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Engaging in identity work through engineering practices in elementary classrooms

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ABSTRACT

This article examines the emergence of identity work in engineering among elementary school students. Engineering has only recently been added to state and national standards in the United States. The purpose of the study was to examine ways that engaging in engineering practices transforms students' views of engineering and themselves. Video of two teachers, each teaching one engineering unit, was analyzed. Across the lessons of these engineering units (designing a parachute and designing a mortar mixture for a stone wall), a sociolinguistic perspective was taken to show how engagement in engineering provides opportunities for identity work among the students and teachers. Analyses of the classroom discourse identified the epistemological and ontological constructions of identity, uses of intertextuality and chronotopes to build identity over time, and ways that collective understandings supported student take-up of an engineering identity. Because engineering is a new discipline in most classrooms, it provides a unique opportunity to examine how disciplinary affinity can be developed through purposeful activity and metadiscourse about participation.

1. Introduction

The *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013) propose the integration of engineering knowledge into science education. Engineering offers new ways to learn science and fosters a unique set of epistemic practices specific to engineering design (Cunningham & Carlsen, 2014; Cunningham & Kelly, 2017a). The standards advocate for three-dimensional learning comprised of science and engineering practices, crosscutting concepts, and disciplinary core ideas. Rather than focusing on science content and process skills, this approach recognizes the ways that substantive disciplinary knowledge interacts with choices about practices and uses of specific and generalized concepts and ideas. Engineering provides one context in which these three dimensions of learning work together.

Although engineering has recently entered elementary education as part of science instruction, efforts to include engineering at this level existed prior to the onset of this round of reform (Cunningham, Knight, Carlsen, & Kelly, 2007; Schauble, Klopfer, & Raghavan, 1991). Despite this history, there has been little research into the teaching and learning of engineering through discourse analysis of classroom interaction in K-12 classrooms (a notable exception is Roth, 1995), and even less about student take-up of engineering practices and identity from this point of view. Affiliation and taking on an academic identity in engineering are related to student learning and are important issues for building students' understanding of disciplinary knowledge. Therefore, we adopt a sociocultural perspective that recognizes how knowledge, practices, and ways of being that comprise identity work are constructed in and through discourse processes.

This article examines the enacted curricula of two classrooms—a fourth grade aerospace engineering unit and a second grade materials engineering unit. We consider the ways that teachers and students construct meaning about the nature of engineering design with a focus on how teachers use engineering curricula to frame and define engineering practices with students. In particular, we focus on how students come to view the work they are doing as "engineering" and themselves as "engineers" as they engage in meaningful, real-world engineering challenges. Central to such identity work are discourse practices. Engineering provides a unique opportunity to examine how disciplinary affinity can be developed through such discourse practices via purposeful activity and metadiscourse about participation.

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2. Cultural studies of education and engineering

2.1. Language and learning in science and engineering

Research in science education has identified ways that language mediates interaction and knowledge acquisition (Kelly, 2014a). Much of the work of inquiry-oriented classrooms, like the ones studied here, concern students learning to engage in sets of disciplinary epistemic practices. Epistemic practices are socially organized and interactionally accomplished ways that members of a group propose, construct, communicate, assess, and legitimize knowledge claims (Kelly, 2016). In science and engineering fields, such practices entail social languages or discourses with particular features, often emerging out of the needs of professional work (Bazerman, 1988) and with unique linguistic features (Halliday & Martin, 1993). These discourses come with ways of being in the world (Gee, 2000) and are potentially alienating for students, as their everyday way of speaking and interacting is often not valued in educational settings (Brown, 2006). In this study, the ways of talking and writing about engineering design projects provided the basis for investigating ways of building affiliation with engineering.

Our sociocultural perspective views members of a group creating particular ways of talking, thinking, acting, and interacting as they affiliate over time (Castanheira, Crawford, Dixon, & Green, 2001; Kelly, 2014b). These ways of being come to define the language of the classroom and set norms and expectations for actions taken among members. Over time, these ways of acting become routinized, and patterns develop that define the cultural practices of the group. Such practices become resources for members as they are internalized and become part of the ways of being in the classroom. Cultural practices are also transformed as members modify these practices to establish and position new identities and ways of being. Student identity is thus constructed over time, draws from multiple social languages, and is dependent on the discourse practices of the local group (Brown, Reveles, & Kelly, 2005). Such local group members are also members of other groups, and thus bring frames of reference to each interaction, including experiences, beliefs, values, knowledge and practices (e.g., ways of knowing, doing, interpreting), that may match or clash with local ones (Kelly & Green, 1998). From this perspective, identity is built through social interaction and importantly, through particular discourse processes (Anderson, 2009; Carlone, Scott, & Lowder, 2014).

2.2. Discourse and identity in education

In our framework, individuals and groups construct identities as they talk, act, and affiliate as a group over time (Gee, 2000; Wortham, 2008). To understand the identity work of participants, analyses must examine actions in moment-to-moment discursive events while situating these events in the larger context of interactional sequences (Wortham, 2008). In everyday life as well as school, people learn through participation in social groups as they construct, negotiate, and shape identities (Nasir & Saxe, 2003; Thompson, 2014). As participating members become familiarized with norms of the group, they build repertoires of discourse and interactions that may be understood, accepted, or rejected by the group (Wenger, 1998). From this point of view, identity is intricately connected to social relations between and among participants

As the field of pre-college engineering education is relatively new, there are fewer studies of students' identities related to engineering than other subjects in education (Cunningham & Carlsen, 2014). However, some initial studies have considered student attitudes and identity. Silver and Rushton (2008) assessed Year 5 students (in the United Kingdom, age 9–10) using Likert-scale questionnaires and children's drawings of scientists and engineers at work to investigate their attitudes toward science, engineering, and technology and their images of scientists and engineers. Capobianco, Diefes-Dux, Mena, & Weller (2011) completed a descriptive study of children in first grade (ages 6–11) regarding their conceptions of an engineer that used the Draw an Engineer Test (DAET) (Knight & Cunningham, 2004). Capobianco, French, & Diefes-Dux, (2012) and Capobianco, Yu, & French (2014) applied the Engineering Identity Development Scale (EIDS)—a Likert-scale instrument that they developed for elementary students and discussed findings related to students' academic identity (i.e., self-beliefs or self-images as students) and views of a possible engineering career (i.e., what engineers do, who students want to become).

In contrast to engineering education, some studies of science education and identity have taken a sociocultural perspective, as reflected in methods focused on discourse and social practice (e.g., Carlone, Scott, & Lowder, 2014; Varelas, Kane, & Wylie, 2012). Such studies focus on identity work rather than making claims about identity itself or even identity development (Calabrese Barton, Kang, Tan, O'Neill, Bautista-Guerra, & Brecklin, 2013). This shift focuses analysis on the social and discursive activity occurring within the locally constructed cultural practices. Calabrese Barton et al. (2013) refer to identity work as "the actions that individuals take and the relationships they form" (p. 38) in a given moment, with the available resources, constrained by the sociohistorical norms, rules, and expectations. The focus on identity work offers educators ways of making sense of participation that recognizes the interactional, fluid, and often contested shifts in positioning that occur in learning contexts. As current reform recognizes the linkages across science and engineering, there is a need to consider how issues of competence, identity, and affiliation may manifest in K-12 engineering education contexts. Our study seeks to complement the current cognitive studies of engineering identity by focusing on student identity as interactionally accomplished through discourse and action in classroom settings.

2.3. Studies of K-12 engineering education

Research in K-12 engineering education is emerging as a new area of scholarship (Cunningham & Carlsen, 2014). Scholars have noted that the real-world connections engineering provides motivates students (Barron et al., 1998) and that engineering design offers students unique affordances to engage in disciplinary practices (Wendell & Kolodner, 2014). Although initial studies of engineering in K-12 school settings have identified the potential educational opportunities of engineering (Brophy, Klein, Portsmore, & Rogers, 2008; Silk, Schunn, & Cary; 2009), many students have limited understandings of engineering and the work of engineers. To the extent that children have any conceptions at all, they often describe engineers as train drivers, auto mechanics, construction workers, and people who use large machines (Capobianco, Diefes-Dux, Mena, & Weller, 2011; Knight & Cunningham, 2004). These views of engineering are understandable given the limited experiences students have with engineering. To provide a basis for the development of engineering practices, we turn to the cultural study of engineering practices.

2.4. Empirical studies of engineering practices

Learning engineering, science, and other academic disciplines entails understanding the nature of the knowledge and the ways that communities produce claims (Kelly, 2008; Ricketts, 2014). In engineering, such claims are often tied to specified features of a local condition. In other academic areas, knowledge may be tied to the interpretation of primary sources (history) or the results of experimentation (science). Such variation suggests a need to