Elementary Students Becoming Engineers through Practice

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Abstract: As part of an efficacy study of elementary school engineering curricula, we are recording all engineering lessons in 24 classrooms. Data collection is split between the treatment and comparison curriculum, and will continue through June 2014. Our observation notes and preliminary video analysis suggest that some students self-identify as engineers, while others do not. Our poster will present an analysis of the contexts and contributing factors leading to students' adoption of self-concepts in engineering.

Introduction

This poster will present a subset of findings from the first of two years of data collection for the Exploring the Efficacy of Elementary Engineering (E4) study, an NSF-funded efficacy study of an engineering curriculum for elementary school students. Data collected for this study includes work samples, teacher surveys and logs, and assessments from students in 351 classrooms, together with intensive video data collection from a subset of 24 of these classrooms. Two different engineering curricula embodying different approaches to teaching engineering are being implemented, with random assignment at the school level, such that each curriculum is implemented by approximately half the classrooms. In the video case study classrooms, the treatment makes up two-thirds of the classrooms, and the comparison is represented in one-third of the classrooms.

In the treatment curriculum, students are presented with a challenge through the context of a story about a child with a problem to be solved. Students are encouraged to think of themselves as engineers, and scaffolded to engage in problems the way an engineer would: for example, in studying structures, the teacher models how to analyze forces on the structures as well as how to brainstorm and test ways to counter those forces. In the comparison, students are presented with information about engineering and the challenge, and given the challenge to solve, without further context: for example, before trying to build a structure, they are given an informative text and pictures of sample structures.

The focus of this poster will be student interest in engineering and the development of an engineering self-concept. We will combine our findings from analysis of the video case studies with student work samples, an assessment of student conceptions of the field of engineering, and a survey of student interest in and attitudes towards engineering—as a topic of study, as a field, and as a possible future career.

Theoretical Framework

The treatment curriculum is designed to engage children and teachers in meaningful activity. Its design is grounded in the learning sciences (e.g., NRC, 2000, 2005; Sawyer, 2006). Research from these fields indicates that students learn concepts and skills through experience as they work and learn in rich contexts (Bruner, 2004; Lave & Wenger, 1991; Rogoff, 1990). The treatment endeavors to build a network of connections as the contextual basis of every unit: each unit is set in a real-world and career context; children are invited to "be engineers" as they learn about engineering practice in a particular field because children's learning is more profound when they engage in realistic disciplinary practices (Roth, 1994; Sawyer, 2006) that include the social and epistemic practices of a discipline and put key concepts into productive use (Duschl, 2008; Duschl & Grandy, 2008; Engle & Conant, 2002). Each treatment unit of study ties in to literacy, social studies, science, and mathematics. In every unit, children are invited to reflect upon and build their own understanding through experience with materials, inquiry, and design, and their knowledge of the world. By engaging in activities that afford reflection on—as well as productive use of—their experience and understanding of science, students are more likely to learn and retain their understanding (Kolodner et al., 2003; Zubrowski, 2002). Lessons are designed to scaffold student learning through teacher questioning, through lesson plans that make disciplinary strategies explicit and encourage students to express and reflect upon their learning (as recommended by Quintana et al., 2004), and through complex activities supported by structuring of problem-solving processes (as recommended by Hmelo-Silver et al., 2007).

The comparison curriculum is primarily drawn from engineering lessons and activities freely available on the internet, featuring both direct instruction and a hands-on component. A few lessons were designed from scratch to match learning objectives featured by the treatment curriculum, for which no available existing lessons were found. The found lessons have been modified to be more strongly appropriate for grades 3-5—most were specified as appropriate for grades 3-12; also the "direct instruction" aspects of the curricula have been improved as necessary with further support for teachers and students and grade-appropriate readings. The intention is for the comparison curriculum to contrast with the treatment curriculum in pedagogical approach.

Methodological Approach

Video data collection in each class includes all lessons and time spent on the engineering curriculum (treatment or comparison). Between one and three cameras are set up in each class—those classrooms nearest to the primary site of data collection include more cameras and observers than those classrooms further removed from the research site. In all classrooms, one camera is trained upon the teacher and a portion of the classroom—students without parental consent are seated off-camera. Where another camera or cameras are available, each follows the same student group throughout data collection. At the end of implementation in each classroom, some students are asked to participate in focus groups, where they are interviewed on a number of topics, including their interest in engineering and self-concept as engineers.

Promising episodes from the video case studies—those showing student attitudes towards engineering—are identified from observation notes and first-pass logging of all files. We look for cases where students talk about engineers or engineering, especially in a personal way, for example when a student says "I'm good at engineering". For these episodes, we develop codes and explanatory theories by repeatedly comparing between theory and data in order to test and refine theory and increase explanatory power. We have collected qualitative measures of student engineering interest and self-concept, which we will compare to coded student work samples, and the student interest/attitude surveys collected from the video case study classrooms. Our goal is to begin to answer the questions, "Does the treatment foster more positive interest in and attitudes towards STEM careers?" "To what extent does the treatment affect students' self-concept as engineers?" and "How do differences in treatment, as well as differences in fidelity and quality of implementation, moderate outcomes?"

Preliminary Findings

Thus far, we have collected video from 15 classrooms, and are in the process of collecting from 9 more. We have noted episodes where students expressed positive or negative self-concepts in engineering. These tend to be associated with success or failure in meeting engineering design challenges. In our continuing work, we test these associations and look for mediating contexts and frames: for example, time available to improve designs and communicate with other teams about what they learned, or a focus on learning through overcoming failure. For final paper see: http://eie.org/sites/default/files/research_article/research_file/icls_poster_proposal_2014.pdf

Potential Significance and Relevance to ICLS 2014

This research addresses the theme "Learning and Becoming in Practice" by examining how students' attitudes and self-concept in engineering change as they engage in different engineering curricula—one of which focuses on engaging students explicitly in developmentally appropriate disciplinary practices of engineering. The potential significance of this work is in developing a better understanding of the contexts and frames that affect students' disciplinary identification and self-concept; also improving understanding of how educational learning environments can be influenced by elements of curriculum design and teacher training.

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