Computers & Education 77 (2014) 101–115

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Implementing mobile learning curricula in a grade level: Empirical study of learning effectiveness at scale

Chee-Kit Looi [a,*], Daner Sun [a], Longkai Wu [a], Peter Seow [a], Gean Chia [a], Lung-Hsiang Wong [a], Elliot Soloway [b], Cathy Norris [c]

[a] National Institute of Education, Singapore
[b] University of Michigan, United States
[c] University of North Texas, United States

ARTICLE INFO

Article history:
Received 16 January 2014
Received in revised form
23 March 2014
Accepted 14 April 2014
Available online 30 April 2014

Keywords:
Scale-up
Curricular innovation
Science inquiry
Classroom practices
Yearly progression

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. With the objective of examining the impact of the curriculum innovation on science teaching and learning, 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, assessment methods, 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.

1. 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 et al., 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 long-term interventions.

* Corresponding author.
E-mail address: cheekit.looi@nie.edu.sg (C.-K. Looi).

http://dx.doi.org/10.1016/j.compedu.2014.04.011
0360-1315/

On the policy perspective, in the context of Singapore, the initiative of the government's third Masterplan (mp3) for ICT in Education (MoE, 2013) 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 study is guided by two research questions:

(1) How to develop and scale up an innovative inquiry-based science curriculum supported by mobile technology?
(2) What are the changes in classroom practices and students' performances brought about by the scaled-up curricular innovation?

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 during the years of scaling with the years of pre-scaling. The findings are discussed and implications drawn for informing relevant studies on technology-supported curriculum development and implementation.

2. Literature review

2.1. 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).

From our reviews of the studies on mobile technology-supported learning, we found that most of them focused on investigating the learning effectiveness from deploying specific pedagogical principles in the mobile learning activities. 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. 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 et al. (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.

However, the current studies most focus on creating learning environments for leveraging the affordances of mobile technologies, focus only on units of at most a few weeks duration or they were add-on activities to some existing curriculum (Ng & Nicholas, 2013). The learning experiences of mobile technology-supported learning activities were short-term in nature. There is no research that considers conceptualizing sustainable learning with mobile technologies via immersion into the national standard science curriculum for sustainable and scalable purposes. Thus, little attention has been put on to trace the trajectory of the transformation of teacher and students behaviors impacted by the long term innovation. Thus, no evidence has been produced to inform the relevant studies relative to the mobile technology use in the science classroom at scaled-up levels. To address these issues, our study reviews the journey of the development of an innovative science curriculum, captures the turning points of the transformation at different development stages, and presents the evidence on how the transformation took place and whether and how students could benefit both in content knowledge and skills at scale.