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Conceptualizing Scaffolding for Science Learning in Classrooms and Museums Using Mixed-Methods Approaches

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Abstract: Scaffolding may support learners working with complex problems, but how to best integrate distributed scaffolds in formal and informal contexts is not well understood. In response, I will integrate distributed scaffolds (e.g., prompts, an e-textbook) in a science curriculum and a museum exhibit. Using a mixed-methods approach, I will analyze how particular patterns of distributed scaffolds support learners in classrooms and museums. These findings may impact how we conceptualize scaffolding and design learning environments.

Introduction

Learners working with complex problems in inquiry-based learning need support from multiple sources, such as experts, tools, and technology. Providing multiple sources of support distributes entry points for learning that accommodate different needs (Tabak, 2004). However, we have yet to understand how to best integrate these sources, or *distributed scaffolds*, into learning environments (Puntambekar & Kolodner, 2005). In response, I will integrate scaffolds in two environments, classrooms and museums, to understand how differences in learning contexts mediate learners' interactions with scaffolds. Scaffolds may include educators, peers, an e-textbook, physical and virtual experiments, and informal assessments. Technology may play an interesting role depending on how many learners it can support simultaneously. Studying the interplay between these scaffolds, especially in patterns and sequencing, is critical to understanding best practices for implementing scaffolds in classrooms and museums.

The objectives of this work are to understand the interplay between distributed scaffolds and effective combinations of scaffolds in each context. Another goal is to identify characteristics of each context that may be leveraged to support inquiry in curricula and exhibits. By studying the integration of distributed scaffolds in two contexts, we can better conceptualize context-mediated characteristics and synergistic design of scaffolds.

Theoretical grounding

Sociocultural theorists posit that learning is mediated through interactions with others (Vygotsky, 1978). A cornerstone of sociocultural theory, the *zone of proximal development* (ZPD), refers to what can be accomplished independently and with assistance (Vygotsky, 1978). One way to support learning in the ZPD is through *scaffolding*. Scaffolding is conceptualized as a dialogue in which an expert establishes common goals with a learner, monitors understanding, provides titrated support, and gradually reduces support (Puntambekar & Kolodner, 2005). Scaffolding may also apply to contexts with multiple learners (e.g., Smit et al., 2012). To simultaneously support multiple ZPDs, we may integrate *distributed scaffolds* that provide targeted assistance across multiple sources (Tabak, 2004). Distributed scaffolds may include social groups, educators, objects, tools, activities, and technology (Ash, 2004; Griffin, 2012; Yoon et al., 2013). Integrating distributed scaffolds may support diverse learners' ZPDs (Ash, 2004) and encourage deeper inquiry (Yoon et al., 2013).

Methods

To study distributed scaffolds, I will use a multi-layered approach that targets each source of support to understand its role. Here, I describe the study design and planned data procedures for the distributed scaffolds.

This work uses activities from *Growing Healthy Plants* (GHP), an eight-week science curriculum for middle-school students centered around a design challenge that drives inquiry about plants' roles in ecosystems. For my dissertation, I will focus on activities about genetics that include scaffolds such as prompts, simulations, e-textbook explorations, and hands-on activities. These activities are being implemented in two contexts: a semi-rural middle school (as part of the curriculum) and a medium-sized science museum (as a pop-up exhibit).

In each context, I will analyze how learners' interactions with distributed scaffolds support their inquiry and how context mediates support. To do this, I will collect (i) video and audio data of participation and (ii) log data from e-textbook explorations. In classrooms, I will collect (iii) written products and (iv) content test scores. In museums, I will collect (v) visitors' feedback about conceptual relationships on a "feedback board."

For video and audio data, I will use discourse analysis (Ash, 2004; Puntambekar, 2013) to analyze how learners engage with distributed scaffolds. I will compare proportions of coded discourse using z-score tests of homogeneity to identify significant patterns. Coded discourse will also serve as input for graphical Markov

models that describe probabilistic sequences in discourse. For the e-textbook log data, I will use Markov models and sequential pattern mining to identify navigation patterns (Witten et al., 2011) and paths of inquiry (e.g., Dornfeld et al., 2017) while using theory to differentiate "noisy" and meaningful patterns. I will use natural language processing (e.g., Sherin, 2012) to analyze students' written products and statistical tests to analyze content test scores, moving toward triangulating students' conceptual outcomes. Similarly, grounded coding of the "feedback board" may reveal salient themes for visitors.

Progress and issues

This dissertation is based on pilot studies of scaffolding strategies (Dornfeld, 2016), collaborative learning (Dornfeld & Puntambekar, 2016), and mixed-methods approaches (Dornfeld et al., 2017). For the workshop, I would benefit from discussing how to model mixed-methods approaches and reconcile findings from multiple data sources (e.g., Suthers & Medina, 2011). Identifying assumptions about scaffolding and analytical approaches is also critical for the success of this work.

Conclusion

Learners engaged in complex problem-solving benefit from distributed scaffolds, but how to best integrate distributed scaffolds is not well understood. In this dissertation, I will implement distributed scaffolds in classrooms and museums to investigate (i) the interplay between distributed scaffolds; ii) effective combinations of scaffolds; and (iii) characteristics of each context that impact scaffolding. Findings may impact how we conceptualize scaffolding across contexts, design learning environments, and combine analytical approaches for diverse data.

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