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Teacher questions: Learning the discourse of science in a linguistically diverse elementary classroom

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ABSTRACT

Using ethnographic and sociolinguistic perspectives the authors examined the quality and quantity of questions asked by one teacher in a diverse fourth grade classroom with a large number of emergent bilinguals and low-income students during a six-week science unit in a school located in the Pacific Northwest of the United States. This study illustrates how teacher questions played a pivotal role in facilitating students' access to both the content and the genre specific language of science.

1. Introduction

Research on classroom discourse, including asking questions, has been an important area of study beginning with the groundbreaking work of Sinclair and Coulthard (1975), Mehan (1979), and Cazden (2001) and spanning the subsequent contributions, particularly in science classrooms, of Chin (2006, 2007), Chin and Osborne (2010), Kelly (2014), Lemke (1990), Tan and Wong (2012), Van Booven (2015), van Zee and Minstrell (1997), and several others. As a whole, this body of work points to the centrality of classroom discourse in knowledge construction. Discourse is at the core of how communities and classrooms develop community norms and expectations, define what counts as knowledge for the group, build affiliation, and provide or limit access both to disciplinary content and language knowledge (Cazden, 2001; Gee & Green, 1998; Long, van Es, & Black, 2013). Teacher questions, a central part of the teaching and learning process, have the potential to enhance or hinder students' access to the content to be learned and the language to access and demonstrate content knowledge.

The new vision for science teaching and learning established in the Framework for K-12 Science Education (National Research Council, 2012) and set forth by the Next Generation Science Standards (NGSS) stresses the importance of creating content-rich and discourse-rich classroom environments. For example, a main component of the standards are the eight science and engineering practices: (1) asking questions and defining problems; (2) developing and using models; (3) planning and carrying out investigations; (4) analyzing and interpreting data; (5) using mathematics and computational thinking; (6) constructing explanations and developing designs; (7) engaging in argument from evidence; and (8) obtaining, evaluating, and communicating information. Clearly, engagement in any of these practices involves both scientific sense-making and language use (Lee, Quinn, & Valdés, 2013), especially practices # 1, 4, 6, 7 and 8. Without question, teachers play a crucial role in translating science, including the use of questions, into reform-based classroom practice (Forbes & Davis, 2010).

This study centers on the first practice, asking questions. The NGSS underscore that asking questions is critical to developing expertise in science. A major goal of the NGSS is for students to learn how to generate questions "about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations (NRC Framework, 2012, p. 56). Given the importance of asking questions in science classrooms, teacher questions can serve as models for the kinds of questions we want students to ask.

Within this context, and given the importance of the teachers' role in generating discourse norms and practices, especially for

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students who are learning English as a second language, the following questions guided this study:

1. What is the nature of teacher talk during content area instruction?
2. What kinds of questions do teachers ask during content area instruction?
3. What purposes do teacher questions serve during content area instruction?

We address the above questions by presenting a fine-grained analysis of the types of questions asked by one teacher during a six-week science unit on rocks and minerals in a Grade 4 classroom located in a low-income neighborhood. The diversity in this classroom, where about half of the students speak a language other than English at home, is of particular importance in considering how students from a variety of backgrounds engaged in science discourse.

1.1. Learning the discourse of science

Discourse is central to the ways communities develop their own norms and expectations, define and frame knowledge, build affiliation, provide access to disciplinary ways of knowing, and invite or limit participation (Cazden, 2001; Gee & Green, 1998). Thus, the nature of science discourse shapes the ways of thinking, knowing, doing and being that occur within the classroom (Gee & Green, 1998). The language of science, characterized by abstraction of reasoning, precision of expression, conciseness achieved by avoiding redundancy, and avoidance of personal opinions and relations (Snow, 2010), is essential for doing science (Lemke, 1990). Students cannot conduct experiments, write lab reports, or understand a film on neuroimaging if they cannot use the appropriate terminology (e.g., zygote, ferrous), grammatical structures (e.g., passive voice, syntactic ambiguity), and specific genres (e.g., research reports, lab directions) that characterize the language of science (Gottlieb & Ernst-Slavit, 2014). The role of such characteristics in the classroom is best summarized by Stoddart, Pinal, Lazke, and Canaday (2002):

> The relationship between science learning and language learning is reciprocal and synergistic. Through the contextualized use of language in science inquiry, students develop and practice complex language forms and functions. Through the use of language functions such as description, explanation, and discussion in inquiry science, students enhance their conceptual understanding. (Stoddart et al., 2002, p. 667).

Earlier research on classroom discourse indicates that teacher talk dominates classroom talk and teacher questions constitute a key component of teacher talk. Typical school conversations involve initiation-response-evaluation (IRE) cycles (Cazden, 2001; Mehan, 2001, 1979), as illustrated in the following dialog:

Teacher: What is the name of the closest star to the earth?	(initiation)
Student: The sun	(response)
Teacher: Very good	(evaluation)

The teacher *initiates* an interaction, often with a question, the student *responds*, and the teacher *evaluates* the response before making another initiation. Unfortunately, this kind of interaction is typical in U.S. classroom contexts and is generally expected by both teachers and students.

A great deal has been written about the dominance of this kind of exchange and about its negative results in terms of the kinds of questions asked (often recall of factual information), the limitations for student participation (only one student at a time), and learning (low-level factual knowledge). If, in addition, there is a short wait time—less than 3 s (Blosser, 2000; Rowe, 1978) then most students do not engage in thinking about the question asked unless directly addressed by the teacher. The brevity in wait time and the type of exchange that occurs is often linked to teachers asking questions to which they already know the answer. Lemke (1982) indicated that when teachers ask questions they know the answers to, the entire lesson can be seen as an interactional transformation of a lecture. The teacher could have given a lecture, yet instead transformed it into IRE sequences to keep students' attention and check for understanding.

In their study of teacher questioning patterns in primary schools, Wragg and Brown (2001) found that 53% of the questions teachers asked are standalone questions while 47% were part of a sequence of two or more questions. Of this 47%, only 10% were part of a sequence with four or more questions (Wragg & Brown, 2001). The prevalence of the IRE sequence in science classrooms is particularly problematic since it runs counter to inquiry-based instructional approaches and because it is often used by teachers who work with culturally and linguistically diverse as well as economically disadvantaged students (Cazden, 2001). It follows that by using this kind of "intellectual hide-n-seek" (Beghetto, 2013) found in IRE sequences, teachers potentially limit all students, particularly economically disadvantaged and emergent bilinguals (students learning English as an additional language), opportunities to think and talk in extended ways about their ideas, questions, and interests.

Much of the early work on classroom discourse has focused on the ways in which teachers and students construct the norms of communication in the classroom and how these often-implied rules for verbal interactions enhance or limit students' opportunities to talk science (Lemke, 1990). Research on teacher questions has garnered important insight into the nature and practice of classroom inquiry.

1.2. The nature of questions, typologies, and teacher questions

Gadamer (1991) argued, "the essence of the question is to open up possibilities and keep them open" (p. 299). With the understanding that questions afford possibilities and potentially function as scaffolding tools for learning, it is no wonder that questions and questioning have been a source of continued research. Earlier research analyzed the philosophy of the question (Gadamer, 1991; Meyer, 1988) and the role of the question within a variety of contexts exploring questions and hierarchical taxonomies as well as typologies (Bloom, 1956; Chin, 2006, 2007; Gall, 1970). Hierarchical typologies were further explored, constructing understandings on the epistemology and function of open and closed questions (Blosser, 1991; Carr, 1998; Kearsley, 1976; Long & Sato, 1983), which influenced how we envision productive discussions in classrooms (Cavagnetto, 2010; Lustick, 2010; Mortimer & Scott, 2003; van Zee, Iwasyk, Kurose, Simpson, & Wild, 2001; van Zee & Minstrell, 1997).

The substantial number of taxonomies, classifications, labels and varieties of questions risks compromising transferability to classroom contexts. However, because teacher questions are such an important component of classroom talk and because they shape students' ways of knowing and being, understanding just how questions are used in teaching and learning contexts is paramount in maximizing their usefulness in classrooms. In fact, Meyer (1988) suggests the nature of scientific inquiry is a means to advance the progression of science through the process of asking questions and then answering them.

In recent years there has been an increasing interest in questioning in science classrooms. Five influential studies deserve attention. Gallas' (1995) study on *science talks* in her combined 1st/2nd grade classroom brought to the forefront the value of