Community-Based Engineering and Novice Elementary Teachers' Knowledge of Engineering Practices

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Abstract: The goal of our research is to study the extent to which a community-based engineering component of a teacher education program can impact new elementary teachers' abilities to identify and respond to students' science and engineering ideas and practices. Our mixed methods study design includes a novel Video Case Diagnosis task where teachers analyze video of elementary students discussing engineering design problems.

Introduction

According to the writers of the *Next Generation Science Standards* (National Research Council, 2013), one fundamental way in which the *NGSS* differ from previous national science education frameworks is that engineering design has been elevated "to the same level as scientific inquiry in science classroom instruction at all levels" (NRC, 2013, p. 337). This shift raises new questions for the elementary teacher education community. How can teacher preparation programs help pre-service teachers develop the knowledge and understanding they need to include both science and engineering practices in their elementary classrooms? Previous work reveals strategies for improving novice teachers' competence in inquiry-based science teaching (e.g., Forbes, 2011). However, there is limited research on how elementary teachers learn to teach engineering design (Hsu, Cardella, & Purzer, 2010), and preparing pre-service teachers to guide their students in both engineering design and scientific inquiry is a new challenge.

In response to this challenge, we propose to develop and investigate an innovative model that introduces novice elementary teachers to "community-based engineering design" as a strategy for teaching and learning in urban schools. The goal of our research is to explore how community-based engineering experiences can contribute to new elementary teachers' abilities to identify and respond to students' emerging science and engineering ideas and practices. The study is in its early stages. In this poster we report on our initial yet significant effort to understand novice teachers' understandings of science and engineering practices with an instrument we introduce as the Video Case Diagnosis task.

Theoretical Approach

Our work is framed by engineering design cognition literature (e.g., Cross, 2004), situated learning theory (e.g., Lave & Wenger, 1991), and the resources perspective on children's science learning. Focused on the "productive conceptual, meta-representational, linguistic, experiential, and epistemological resources that students have for advancing their understanding of scientific ideas" (Warren et al., 2001, p. 531), the resources perspective is aligned with the idea that students come to school with "funds of knowledge" from their experiences at home and in their communities (Moll, Amanti, Neff, & Gonzalez, 1992). These funds of knowledge can be used as a foundation for engaging students who are typically left on the margins of school science. A key objective of the proposed study is to use community-based engineering experiences as a situated learning context to help new teachers identify and build upon the resources of students in urban elementary schools. Studies of professional engineers have revealed that the enterprise of engineering draws upon individuals' cognitive, sociocultural, and affective resources (Cardella, Atman, Turns, & Adams, 2008).

Our research question has two parts: During the course of community-based engineering experiences, what is the evolution of novice urban elementary teachers' (a) understandings of engineering practices and their relationship to science practices and (b) identification and response to *students'* engineering and science ideas and practices?

Methodological Approach

Participants in the study are graduate students in their final year of an elementary teacher preparation program. During their science teaching methods course, they solve a sample community-based engineering problem developed by the course instructor and expert elementary science educators and design and implement a community-based engineering mini-lesson. A subset of participants then attends a summer institute where they create and implement with elementary students a full community-based engineering module that is connected to the school district's science curriculum.

We employ a mixed methods study design. We measure teachers' understandings of science and engineering practices with a new instrument called the Video Case Diagnosis task. Building upon work that uses video cases of student work in science and mathematics (Hammer & van Zee, 2006; Norton, McCloskey, &

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Hudson, 2011; van Es & Sherin, 2008) the VCD task asks novice teachers to watch a brief video of elementary students attempting to solve an engineering design problem. It then asks teachers to list (a) the ideas that the students express about science phenomena and engineering solutions, (b) the science and engineering practices in which the students engage, and (c) three suggestions for how the teacher could respond productively to the students. To develop the scoring rubric, we synthesize expert science educators' and science education researchers' responses to create an "exemplar" answer for each video case (Norton et al., 2011). Additional data sources for the overall study include video recording of the novice teachers during community-based engineering tasks and written artifacts from the summer institute and methods course assignments, which involve the critique and revision of science and engineering lessons.

Preliminary Findings

Our preliminary findings are primarily based on the initial administration of the Video Case Diagnosis task. This exploratory stage serves the dual purpose of informing us of novice teachers' initial understanding of science and engineering practice and serving as a pilot version of the instrument. Thirty elementary pre-service teachers participated in this pilot run. The video featured two fourth-grade students engaged in conceptual planning for a device that could lift a heavy object out of the ocean. The boys use verbal language, written notes, sketches, and rough physical prototypes to communicate their design ideas to each other and create an initial design plan. Preliminary analysis of teacher responses indicates that they tend to focus on two aspects of the students' work: a) students' use of science and engineering technical vocabulary (e.g., "lever," "weight") and b) the students' physical prototypes, including the rudimentary lever the students created out of a water bottle and pencil. Preliminary analysis also indicates that the teachers do not frequently notice the important engineering practices of problem identification and consideration of multiple solutions. In our poster we present detailed findings from these initial exploratory stages.

Relevance to Conference Theme: "Learning and Becoming in Practice"

Our work contributes to the conference theme through its dual focus on pre-service teacher engagement in engineering practice as well as their learning to notice and respond to young students' science and engineering practice. We investigate how novice teachers, especially in tightly constrained urban elementary schools, *learn* about science and engineering practice, and *become* science and engineering educators.

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