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Enacting a technology-based science curriculum across a grade level: The journey of teachers' appropriation

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ABSTRACT

Studying teacher enactment of an innovation helps us understand the process of effective spread of a curricular innovation to teachers who have differing levels of content readiness, pedagogical orientations, teaching competency, different student profiles, and professional development experiences. Towards this, we explore how different teachers in the same grade level appropriated a common science curriculum enabled by mobile technologies in their classrooms. The innovative science curriculum: Mobilized 5E (Engage–Explore–Explain–Elaborate–Evaluate) Science Curriculum was developed through an iterative cycle of design-based research. As curriculum designs were not self-sufficient by themselves, the enactments of the teachers differed in how they leveraged on students' artifacts, how they integrated the technology into the class, the ways in which they interacted with the students, and how they scaffolded students' activities in a mobile learning setting. In this study, the teachers' enactments of mobilized 5E lessons were observed, analyzed and compared, with the aim of exploring the differences of lesson enactment amongst them. The results showed that teachers' different pedagogical orientations affected their instructions, especially their ways of technology integration in the class, and their patterns of interactions with the students. Based on the exploration of the teacher enactment of the mobilized 5E curriculum, implications are drawn concerning the implementation of innovative curricula implementation and the supports for teacher professional development of such innovation with the ultimate purpose of sustaining and scaling.

1. Introduction

The literature on technology-based curricular innovations is packed with examples of pilot studies and proofs-of-concepts. It is rarer, in fact, in the literature, to see a project move through the various phases to where the innovation actually has become an integral part of routine classroom practices (e.g., Dede, Honan, & Peters, 2005; Penuel, Fishman, & Cheng, 2011; Sabelli, 2008; Schneider & McDonald, 2006). Successful research intervention projects usually work with a few highly motivated teachers, but for long-term sustainability and scaling up of the innovation will require the average teachers to work with the designed curriculum and the proposed pedagogy (Penuel & Fishman, 2012). As the adoption of such a curriculum is not a one-to-one mapping of the designed curriculum to the classroom, teachers must always adapt it for their own use (Barab & Luehmann, 2003).

Unsuccessful implementation of curricular innovation is often traced to a lack of understanding of the role of teachers in playing a key role in making educational reforms successful (Dori & Herscovitz, 2005), and to a lack of knowledge of how to lead the teachers to implement the innovation in a way corresponding to the intentions of developers. Our review of relevant research work on mobilized curriculum suggests that relatively more research has been focused on the instructional design of mobile phone-facilitated curricula, the design of mobilized learning environments, and the learning effectiveness of mobilized curriculum (Gedik, Hanci-Karademirci, Kursun, & Cagiltay, 2012; Martin & Ertzberger, 2013; Rau, Gao, & Wu, 2008). Less research is done on investigating the differences in teachers of curriculum implementation to inform the sustaining and scaling of the mobilized curriculum.

Mobilized 5E (Engage–Explore–Explain–Elaborate–Evaluate) Science Curriculum (M5ESC) is a product of our collaboration work with a primary school in Singapore. As the M5ESC was first developed and studied over a period of five school years (Looi, Zhang, Chen, Seow, &

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Chia, 2011), the researchers expected there must be many challenges and issues faced by science teachers at local primary schools who might not be familiar with the new instructional and learning approaches. To address the research deficiency on teacher enactment of mobilized curriculum, to expose challenges faced by different teachers in their enactments, and to ensure that the students receiving the curriculum could all benefit from engaging in the mobilized learning activities, it is necessary and essential for us to study how teachers adopt and adapt an innovation in their own classrooms (Puntambekar, Stylianou, & Goldstein, 2007). Only through watching teachers' lesson enactments in detail could we get deep insights into how they enacted the designed lessons in the classrooms, whether and how their instructions facilitated students' learning as intended, and which aspects could be improved for successful implementation.

The literature review in this paper is targeted towards providing the theoretical background on the role of teachers in successful curriculum implementation, and on studying their classroom performances and their pedagogical orientations. This study uses a case study approach to examine the enactment of the curricular innovation by four teachers, especially on how they appropriate the curriculum based on their pedagogical beliefs, their perceptions of the students' needs and ability levels, and their perspective of the use of technology, as well as their classroom interactions with students. The findings point us to teacher differences on the lesson enactment and thus expose their deficiencies concerning the competencies required for M5ESC instruction. Meanwhile, the changes in teachers' pedagogical orientations and their performance in teaching practices over time could be detected to further illuminate teachers' appropriation of the curriculum.

2. Literature review

2.1. Teacher roles

Barab and Luehmann (2003) discuss issues of sustainability and local adaptation as crucial for scale. They describe the teacher's role in local adaptation as identifying local needs, critiquing the innovation in the light of those needs, visualizing possible scenarios of implementation, and finally making plans or decisions concerning the implementation. Teachers will be ultimately involved in the adoption, customization, and implementation process, and they are continually remaking and contextualizing the innovation in terms of their local context. Lessons learned from prior technology-based educational improvement research clearly indicate the importance of empowering teachers and building capacity to effect deeper changes in teachers' beliefs, knowledge, and practices (Fishman, 2005). Deep changes go beyond the superficial piecemeal changes in structures and procedures but work toward integrated changes in beliefs, norms of social interaction and pedagogical approaches enacted in teaching and learning practices (Coburn, 2003). Teachers are more likely to embrace and practice classroom innovations when they can see the connection between the use of technology, the learning needs of their students, and the content of the mandated curriculum.

The uptake of research innovations to real-world practices is generally low because few were robust treatments that addressed problems that seriously concerned practitioners (Dede et al., 2005). When robust designs that addressed serious problems of practice were tried, they had the potential to reach scale (Cohen & Ball, 2006). Based on Coburn's (2003) definition of scale: scale can be defined as encompassing four interrelated dimensions of depth, sustainability, spread and shift in reform ownership. Notably, the depth refers to deep and consequential change in classroom practice, altering teachers' beliefs, norms of social interaction, and pedagogical principles as enacted in the curriculum. In Marx's (2012) comments on the issues of large-scale interventions in science education, he emphasized the focus should be paid on supporting teachers to be more effective in classroom instruction as students' achievement would be influenced by teachers' instruction significantly. Thus, the continuing emphasis of teachers' role in the curriculum implementation is an inevitable element of the research into innovation implementation and scale.

2.2. Teacher enactment

In our review of current ICT-facilitated research, especially research on mobile learning, few focused on the long-term classroom observation of teacher enactment. Most current studies conducted short term or topic-based classroom observation (Clough, Jones, McAndrew, & Scanlon, 2008; Ruchter, Klar, & Geiger, 2010) which were not adequate for observing teachers' overall performance on different instructional events, their changes (e.g. pedagogical beliefs), and student performance and achievement over time. As a result, how teachers use the planned curriculum in the actual classroom in the long term has been the crucial element in the implementation of an innovative practice. The failure of detecting the problems in the teacher enactment will probably lead to the desired effects being far from becoming a reality (Rodríguez, Nussbaum, & Dombrovskaia, 2012).

We have known for a long time that the model of getting to scale by just having a curriculum does not work, that it is a myth that "good" curriculum and teaching practice are self-explanatory and self-implementing for further scaling and implementation (Elmore, 1996). This model overlooks the complex process with which local curricular decisions are made, the entrenched political relationships that support existing textbook-driven curricula, the weak incentives operating on teachers to change their practices, and the extraordinary costs of "making large-scale, long-standing changes of a fundamental kind in how knowledge is constructed in the classrooms" (p. 19). Morris and Hiebert (2011) attribute the variation in instruction in classrooms with teachers implementing the same lesson plan in different ways to differences in the expertise of the teacher or differences in the context that prompt teachers to change the plans.

Creating a curriculum as an ongoing process, the product of which is a composite of what is intended (planned curriculum), what actually happens (enacted curriculum), and how what happens influences those involved (experienced curriculum) (Marsh, 2009). Marsh proposes that desirable educational experiences arise when the interaction of these three curricula is flexible and evolving; and, therefore, it is not about "best" practices or "most correct" answers to fundamental curriculum questions.

Building on Marsh, we propose our conceptual model for the study of teacher enactment (see Fig. 1). The planned curricular innovation is co-designed by participating pioneer teachers and researchers. This is then enacted by these pioneer teachers, and later on at a scaling stage, by teachers new to the curricular innovation. The enactment curricula is what the teacher does in the classroom, generating experiences and reflections to all those involved (the students and the teacher) as the experienced curriculum. Researchers as meso-level mediators interpret the experiences, processes and outcomes of the experienced curricular innovation, and work collaboratively and iteratively with teachers to