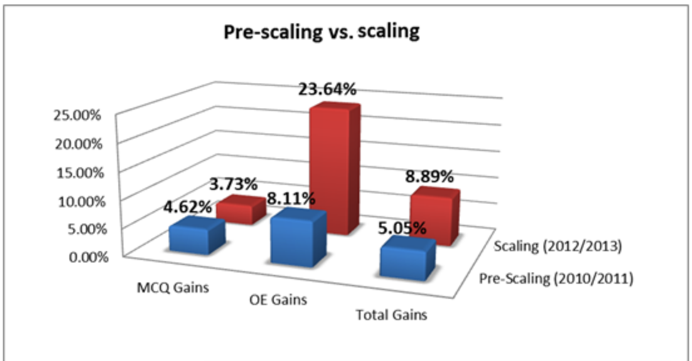
Table 4. SA1/SA2 HA-MA-LA Gains of Year 2013

	MCQ Gains	**OE Gains**	**Total Gains**
All classes	6.91% * t=5.978	20.33%* t=18.514	10.07%* t=13.626
HA classes	3.53%* t=3.24	16.30% * t=15.021	7.7% * t=10.1
MA classes	10.98% * t=5.52	23.07% * t=12.527	13.86% * t=10.643
LA classes	6.41% t=1.449	23.55%* t=4.587	8.03%* t=3.198

*: Statistically Significant

Overall Performance Gains and HA-MA-LA Effects in four consecutive years

We seek to compare the SA1/SA2 performance gains of Year 2012 and 2013 (scaling phase) with the previous Year 2010 and 2011 (pre-scaling phase). As Figure 3 shows, there was a prominent average improvement of 23.64% in OE scores in 2012/2013 compared to the average 8.11% improvement in 2010/2011. The average 8.89% improvement in total scores in the scaling phase is also higher than the average 5.05% improvement in the pre-scaling phase.

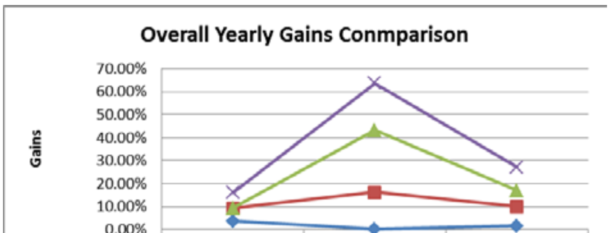


	MCQ Gains	OE Gains	Total Gains
Pre-Scaling (2010/2011)	4.62%	8.11%	5.05%
Scaling (2012/2013)	3.73%	23.64%	8.89%

Figure 3. Comparison of Pre-scaling and Post scaling on Performance Gains

A yearly comparison of performance gains was also conducted to investigate the differences between the years, as shown in the following Figure 4. It is noted that LA cohort of year 2012 achieved the most prominent 60.3% increase as OE gains. The overall OE gains of year 2012 (27%) is the highest amongst the years, followed by year 2013 (20.33%). The MA cohort of year 2012 also achieved the highest OE gains (29.55%), followed by the MA cohort of Year 2013 (23.07%). The LA cohort of Year 2012 experienced the larger improvement in both MCQ scores (13.16%) and total scores (23.49%) than other years.

Comparing to year 2012, year 2013 had a more balanced result in MCQ gains (6.91%) , OE gains (20.33%) and total gains (10.07%). The HA cohort of Year 2013 experienced higher gains in OE scores (16.3%) and total scores (7.7%) than previous years. The MA cohort of Year 2013 had the highest improvement in MCQ gains (10.98%) and total gains (13.86%) in the four years.



	MCQ Gains	OE Gains	Total Gains
2013 Cohort	6.91%	20.33%	10.07%
2012 Cohort	-0.10%	27%	7%
2011 Cohort	5.60%	16.10%	8.50%
2010 Cohort	3.70%	0.10%	1.50%

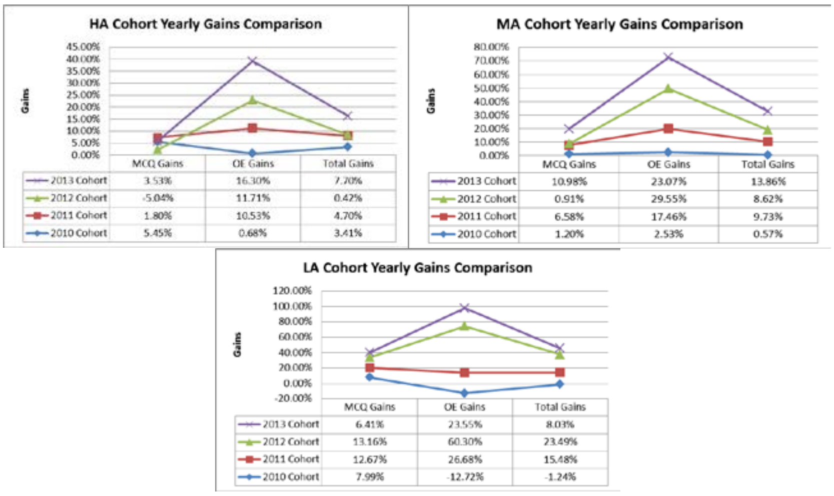


Figure 4. Comparison by Year of Performance Gains

The comparison of performance gains from SA1 to SA2 over the four consecutive years provided an overall map of the effectiveness of implementation of M5ESC at the grade level. In summary, the students in P3 were responding well to OE questions, thus suggesting that the students had developed deeper understanding of the concepts. The whole cohorts of years 2012 and 2013 improved significantly on the OE questions than on the MCQ when compared with how they did on the OE questions in 2010 and 2011. It suggested that the elaborated M5ESC and teachers' adaptation of the curriculum in scaling phase contributes more to students' progress in science learning.

The learning experiences of M5ESC are generally significantly benefiting the MA and LA groups. The HA group already had high scores on both the SA1 and SA2 tests and on both sections, MCQ and OE. With the elaboration of the M5ESC and the development of teacher competency on the M5ESC implementation, the SA1/SA2 gains in Year 2013 are more robust than Year 2012. All HA-MA-LA cohorts of year 2013 have generally achieved significant increases in both MCQ and OE scores. The HA cohort of Year 2013 was still capable of making prominent progress in both MCQ and OE. It is essential that the students were not doing better on OE at the expense of MCQ.

Discussion

Scaling an innovation which has been developed by design-based research requires a long time frame and deployment of a range of methodologies, including design-based research studies in classrooms and small-scale field tests to establish the feasibility of implementing interventions in multiple settings (Sloane, 2008). During this process, we need to identify the barriers encountered by different stakeholders. Teachers as the most important stakeholders in the scaling process of the curricular innovation are most often discussed and their teaching are the most essential components for educational progress (Bybee, 1993). During the observation of teachers' implementation of M5ESC in the classroom, we found the enabling factors which support all the teachers to enact M5ESC in their own classes despite their pedagogical beliefs, teaching styles and ability level of the students in their class or classes. One enabling factor is devoting many opportunities and time for teacher to have professional development and professional learning.

In the school at the outset, we recognized the need for curriculum support if the curriculum was going to be changed substantially. Thus, the school hired curriculum developers to take a leadership role in changing the curriculum but work with the teachers in a collaborative relationship. Thus, a team co-designed the revised curriculum - with teachers playing a supportive role, but not a time-consuming leadership role.

Initially at the beginning of the project, neither the curriculum developers nor the teachers had experience with the MyDesk software, with smartphones, and with inquiry pedagogy. Thus, no one really understood how the affordances of the technology (hardware + software) could be best leveraged when creating learning activities for the students. Therefore, we borrowed the notion of "agile development" (Sutherland, 2013) that is gaining currency in the web development world and applied the "agile" notion to arrive at "agile curriculum development." Thus, rather than developed a whole semester's worth of curriculum at one go, we developed one lesson and tried it out. Based on how that lesson was received by the students and the teachers, we tweaked our design techniques on the next lesson. This iterative design proved to be a productive development strategy.

At the school, by and large, the students were scoring well on their end-of-year tests. Thus, teachers asked: "Why do you want me to change? I am already clearly doing a good job." But, as responsible professionals, when the principal gave them a lesson embodying the new curriculum, pedagogy, and technology, the teachers enacted the lesson - even though they were uncertain as to its value. However, once the teachers saw the positive change in the students' behaviors and performance, they were more willing to cooperate in helping to change the subsequent lessons.

The school had common planning periods where they met to discuss educational issues, e.g., once a week, the P3 science teachers met together. However, the teachers felt that they needed to actually see teachers more experienced in the inquiry-oriented pedagogy actually enacting a lesson. In science, the teachers re-arranged their schedules, reducing the amount of time they met in common, in order to allow them time to visit each other's classrooms - to see inquiry-oriented pedagogy being enacted. Conversation is good, but first-hand experience is also important. Interestingly, now that other primary schools are looking to adopt the curriculum/pedagogy/technology used at the school, these other schools are sending their teachers over to observe the the school teachers in action.

While the research literature is filled with educational studies that take two weeks from start to finish, we have found that for an innovation to truly have an impact, serious time must be allotted to that making that innovation stick. Invariably things go wrong; invariably mistakes are made. At the school, a small team started 5 years ago with a pilot science classroom and over the years, the team has grown and grown; now essentially all the P3 and P4 faculty are involved - hence the label: cultural change.

Conclusion

The success of the curriculum innovation in terms of changes in classroom practices and in students' learning performances on their science assessment is due in large part to the strategies that supported teachers' enactments of the curriculum through a continuous consultative process of fine-tuning the curriculum and implementation, as well as the dual interaction among the factors of innovation. In this curricular innovation on mobile learning, the results provide some validation that the scale-up of M5ESC is effective. Based on classroom observations over the four years, we know that teachers had transformed their pedagogical approaches in more constructivist ways (Voogt, 2010), that they conducted more student-centered activities and emphasized students' autonomy in the experimental and hands-on activities. They particularly extended the ways of using technology in both classroom and outside of classroom. They experienced changes in their own teaching as well as changes in students, and appreciated the positive impact brought by the curricular innovation. The comparative analysis of four consecutive years' test scores demonstrates a progression of improvement in the students' performance as the curricular innovation was continuously improved.

The scaling trajectory reflects a process of researchers collaborating with the implementing teachers to study the adoption and the adaptation of the curricular innovation as it goes to scale to more classes. The work enables us to better articulate M5ESC, the supporting resources, and the enculturation and scaffolding required by the implementing teachers. It also helps us to understand the teacher learning and professional development models in terms of their impact, efficacies as well as weaknesses. Moving from employing a direct instruction, memorization-oriented pedagogy to an inquiry and question-asking pedagogy requires a major change in teachers' behaviors and beliefs. After enacting an inquiry lesson where there was substantial group discussion and observing the impact of that discussion on the students, one teacher, who had been quite skeptical and vocal about that skepticism, commented: "The children can learn without me." In summary, we established that M5ESC can transform classroom practices and raise student achievement in the context of the scale-up to all classes in a grade level and implementation of the curriculum.

Various strategies were adopted and fine-tuned in the design-based research process through collaborative work between teachers and researchers over the two years of scale-up implementation. The strategies recognize the range and diversity of teachers' local needs as well as the necessary adjustments they need to make in order for the innovation to be useable and effective, and how the school can support them to know how to adapt the innovation and yet retain the essence of its efficacy. Innovation is indeed a complex process and scaling innovation is even more. Drawing on our efforts on this five-year curricular innovation for educators and researchers, we conclude that the success of the innovation can be maximized if the long-term trajectory of implementation could follow the design-based research and emphasize the evidence-based efficacy intervention (Penuel & Fishman, 2012). This narration of the ongoing research journey from innovation to practice and to scale can inspire other research initiatives that will address the multi-term, multi-pronged, multi-level and systemic aspects of school-based innovations, and that yet at the same time, advance theory, frameworks, design principles, resources and strategies for effective and sustainable mobile learning.

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