Teacher Discourse Moves that Support Dialogic Interactions in Engineering in Linguistically Diverse Classrooms

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Researchers and educators have long recognized the role that oral discourse plays in fostering student learning.\textsuperscript{1,2} Historically, much of classroom instruction has relied on the Initiate-Respond-Evaluate (I-R-E) pattern of oral discourse.\textsuperscript{3} In this pattern, the teacher initiates discourse through asking a question, the student responds to the question, and the teacher evaluates the students’ response, giving feedback through brief words and phrases such as great or not quite. This pattern of oral discourse, though prevalent in many educational settings, is associated with negative student outcomes when compared with oral discourse structures that enable students to share divergent opinions and hold sustained discussions.\textsuperscript{4,5}

Under the recognition that oral discourse is important to learning outcomes, many researchers have studied how teachers can use discourse moves that promote sustained discussion among students. Though research has studied how K-12 teachers can use particular discourse moves to foster sustained student discussions in science,\textsuperscript{6,7} relatively little empirical research has studied how K-12 teachers can use discourse moves to foster student discussions related to engineering design, especially when these teachers are working with large populations of English learners. The purpose of this exploratory study was therefore to identify the discourse moves that two middle school teachers used to foster dialogic exchanges between their students, many of whom were English learners, as they engaged in engineering design activities.

**Related Literature**

Many teachers engage in discourse that is monologic—or to use van de Weghe’s phrase, they play the game of “What’s on my mind?” (p. 88). Decades of research has indicated that monologic patterns—most notably, the I-R-E patterns—dominate classroom discourse regardless of academic discipline.\textsuperscript{1,8} Nystrand and colleagues found that even in disciplines in which one would expect a high level of dialogic discussion—such as in social studies and English/language arts—I-R-E patterns dominated.\textsuperscript{9} Specifically, Nystrand’s research team visited over 200 eighth-grade and ninth-grade social studies and English classes four times each. They found that only 6.69% of instructional episodes had even one dialogic spell—or a spell in which the teacher was not directly asking questions to lead the conversation—and that the average length of these discussions was 50 seconds in eighth grade and under 15 seconds in ninth-grade.

Although there are many ways to encourage dialogue in the classroom, Nystrand and colleagues found that teachers could use five key oral discourse moves to promote dialogic discussion, and these strategies have been used with success in other disciplines as well.\textsuperscript{10} Van de Weghe described the purpose of dialogic discussions as playing the game of “What’s on our minds?” (p.88). According to Nystrand, to support this type of discussion, first, teachers can ask authentic questions, or questions with no pre-determined answer. Second, teachers can incorporate uptake, or using what a student has said in their subsequent instruction and encouraging other students to use what previous students have said. Third, teachers can evaluate students’ responses beyond a simple one-word or one-phrase responses, such as mm-hmm or right. Instead, their level of evaluation can include responses that elaborate on students’ comments or use their comments as the basis for follow-up questions. Fourth, teachers can ask questions with a high cognitive level,
or questions that move beyond basic recall and enable students to engage in bigger questions such as why and how something has occurred. Fifth, and most importantly, teachers can encourage students to contribute their own questions to the conversation. Student-generated questions had the greatest impact on whether or not a conversation would become dialogic or would stay monologic. In Nystrand’s research, the presence of just one student question raised the rate of a dialogic spell by 200%.

Although Nystrand’s study has broad application to Science, Technology, Engineering, Mathematics (STEM) disciplines, it was conducted in history and English Language Arts (ELA) classrooms. Other researchers, however, have studied discourse in science classrooms to determine what teacher discourse moves promoted dialogic spells in whole-class discussions. Zhai and Dillon, for instance, found that when teachers used storytelling and analogies to teach aspects of botany, their students were more likely to construct elaborate verbal explanations in their subsequent discussions.11 McNeill and Pimentel’s research in urban high school classrooms in many ways reflected the findings of Nystrand and colleagues.6 They found that dialogic discourse was more likely to occur when science teachers made explicit connections to previous students’ comments and when they asked “open-ended questions,” or questions that Nystrand would have termed authentic and cognitively challenging.

Collectively, these studies point to oral discourse moves that teachers can provide to encourage dialogic interactions among students. While some of these oral discourse moves appear to apply across content areas (e.g., asking open-ended questions), other oral discourse moves (e.g., using analogies) may be more specific to particular disciplines, such as science. The purpose of this study was to identify oral discourse moves that promoted dialogic interactions between students in the context of engineering specifically.

Context of the Study

To investigate teacher discourse moves, we conducted two case studies with two middle school teachers from different school districts in the rural Western United States. Each teacher represented one case. Both taught classes with higher-than-average populations of English learners (ELs) for their state: Darryl (pseudonym) taught in a middle school in which 10% of the students were ELs, while Alex (pseudonym) taught in a middle school in which 15% of students were ELs. Both teachers taught mandatory, introductory Technology and Engineering (TE) classes to middle school students, and thus their classes reflected the overall population of their schools. At the time of the study, Darryl had taught for about 29 years, whereas Alex taught for about nine years. Both were considered expert TE teachers and leaders in their communities, and both expressed interest in incorporating discussions into their design instruction.

Darryl and Alex provided their students with a variety of engineering design challenges, along with opportunities to discuss those challenges. For instance, Darryl’s students addressed challenges such as designing devices and systems for organizing middle school lockers, designing safety procedures for their middle school woodshop/lab, designing paper rockets that carried cube satellites a specified distance when launched by an air gun compressor, and designing structural columns that could withstand a specified amount of pressure when placed in a compression machine. Alex’s challenges included designing a Styrofoam airplane that could
fly a specified distance, designing an improved chair for middle school students, and selecting appropriate flooring materials and designing a floor layout for a house occupied by a family with dogs and small children.

**Methods**

We audio-recorded two engineering units taught by each of the two teachers, for a total of about 810 minutes of classroom instruction. The audio-recordings were transcribed into writing. To determine whether a dialogic spell occurred, we identified all instances in which students spoke without the interjection of a new question posed by the teacher. After identifying these instances in the data set, we then went back and identified what teacher oral discourse moves immediately preceded the dialogic spell. We then used constant comparative analytic methods to identify patterns in those instances of teacher discourse that proceeded a dialogic spell. We developed codes to determine patterns and characteristics related to teacher involvement and engagement prior to these student discussions or unsolicited student comments.

**Findings**

After examining the coded content of the transcripts, we discovered two specific oral discourse moves that contributed to dialogic spells and unsolicited comments from students during whole-class discussions. Specifically, asking students to make connections to their life experiences and asking open-ended questions contributed to dialogic spells. We provide examples from each category below.

**Finding One: When teachers asked students to share relevant life experiences, they were more likely to engage in dialogic spells.**

Two examples will illustrate how this type of oral discourse move contributed to dialogic spells. In Darryl’s classroom, the teacher asked students to share a time that their parents had been injured at the workplace. The purpose of this question was to help them brainstorm a variety of injuries and then to connect these injuries back to lab safety. Darryl’s lab included a variety of potentially dangerous equipment, such as welding and cutting equipment. For one engineering challenge, therefore, Darryl asked his students to act as safety engineers by designing a series of systems and procedures that would keep students safe in their lab.

To begin this unit, he asked students to identify and share possible workplace injuries. Multiple students, including the English learners, chimed in with a variety of responses, ranging from instances when their parents hurt their backs from lifting heavy objects, to instances when their parents’ hands were crushed by operating machinery, to instances when their parents slipped and fell. This oral discourse move—asking students for their personal experiences relevant to the design challenge—prompted student discussion that was sustained without the interruption of a new teacher question.

As a second example, Darryl’s students redesigned their middle school parking lot. To help students identify problems with their existing parking lot, he posed the following question: “What’s your experience in the parking lot been like?” Students shared a variety of experiences
without further teacher prompting. The following experiences, both shared by English learners, included the following: “When my dad drops us off, he doesn’t go up to the sidewalk where you can walk to the school. He goes in between parking spaces, so we have to cross. We almost get hit every time.” A second student responded with, “My dad dropped me off one morning, and he told me to look both ways before I got there. I looked both ways. I crossed the street, and about to cross the street to the door. Some car honked and almost hit me. I had to run across the street.”

Darryl then used these student experiences to identify existing problems with the middle school parking lot as part of the “defining the problem” stage of the engineering design challenge. These examples, along with others, indicating that dialogic spells may be more likely to occur when teachers encourage students to share their personal experiences, and then explicitly connect those experiences to the design challenge. This type of oral discourse move appeared to prompt discussion both among students who spoke English as a first and a second language because students from both categories tended to verbally respond to these prompts and to maintain the conversation without further teacher interjection with a new question. This particular discourse move is particularly important in the engineering design process as it helps students develop a better understandings of problems to be solved and specific needs to be addressed later in the design process.

**Finding Two: When teachers asked open-ended questions, students were more likely to engage in dialogic spells.**

For the purpose of this study, we define open-ended questions such as those with no pre-determined answer, regardless of their cognitive level. This discourse move is also important in TE classes in that it helps students understand potential problems and can improve troubleshooting. Several examples will demonstrate how this type of question led to dialogic spells. For instance, Darryl asked students, “What do you think is the problem you’re trying to solve by making these rockets?” This question elicited a variety of student responses, such as the following:

- Student One: Keep satellites into space.
- Student Two: Getting it to fly.
- Student Three: No jiggles.
- Student Four: It should get into space.
- Student Five: That it don’t jiggle, because if it doesn’t jiggle, it has the most likely more chance of actually flying that 120 yards.

As a second example, one student stated, “My rocket exploded,” to which Darryl responded with, “What do you think caused it to explode?” This question prompted a series of comments among students, such as the following:

- Student One: It was too tight. I put way too much tape on it. I left one tiny little strip with zero tape on it so it exploded. Two and a half feet of my rocket was annihilated. Then I still have about that much left.
Student Two: Surprisingly, my watch survived. It exploded right up to the watch. It was only two inches left.

Student One: He put his watch on the rocket.

Student Two: My watch had broken. It’s one of these where it’s all rubber. The rubber had been worn down, so I tricked the mechanism out, because it’s like a little [inaudible 20:12] thing. It was in a plastic bag so it was waterproof. I took it out of the plastic bag and put it in my pocket, the clock. I was kind of hoping my rocket would explode, because I wanted my watch to explode. It didn’t.

Alex’s instruction included no instances of dialogic spells in comparison to Darryl’s instruction. We speculate that this relative absence of dialogism may have occurred because he felt that he had to follow district-mandated scripts more closely. These scripts included step-by-step lesson plans, which included worksheets and pacing guidelines for teachers to follow. These pacing guidelines did not often solicit student experiences or encourage teachers to ask open-ended questions in a discussion-based format.

In summary, we found that two teacher discourse moves—asking for personal experiences and asking open-ended questions—led to dialogic spells among the students. This finding echoes findings from other studies in the sense that it confirms that open-ended questions and establishing relevance to students are two tools for supporting sustained discussion. At the same time, however, this study makes a contribution to existing empirical literature by verifying that these oral discourse moves are effective in an engineering context and by specifying how these discourse moves might be applied to engineering specifically, including among teachers who teach high populations of English learners.

**Discussion and Implications**

Although we found that these two oral discourse moves promoted dialogic spells, like Nystrand, we found that most of the transcripts did not include any dialogic spells. Moreover, we did not code the complexity of students’ comments. In many cases, such as Example One under Finding One, students did not seem to build off others’ responses in rich and cumulative ways. In this example, students simply recited new responses without elaborating on previous students’ responses. Future research can identify additional scaffolds that teachers can use to encourage students to build off of each other’s responses. It may be that multiple teacher oral discourse moves work in tandem toward this goal. For instance, if Darryl had modeled and encouraged uptake more, than perhaps this cumulative nature of knowledge and engineering design thinking may have appeared more fully in student comments.

We conclude by asserting that dialogic instruction is possible in engineering, as it is possible in other academic disciplines. Moreover, principles which have been shown to work in other academic disciplines—such as establishing relevance by soliciting students’ experiences and asking questions with no known answers—also work in engineering, including among middle school English learners. Discourse moves to create dialogic discourse in TE classes are especially valuable in helping students understand problems and troubleshoot problems in testing
phases in the design process. This study has implications for pre-service teacher educators and in-service professional development providers who want to build TE teachers’ capacity to lead sustained dialogic discussions. Specifically, educators of TE teachers can emphasize the importance of soliciting student experiences and asking open-ended questions in order to foster student discussion in linguistically diverse classrooms.

References


