

Transforming Primary Science Learning via a Mobilized Curriculum for Sustainability

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Abstract: Over a year of time, we co-designed primary three science curriculum to integrate 1:1 mobile technology with teachers. The form teacher of the experimental class in a Singapore school enacted the curriculum as her regular teaching. This paper proposes a cyclic model of how to “mobilize” the curriculum in align with the national primary science syllabus. Preliminary results of the enactment are also presented.

Keywords: Primary science, 1:1 mobile learning; mobilized curriculum; sustainability; transform

1. Introduction

The history of education reform has fundamentally revolved around curriculum development and implementation [1]. With the availability of affordable mobile devices and software applications, educators are trying to integrate the affordances of mobile devices to support science learning. By coupling the technical infrastructures for mobile learning with good curriculum and pedagogical design, teachers can transform science teaching into personalized learning journeys for individual students.

However, although there have been studies on mobile-assisted inquiry-based science learning (e.g., [2][3]), most of them were short-term explorations that may not have to be an integral part of schools’ existing science curriculum. In this paper, we report our first year’s experience on our three-year study to transform the existing science curriculum into a “mobilized” curriculum which is delivered via a smartphone and enact-able in a typical classroom. We envision that the transformation of the curriculum will have the following characteristics: first, the process will result in a gradual but fundamental change of the nature of the mobilized curriculum; second, the change will be sustainable; and third, the process may be challenging and costly in terms of time and effort.

Norris and Soloway [4] used the term “mobilized lesson” to describe a lesson that starts with an existing, perhaps paper-based lesson design, but then is transformed to make use of mobile technologies’ affordances. The “mobilized curriculum” is a transformation from a more content-centered and teacher-centered to a systematic student-centered and mobile technology-mediated practice to foster personalized and self-directed learning [5].

Providing students with 1:1 ownership and 24/7 access to mobile devices and Internet access would also allow students to use their devices to support informal learning. Our work in mobilizing science lessons is thus framed in the broader context of constructing “seamless learning” environments to bridge formal and informal learning [6][7]. We want to go beyond classroom learning and explore the pervasive and longitudinal use of mobile technologies. Therefore, we aim to design a curriculum that facilitates student-centered learning activities that bridge their learning in formal and informal settings by developing student inquiry competence and self-directedness. In this paper, we describe the design of curriculum, enactment of the mobilized lesson in a Primary classroom and report changes in

the learning outcomes of an experimental class which used the mobilized curriculum for Science. The entire process was guided by a mobilized curriculum model that we developed. Due to the space constraint, we will not present how the model was developed and instead focus on how it is applied. Interested readers may refer to [8] for more details.

2. Context and the Existing P3 Science Curriculum

2.1 Context

We are conducting our study in a Nan Chiau Primary School. Thirty-nine students from a mixed-ability Primary 3 (P3) class are involved in the study. The science teacher, Grace (a pseudonym), has been teaching in the school for about three years. The school chose her to teach the class because she felt comfortable in using technology and is quite receptive to new ideas. She wanted to collaborate with the researchers to enrich her knowledge and skills in using mobile learning to improve student learning.

Prior to the introduction of mobile devices in early 2009, we observed the classroom practices and the students' behaviors to understand the environment and culture. We collected student worksheets, assignments, and teacher resources. Based on the classroom observations and analysis of student artifacts, formative feedback was given to the class teacher to improve the classroom management. After six weeks of observation, we embarked on our plan to mobilize the P3 Science curriculum.

2.2 Curricular materials to be re-designed for mobile technologies

There are five themes to be covered in the P3 and P4 Science Syllabus: Diversity, Cycles, Systems, Energy, and Interaction. The syllabus emphasizes the need for a balance between the acquisition of science knowledge, process and attitudes. Central to the curriculum framework is the inculcation of the spirit of scientific inquiry.

We aim to transform the curriculum by deconstructing its components (e.g. learning objectives and their relationships, concepts, and learning activities) and reconstructing them according to a Mobile Inquiry Learning Experience (MILE) framework, which is more student-centered and takes advantages of the affordances of mobile technology. We adopted a co-design process because teachers and researchers possess different sets of expertise and thus can create interesting synergy of ideas. It is only through collaboration that the innovative pedagogy can be realistic and put into practice. The notion of transformation also means that we have to create a new curriculum which is a transformation of the existing curriculum but to fit into the current school schedule. This has proven to be very challenging but possible and here lies the crux of the technology integration reform effort that we would like to address in this paper.

3. Transforming the Science Curriculum

Since we have identified curriculum development as the major task for our study, we combined teacher professional development (TPD) and curriculum development into a teacher-research co-design approach. The school identified a few science teachers including Grace to participate in a curriculum taskforce with the researchers to work on the design of mobilized lessons. We adopt HTC Tytn II Windows Mobile phone that comes with digital camera, stylus pen, keyboard, 3G Internet surfing plan and educational applications (e.g., GoKnow® (<http://www.goknow.com/>) applications such as KWL-table for organizing what the user wants to Know, Wonder and has Learned, PicoMap for concept mapping, and Sketchy for creating animations).

Curriculum mobilization entails a holistic view of how learning activities can be organized via technology so that learning is situated in authentic contexts. The Mobile Learning Environment (MLE) provides the infrastructure to develop a learning project. A project is a container of related and interdependent learning tasks. Each task is an instantiation of how mobile computing can be an enabler for personalized learning: (a) allowing multiple entry points and learning pathways, (b) supporting multi-modality, (c) enabling student improvisation *in-situ*, and (d) supporting the sharing and creation of student artifacts on the move [7]. Students can pursue their inquiry in a personalized way, without having to do the tasks in a linear sequential order. A good curriculum design will harness these affordances to transform science curriculum into a mobilized one that makes science learning motivating, engaging and holistic.

The above design principles are illustrated in the example below. As part of the mobilized curriculum, students need to download the files teachers prepared for them by synchronizing their smartphones with the GoManage server. The mobilized curriculum is designed with the learning objectives of the existing fungi topic in the national curriculum in mind. We anticipate that the diverse action verbs in the project objectives shown to the students (such as “Recall the characteristics of living things”, “State the characteristics of fungi”, etc.) could lead to the development of both process skills and higher-order thinking skills. For example, students use KWL application to plan and monitor their own learning. They need to demonstrate planning, analytical, reasoning and evaluating skills, as well as to develop metacognitive skills to manage their own learning journeys.

We have adopted the metaphor of *deconstructing* and *reconstructing* to describe our curriculum redesign process [5]. Informed by the data collected from the practices above, we developed a curriculum development model as illustrated in Figure 1. This mini cycle is embedded in larger cycles when we were considering the overall design for the diversity theme. This means such a cycle is an iterative process that is interwoven across our whole design journey, and now we zoom into one of the basic units to elaborate the rationale and process. We use dashed line to indicate that in reality the order of the steps might change or some steps could be combined when curriculum developers are more experienced with the design process. The solid line arrows indicate that the formative evaluation of the design are on-going because of the nature of research design and co-design approach we adopted.

We will explain the use of the design cycle depicted in the model with examples of the mobilized curriculum we have designed. The explanation below will be illustrated by a lesson plan on fungi which is summarized below,

Activity 1: Look at the slides presented by the teacher and understand that that fungi come in different shapes, sizes, and colour. (Corresponding out-of-class activity: to update KWL daily)

Activity 2: Watch a video on Fungi on YouTube with the smartphone and complete a worksheet on *Are Fungi Living Things?*

Activity 3: Engaged in a Jigsaw activity to research about the characteristics of fungi

Activity 4: Complete a compare and contrast activity on *Are fungi plants?*

Activity 5: Complete a PicoMap to show their understanding on fungi

Activity 6: Play the role of a Fungi detective in the Grand Challenge – take photos of fungi in daily life

Step 1 Deconstructing: Analyzing learning objectives and student learning difficulties

“Deconstructing” means to understand the key learning points in a theme, to make the relationship between the topics and concepts visible to teachers and students, and to seek coherence in the mobile curriculum. The taskforce analyzed and deconstructed the topical content of Diversity in the curriculum to identify the overarching learning goal:

Classification of living and non-living things according to characteristics and purposes.
More detailed lesson plans with consideration will be subsequently designed.

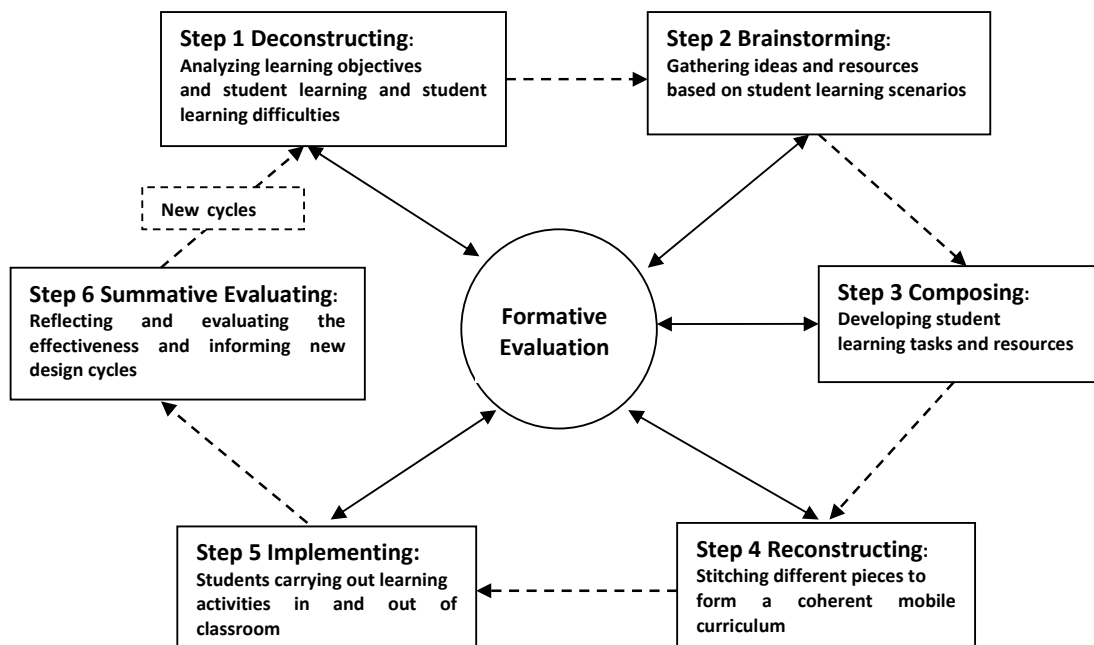


Figure 1. A collective curriculum mobilization cycle

The other outcome of deconstruction was the identification of the epiphany of how materials could be re-sequenced based on students' learning difficulties. For example, our observation showed that students did not necessarily make connection between the general characteristics of living things to specific cases like fungi. Therefore, we designed a comparison table for students to compare and contrast the characteristics (Figure 1a) in Activity 2 of the fungi lesson plan. This pushed for a restructuring of the learning content. Next, we created learning scenario that defines the students' learning experiences and what they need to achieve. Students learned by participating in class activities, deciphering the textbook concepts, and corroborating information from the Internet. They were involved in the inquiry process in both formal and informal settings which include observing things around them, collecting data and working in groups to reach consensus on their the characteristics of living and non living things; as well as consolidating their learning by creating a digital animation to showcase the characteristics of fungi.

There were formative and summative assessments involved in the process. We identified and addressed the possible misconceptions of the topic in the activity designs. For example, in the scenario planning for the MLE on fungi, the teachers wanted to provide students with thought-provoking and attention-arresting triggers. A YouTube video clip about *fungi* was chosen for such a motivating and anchoring event (Activity 2). After this introduction, we wanted to assess the students' prior knowledge and provided scaffolding to help them engage in self-directed learning, and to make sure that they were able to relate their learning to the prior concepts learned in plants. One way to serve the purpose was to ask them to fill in and frequently update their KWL files (Activity 1) (see Figure 2(b)).

Step 2 Brainstorming: Gathering ideas and resources based on student learning scenarios

As part of inquiry learning, we wanted the students to work in groups to conduct an experiment on bread mold. The students recorded their observations in writing and

phototaking. We also wanted them to engage in collaborative learning using the jigsaw method (Activity 3). To bring closure, we introduced a “grand challenge” activity (Activity 6) asked them to identify examples of fungi in their environment.

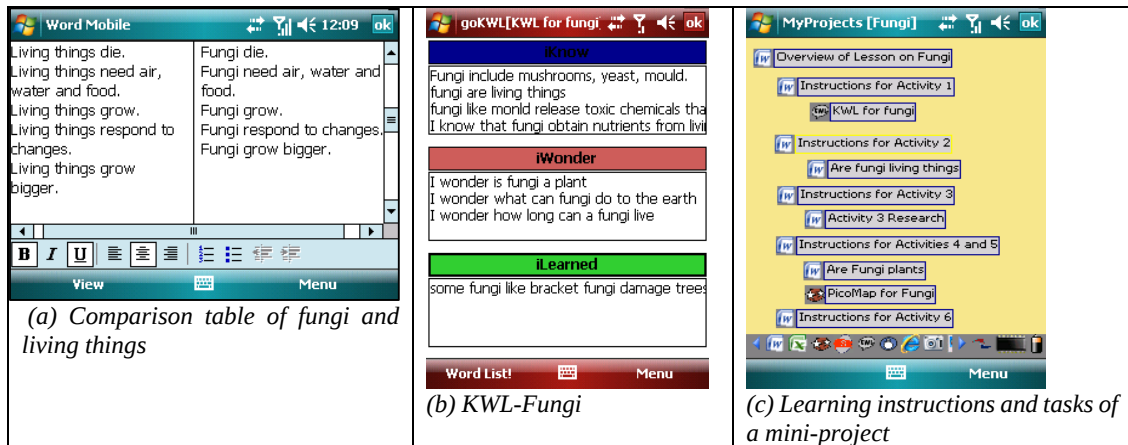


Figure 2: Some smartphone snapshots pertaining to the MLE fungi lesson

Step 3 Composing: Developing student learning tasks and resources

After the brainstorming session, the taskforce selected relevant ideas for further development. For the topic of fungi, the tasks are:

1. To create a presentation that will impress the students with the idea of diversity of fungi. The teacher has to make this presentation visually attractive (e.g. Activity 1).
2. To find a multimedia resource that introduces the students to the characteristics of fungi as a living thing (e.g. Activity 2).
3. To create a resource to help students research the characteristics of fungi using the jigsaw method. This activity cannot be more than 1 hour (e.g. Activity 3).
4. To create an activity to help students to compare and contrast fungi and plants. The students should be able to create a concept map of fungi after this (e.g. Activity 4).
5. To create opportunities for students to apply what they have learned about fungi in their daily experiences (e.g. Activity 6).

The composing stages entail creative thinking and good understanding of a) content; b) student learning difficulties; c) the mobile affordances; and d) the related applications.

Step 4 Reconstructing: Stitching different pieces to form a coherent mobile curriculum

In reconstructing, we developed the flow of events and learning activities according to the desired outcomes of the learning scenarios. We also stated the desired pedagogies and how the teacher should facilitate the learning. Finally, the resources for the students were packaged in a MLE project and disseminated to the students through the GoManage server. Although the introduction of tasks suggested a sequence of activities which warranted the logical flow of inquiry process, students had more flexibility in controlling their own pace and sequence for the task because they could open the files in any order and freely switch among them (e.g. Word, Excel, Sketchy, PicoMap, and KWL). Figure 2c shows available curriculum materials including instructions of a mini-project on fungi.

Step 5 Implementing: Students carrying out learning activities in and out of classroom

Grace distributed the MLE lesson package to the students' handhelds through the GoManage Server. This enabled learning to take place anywhere and anytime. The students

read the lesson overview before Grace started the lesson. By reading the overview, the students had a broad idea of their learning activities and were also aware of the learning objectives. This document also informed them about the schedule and deadlines of the tasks. As researchers, we made observations and interventions during class time. Together with Grace, improvisation and fine-tuning were done during or after class. We also provided timely feedback to help Grace improve her classroom management and facilitation skills. We also observed how the students responded to the activity design. In addition, we collected student artifacts to triangulate our findings about the impact of MLE lessons on student learning. These data will serve to inform the iterative design of our next cycle.

Step 6 Evaluating: Reflecting and evaluating the effectiveness and informing new design cycles

Two researchers stationed in the school to observe all the science lessons. They emailed, and/or talked with Grace almost every day for evaluation of the lessons. Furthermore, the taskforce discussed the results of their formative assessment weekly. Researchers reported classroom observations and selected students' work for analysis. The total teaching time remains unchanged, but there was a significant increase in the preparation time of mobilized lessons. However, once this preparation was done, the revision to mobilized lessons can be easily adopted by other teachers.

4. Teacher and student changes as results of the enacted curriculum

Given the space limit and focus of this paper, which is to describe the process of how to "mobilize" the science curriculum, we may not be able to provide detailed account of the impact of the enacted curriculum. Nevertheless, we present some significant teacher and student changes as below.

4.1 Students are engaged in inquiry-based learning

Students were able to conduct research by formulating questions, conducting online search, collecting data, producing animations, concept maps, and other digital artifacts to reflect their understanding as well as negotiate meanings collectively. For example, after we modeled how to compare the characteristics of living things and fungi as shown in Figure 2(a), they were able to design their own comparison tables. They used their inquiry process skills such as finding evidences, evaluating what they have found, and making comparisons. The use of educational applications also augments Grace's ability to identify students' misconceptions through their multi-modal (pictorial, textual, or even verbal) artifacts. There was an emergence of participatory learning culture among the students when they communicated ideas, shared learning tasks, and sent their artifacts to each other for critique.

4.2 Students showed signs of collaborative and self-directed learning

Students could conduct independent research online, such as searching for relevant YouTube videos, because they had unlimited data plan for their phones. Questions raised by them during class focus more on the content of the lesson, as compared with the pre-intervention stage where questions were centered around the clarification of teacher's instructions. The changes in the nature of the questions could be attributed to students engaging in independent research. They used KWL to record their thinking over time, which facilitated their self-directed learning and also became a means of formative assessment. Student questions in *What I Want to Know* reflect deeper thinking and are more

relevant to what they were doing. We consider behaviors such as student formulating their own questions and feeling less inhibited when asking questions as very significant cultural changes. Furthermore, they often worked in small groups and sometimes engaged in Jigsaw activities. They had to complete tasks within certain amount of time with their phones. They exchanged their phones to receive quick feedback to their work in progress. These are the most significant indicators of pedagogical change towards socio-constructivism.

4.3 The teacher positioned herself as a facilitator

There were obvious changes in class structure when implementing the mobilized curriculum. For Grace, she used to be under pressure to cover the syllabus through teacher-centered approach. Now she was able to switch to student-centered learning. She was inclined to give students more time to construct their understanding rather than feeding them with information. With more time to observe students learning with mobile devices, she learned to identify student learning difficulties when she facilitated student learning. The MLE lessons gave Grace more breathing space and she was able to focus on the natural flow of the lessons. As a result of using the redesigned curriculum using the mobile devices, she shared with us that she had more time to reflect on her lessons even during class. She could think on her feet and improvise on the lessons in real time.

4.4 Positive outcomes from Science Summative Assessment

The class which we studied was the only class among the 6 Mixed-Ability classes to receive the intervention of the mobilized lessons over 8 month periods. A year-end science exam was taken by the all the students in the cohort of Grade 3 students. Using a common exam paper done before the introduction of the mobilized lesson as a co-variate, we conducted a one-way analysis of co-variate (ANCOVA) to determine the differences of their year-end Science exam scores as shown in Table 1.

Table 1: ANCOVA on year-end science exam scores across 6 mixed ability classes when holding the exam scores before the introduction of mobilized lessons constant

Class	N	Mean Total year-end score	SD	Adjusted mean Total year-end score
3D	39	75.49	7.786	71.50
3E	39	76.67	8.588	74.11
3F	41	71.63	8.952	68.22
3G	36	41.36	16.507	48.90
3H	40	55.95	12.704	59.31
3I	39	72.13	7.706	71.87

After controlling the exam score before the introduction of mobilized lessons constant, the ANCOVA results showed that there was a significant difference ($F(5,345) = 31.619, p < .01$) on year-end science exam scores among the 6 mixed ability classes. The class difference explained 41.1% of the variance in the year-end exam scores. The experimental class P3E which used the mobilised curriculum had the highest score among the 6 classes. Note that in performing this statistical analysis, it was not our intention to compare the effectiveness between the science curricula with and without mobilization, but between the ENTIRE new curriculum and the regular curriculum. As we have adopted design research, rather than

experimental design, for the two-year study, we have concentrated our limited resources in developing, enacting and refining the mobilized curriculum, rather than diverting our attention to implementing a non-mobilized version of the new curriculum.

5. Discussion and Conclusion

In this paper, we discussed why we need to redesign the current P3 science curriculum, and how we deconstructed and reconstructed the curriculum in order to harness students' meaningful learning with the aid of mobile technologies. We articulated our proposed design process in transforming the current curriculum into mobilized learning activities, and our experiences in using this framework to design P3 science activities. The *mobilized* curriculum for the theme of *Diversity* has been implemented while more units are currently being developed. The new *mobilized* learning activities are aimed at providing a holistic learning scenario to engage students in student-centered inquiry learning, not conventional drill-and-practice lessons. They also enable the teacher to blend technology into core teaching and learning rather than to use it as add-ons to their routine practices.

Our work on *mobilizing* science lessons was situated in the broader context of constructing "seamless learning" environments to bridge formal and informal learning. We strongly believe that students need to nurture personalized and collaborative learning as a habit of mind and treat their handhelds as both a lifestyle device and a learning device [9]. Our longer-term goal is to reinforce seamless learning through our mobilized curriculum by fostering self-directed learning and providing necessary inquiry-based science learning tools such as the MLE applications. Our future work will look at the use of the mobile technologies beyond classroom learning so that we extend our work from classroom learning to the space of seamless and longitudinal use of mobile technologies.

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