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Understanding science teachers' enactments of a computer-based inquiry curriculum

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ABSTRACT

In order to spread and encourage the use of innovative computer-based inquiry curricula in classrooms, it is fundamental to understand how teachers enact the curricula. It is also essential to study what kinds of teaching practices can enhance students' science learning. Based on a two-dimensional framework, the case study explored teachers' enactments of a computer-based inquiry unit on the topic of plate tectonics, and examined how the enactments might impact students' conceptual understanding and inquiry abilities. Two secondary teachers and a total of 62 students participated in the study. Data included students' performance during the unit, pre- and post-unit tests, videos of the lessons, and teacher interviews. The findings showed that during the unit, the two classes' performances were significantly different. The unit test results indicated that there were also significant differences in the conceptual item scores of the two classes, but not in the inquiry item scores. The video analysis showed that the two teachers had distinct enactments in terms of the cognitive and guidance dimensions. Both of the teachers' discourse was focused on the conceptual domain. However, the teaching strategies involved and the classroom social norms being shaped were diverse. Regarding the guidance dimension, one teacher provided a highly-structured, step-by-step approach in contrast with the other teacher's more freely–structured, segmented approach. By associating different teaching enactments with students' learning both during and after the unit, we discuss how the pedagogical features presented in the teacher enactments might contribute to students' conceptual and inquiry learning.

1. Introduction

Over the past decades, studies on educational technology have shown that innovative technology-rich curricula can provide great opportunities for engaging students in inquiry practices (e.g., Lee, Linn, Varma, & Liu, 2010). By interacting with computer tools, students can generate and test hypotheses, collect and visualize data, evaluate evidence, construct explanations and express their models (Linn, Davis, & Bell, 2004; van Joolingen, de Jong, & Dimitrakopoulou, 2007). In addition to well-designed inquiry activities and suitable affordances provided by technology, studies have highlighted the significant roles teachers play in student learning of computer-based inquiry curricula in classroom settings (Kim, Hannafin, & Bryan,

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2007; Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010; Webb & Cox, 2004). In order to facilitate student learning in computer-based inquiry environments, teachers have to *envision the lesson, enable collaboration, encourage students, ensure learning,* and *evaluate achievement* (Urhahne et al., 2010). This is demanding as it requires knowledge of and familiarization with computer tools for integrating inquiry elements into the curriculum, and to identify and respond to students' needs (Webb & Cox, 2004). Although some studies have pinpointed the challenges and constraints teachers encounter (Kim et al., 2007), few have explicated how teachers should act when traditional teaching settings are transformed into computer-based environments (e.g. Chang, 2013; van Joolingen et al., 2007).

Due to different knowledge, beliefs, values and experience, the ways in which teachers enact computer-based inquiry curricula can be very different, and have consequences for student learning (e.g., Liu, Lee, & Linn, 2010; McDonald & Songer, 2008). Through the analysis of the relationships between teachers' enactments and students' learning performance, these studies identified some promising forms of teacher instruction to support students' conceptual understanding, such as helping students make links between learning activities and science concepts (Puntambekar, Stylianou, & Goldstein, 2007) and responding to students' needs during instruction (Chang, 2013). Although these instructional suggestions provided insightful applications, it remains largely unknown what kinds of teaching strategies teachers use across the sessions, what types of classroom social norms are shaped, and how students' inquiry practices are influenced by various teaching enactments. Following the preceding research, this study aimed to explore teachers' enactments of a computer-based inquiry curriculum on a continuous and more extended time scale, in contrast with the in-depth analysis of discrete events in previous studies. We employed different dimensions and levels of analysis to understand teachers' enactments of a web-based learning unit on the topic of plate tectonics, and examined how their enactments might contribute to students' conceptual understanding and inquiry performance.

Based on Duschl (2008) and Furtak, Seidel, Iverson, and Briggs' (2012) perspectives on inquiry-based science teaching, the study proposed a framework for capturing teachers' enactments of a computer-based inquiry curriculum. The framework adopted two dimensions: the *guidance* and *cognitive* dimensions, to depict teaching practices. The cognitive dimension identifies the teaching strategies (identified from the video analysis) and the domains (conceptual, epistemic, social or technological) that the teacher draws upon to support students' learning, whereas the guidance dimension illustrates how the teacher strikes a balance between teacher-led instruction and students' discovery learning (Furtak, Seidel, Iverson, & Briggs, 2012). This two-dimensional framework provides multiple perspectives on teaching practices of computer-based inquiry curricula, and helps us better understand how that might influence students' science learning.

2. Literature review

Considerable research has emphasized the significance of the roles teachers play in supporting students' scientific inquiry practices (e.g. Crawford, 2007; Jones & Eick, 2007; Lucero, Valcke, & Schellens, 2013; Seung, Park, & Jung, 2014). Research has indicated that teachers' beliefs and knowledge about inquiry-based teaching, their knowledge of subject matter, and their practical knowledge (van Driel, Beijaard & Verloop, 2001) all influence successful classroom inquiry. The multiple roles teachers must perform, including motivator, diagnostician, guide, innovator, experimenter, researcher, modeler, mentor, collaborator and learner (Crawford, 2000), create challenges and difficulties when teaching scientific inquiry. It is believed that computer-supported, classroom-based science inquiry is even more demanding for science teachers because computer tools add another level of complexity to classroom inquiry (Kim et al., 2007; Puntambekar et al., 2007). However, research on teaching and learning scientific inquiry in computer-supported environments has not given enough attention to the teacher, despite the essential role the teacher plays in classroom inquiry (Kim et al., 2007; Urhahne et al., 2010).

A review of the literature highlighted two key issues in the field of teacher instruction in computer-supported learning environments: (1) identifying the factors and how they influence successful inquiry instruction, and (2) exploring the teacher's roles in computer-supported inquiry classrooms.

2.1. Factors influencing successful inquiry instruction in computer-supported learning environments

By means of the analysis of large-scale data, previous research has identified the factors that influence successful computer-supported inquiry instruction. For instance, to provide stronger evidence for connecting inquiry instruction with student performance, Lee et al. (2010) compared how students' performance was influenced when 27 teachers changed their instruction style from typical methods to computer-supported inquiry instruction. The findings demonstrated that inquiry units had more advantages in terms of promoting the students' knowledge integration than typical methods. Moreover, the results of mixed effects analysis of variances pointed out that teachers who held beliefs consistent with inquiry pedagogy, had more workshop experience, and received instructional support or had the help of a collaborator at school, were likely to have better student learning outcomes. Another large-scale study (4513 students taught by 40 teachers) involving a teachers' self-report survey and hierarchical analysis by Liu et al. (2010) showed similar results. The researchers reported that teachers who valued inquiry teaching practices and had higher workshop attendance and colleague support, were more effective in terms of enhancing student success in learning scientific inquiry. Although teachers' use of technology was not a significant predictor of student learning outcomes, the authors noted that this might be due to the fact that all of the teachers involved in the study actually frequently used technology. This group of studies helps us to understand the effects of various teaching context factors on student learning outcomes, and points out some directions for improving the implementation of computer-based