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Examining the work of "scaffolding" in theory and practice: A case study of 6th graders and their teacher interacting with one another, an ambitious science curriculum, and mobile devices

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ABSTRACT

This case study features a class of sixth-grade students and their science teacher enacting a curriculum designed to teach the particulate nature of matter and phase changes. The class used a mobile device with several applications that supported reading, writing, viewing, and modeling. We examine the role of the teacher, the device, the peers, and the curriculum itself in scaffolding student learning.

For decades, metaphor has been recognized for its importance in advancing science (Gergen, 1990). Given its prominence in both the theoretical and practice literatures, *scaffolding* has proven to be one of those metaphors that has been enlisted many times and in many ways to advance scientific thinking since its introduction in Wood, Bruner, and Ross (1976). Historically, scaffolding assumed expert individuals interacting with learners, typically face-to-face (Stone, 1998; Wertsch, 1991; Wood et al., 1976). Over time, however, researchers have become increasingly interested in the role that artifacts play in scaffolding learning and development, as well as the role that activities and contexts play as scaffolds in creating zones of proximal development (Palincsar, 1998; Reiser, 2004; Tabak, 2004). Pea (2004), in fact, worried that scaffolding has become "a proxy for any cultural practices associated with advancing performance, knowledge and skills, whether social, material, or reproducible patterns of interactivity (as in software systems) are involved" (p. 423). To redress this concern, Pea (2004) called for research that pushed researchers to identify the work that the concept of scaffolding does in theories of learning and instruction.

In this paper, we address this question through the construction of a case study of a class of sixth-grade students and their science teacher who was enacting a curriculum designed to teach the particulate nature of matter and phase changes in matter with the support of a mobile device. We present data from three lessons to explore the role assumed by: the curriculum, the features of the device in which the curriculum was embedded, peer interaction, and—critically—in our estimation—the teacher. Using field notes and transcripts of whole-class and small-group interactions, we explore the value-added of investigating these interactions for evidence that the metaphor of scaffolding has explanatory power in accounting for the students' interactions within their pairs, with the device, and in class-wide contexts. We explore the ways in which the curriculum itself, as well as the teacher, must be taken into account to characterize the learning context. We investigate two questions: (1) Which features of this rich instructional context represent scaffolds for learning? and (2) How does a case study of students in interaction with one another, mediated by the mobile

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device, inform the design and study of an instructional context designed to constitute multiple and overlapping zones of proximal development?

As suggested by our introduction, in our work, we pair Vygotsky's best-known construct, the zone of proximal development, with scaffolding. Wood et al. (1976) did not refer by name to the ZPD, but they did invoke the ZPD to the extent that they suggested that adults play the essential role of controlling the elements of a task that are beyond the reach of learners so that these learners can focus their efforts on the elements of the task that are within their range of competence. Important to our work is the tenet that the ZPD is *created* in the course of collaboration and that the mechanisms that propel the learner's development include internalization and externalization; internalization being a process of "grow[ing] into the intellectual life of those around them" (Vygotsky, 1978, p. 88), while externalization occurs as "the teacher, working with the school child on a given question, explains, informs, inquires, corrects, and forces the child himself to explain" (Vygotsky, 1987, pp. 215–16).

Before describing the study, we note that peer-mediated learning with technology is a complex and fairly new enterprise (Goodyear, Jones, & Thompson, 2014). There is evidence that students who struggle in academic contexts demonstrate higher levels of engagement and motivation when engaged in on-line, collaborative learning opportunities (Henry, Castek, O'Byrne, & Zawilinski, 2012) Furthermore, students who have access to digital learning environments have shown greater gains on performance-based assessments in science (Kennedy, Rhoads, & Leu, 2016). However, there are certain conditions that appear to be necessary to realize these advantages. The extant research, most of which has been conducted at the post-secondary level, points to the benefits of: (a) allowing learners to take control of elements of the lesson (Mercer, Warwick, Kershner, & Staarman, 2010), (b) providing supports and multiple resources for making sense of and connecting complex ideas (Means, Shear, & Roschelle, 2015), and (c) providing learners the means to share multiple representations of their learning (Bereiter & Scardamalia, 2006).

Despite the potential of these technologies, Kreijns, Kirshner, and Jochems' (2003) review of the research indicates that their promise has not, in fact, been achieved. Factors such as group size, composition, and the nature of the task all influence the effectiveness of collaborative learning, with all of the predictive factors related in some way to social interaction; that is, if there is no social interaction, there is no real collaboration. The challenge to the research community is to capitalize on the potential of computer-supported collaborative learning to engender a sense of community among the participants. We submit that the development of exploratory case studies, such as the one reported in this paper, can advance the field's understanding of the potential of technology and of the scaffolding features that optimize its use.

1. Research setting and methods

This study was conducted in a racially and socioeconomically heterogeneous 6th grade science class located in a middle school in a middle-sized in the Midwestern section of the United States. The teacher was an experienced 6th grade teacher who was comfortable with both the science and the technology. The classroom had 34 students, four of whom had an Individualized Education Plan.[1] The 34 students were grouped into pairs by the classroom teacher who described the pairs as, "diverse with respect to their levels of academic achievement" and "likely to work together productively."

The method we employed was exploratory case study (Yin, 1994) guided by the open research questions identified above. We were present in the classroom for each day of instruction, videotaping every lesson with the use of a wide-angle lens and a wireless microphone on the teacher that captured her talk with the whole class, as well as the exchanges she had with the student pairs when they were engaged in small-group work. In addition, we audio-recorded each small-group interaction among the focal pairs and the researchers took field notes to capture small-group interactions (e.g., challenges with the technology, uses of writing and drawing on paper vs. in the digital devices, forms of assistance provided to one another). In addition, at the conclusion of the curriculum, students were surveyed regarding their satisfaction with the curriculum, including the applications, and were invited to identify how the curriculum and applications could be enhanced. Parents/guardians signed and returned written consent forms permitting the researchers to collect and analyze: video and audio of classroom activity and student artifacts. The students were informed that they were assisting the researchers to study how 6th grade students learned with the innovative technology that we were using with their class. Anonymity was assured and all names reported in this paper are pseudonyms.

The curriculum[2] *WeInvestigate*, consisted of 12 "lessons," taught over five weeks. The conceptual terrain selected for this curriculum—specifically, describing matter and changes in matter, both in terms of their macroscopic properties, and their nanoscopic structure and behavior—is one that has been very well studied by science educators (e.g., Andersson, 1990; Berkheimer, Anderson, & Blakeslee, 1990; Smith, Wiser, Anderson, & Krajcik, 2006). Hence, student alternative conceptions and challenges with the content are well documented (e.g., Novick & Nussbaum, 1978, 1981; Osborne & Cosgrove,1983). As a result, there are a number of evidence-based learning progressions, learning performances, instructional strategies, and activities designed to teach this content (e.g., Lee et al., 1993; Smith et al., 2006). Thus, after careful consideration of the science education literature and in consultation with the teacher-participant, the science topics integrated into *WeInvestigate* focused on the following concepts: the particle nature of matter, describing matter as solid, liquid, or gas (both macro- and nano-level behavior and structure), and changes in states of matter (again, both macro- and nano-level), including how changes in energy affect

[1] Students deemed eligible for special education services are provided an Individualized Education Plan, which identifies accommodations for which the students may be eligible.

[2] The curriculum was developed by the authors and was informed by *Investigating and Questioning our World through Science and Technology* developed by Krajcik, McNeil, and Reiser (2008).