NCTM NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Discussion
Research Brief

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What Are Some Strategies For Facilitating [redacted] Productive Classroom Discussions?

One area that has been given a great deal of attention in the mathematics education literature, particularly over the past 25 years, is classroom discourse. This is evident not only in the body of published articles but also in the many policy documents calling for more student talk in mathematics classrooms (see, e.g., NCTM's *Principles and Standards for School Mathematics* [NCTM, 2000] and the Common Core State Standards [NGA Center and CCSSO, 2010]). Although these documents often use different language to describe their communication standards, they are all based on the common assumption that students learn mathematics best when they are given opportunities to speak about mathematics using the language of mathematics. Discussion, which is promoted in all of the documents, can therefore provide students with opportunities to communicate mathematically.

Because many of us learned to teach through the "apprenticeship of observation" (Lortie, 1975) in traditional classrooms, calls to shift from recitation to discussion-based lessons can be challenging. Many teachers are understandably unsure and overwhelmed by the call to use rich tasks and to facilitate discussions in mathematics class (see, e.g., Ball, 1993; Chazan, 1993). Over the past 15 years, fortunately, the field has begun to tackle the problem of providing teachers with guidelines and tools to support the facilitation of productive classroom discussions. Nine strategies for facilitating productive discussions are listed below and are discussed in more detail throughout the remainder of the paper.

- Attend to the classroom culture
- Choose high-level mathematics tasks
- Anticipate strategies that students might use to solve the tasks and monitor their work
- Allow student thinking to shape discussions
- Examine and plan questions
- Be strategic about "telling" new information
- Explore incorrect solutions
- Select and sequence the ideas to be shared in the discussion
- Use Teacher Discourse Moves to move the mathematics forward
- Draw connections and summarize the discussion

Attend to the Classroom Culture

The Discourse Project was a five-year, professional development–based study aimed at understanding how mathematics teachers' attention to their classroom discourse could impact their beliefs and practice over time (see Herbel-Eisenmann & Cirillo, 2009). An important realization that teachers involved in the project had was that if they wanted to change the classroom culture by moving students toward a more open, student-centered discourse, they needed to invite their students to participate in this shift. For example, in a book chapter focused on her action research in the Discourse Project, middle school teacher Jean Krusi (2009) wrote about how she involved her students by asking them what makes a good classroom discussion. Together, Krusi and her students constructed a list of five norms for classroom discussion: "Everyone is listening; Everyone is involved; Everyone puts out ideas; No one is left out," and "Everyone is understanding—if not at the beginning, then by the end" (p. 121). Krusi found that, in addition to emphasizing these kinds of social norms, she also needed to mention mathematical norms, such as what counts as evidence in mathematics. As the school year came to a close, students commented that they were participating more compared to the beginning of the year, and that they thought that the discussions were fun.

This example from Krusi's class is consistent with other recommendations from the literature. For example, Chapin and O'Connor (2007) insist that the most critical condition that will support both language and mathematics development is for teachers to establish conditions for *respectful discourse*. Similar to Krusi's student-generated norms, Hiebert et al. (1997) proposed the following norms of the classroom culture: Tasks must be accessible to all students; every student must be heard; and every student must contribute. Discussion is most productive when these kinds of prerequisite conditions of respectful and equitable participation are established in advance (Chapin & O'Connor, 2007). As mentioned above, accessible, high level tasks are also a critical element of a good discussion.

students say (Nystrand, 1990, 1991). These kinds of interactions are often characterized by "authentic" questions, which are asked to get information (e.g., "Can you tell us how you decided the answer was 5?"), not to test what students know and do not know. The primary function of a discussion is to construct group knowledge (Bridges, 1987), and questions are the key to fruitful discussions. The research on questioning is vast; therefore only a brief overview is provided below.

Examine and Plan Questions

Examining one's own questions and questioning patterns is an important start when looking more closely at the classroom discourse (see, e.g., Herbel-Eisenmann & Cirillo, 2009). This examination alone, however, has not been shown to do enough to support teachers in facilitating productive discussions that "focus on mathematical meaning and relationships and make links between mathematical ideas and relationships" (M. Smith & Stein, 2011, p. 50). A single, well-formulated question can be sufficient for an hour's discussion (Dillon, 1983). However, many studies have shown that while teachers ask a lot of questions, these questions frequently call for specific factual answers, resulting in lower cognitive thought (Gall, 1984; Perrot, 2002). Some question-types open up discussion, while others are more "closed" (Ainley, 1987). For example, one type of question takes the form of part-sentences "left hovering in mid-air for the student to supply the missing word or phrase" (Ainley, 1987, p. 24). An example of this 'fill-in-the-blank' type of question is: "This polygon has three sides so we call it a ...?" This kind of question is closed, both because it relates to matters of established fact and because the teacher has one "right" answer in mind. On the other hand, it creates the illusion of participation and cooperative activity (Ainley, 1987).

Examples of well-formulated questions are: "What is the relationship between the solutions to a quadratic equation and its graph?" or "Why did you solve the quadratic equation to help you graph the parabola?" To answer to these types of questions, students need to provide more than just one-word answers because the answers are complex and require a deeper level of thinking to give complete answers. More open questions are often better for opening discussion and maximizing the chances of individuals to contribute to the discussion, yet such questions tend to be underused (J. Smith, 1986). It can be useful to plan not only tasks but also good questions in advance of the lesson (M. Smith & Stein, 2011), and to consider what questions we can ask to avoid too much "telling."

Be Strategic About "Telling" Information

In a series of papers titled *Arbitrary and Necessary*, Hewitt (1999, 2001a, 2001b) urged mathematics educators to consider teaching approaches that allow students to discover the necessary (e.g., that the ratio of a circle's circumference to its diameter is a constant number that is approximately 3.14), while only telling students that which is arbitrary (e.g., that this constant ratio of a circle's circumference to its diameter is denoted as pi (π)). This distinction between what to tell versus what to allow students to discover goes against traditional teaching methods where teachers were typically the deliverers of all information, both arbitrary and necessary.

Lobato, Clarke, and Ellis (2005) pointed out several drawbacks to the "teaching as telling" practice. Telling is undesirable when it: (a) minimizes the opportunity to learn about students' ideas and strategies; (b) focuses only on the procedural aspects of mathematics; (c) positions the teacher (rather than the students) as arbiters of mathematical truth; (d) minimizes the cognitive engagement on the part of students; (e) communicates to students that there is only one solution path; and (f) represents premature closure of mathematical exploration (p. 103). As an alternative to telling, the authors put forth the strategy of *initiating*. Initiating includes but is not limited to the following actions:

- Summarizing student work in a manner that inserts new information into the conversation
- Providing information that students need in order to test their ideas or generate a counterexample
- Asking students what they think of a new strategy or idea (perhaps from a "hypothetical" student)
- Presenting a counterexample
- Engaging in Socratic questioning in an effort to introduce a new concept
- Presenting a new representation of the situation (e.g., a graph to accompany a table of values)

These strategies offer alternatives to directly telling students information so that the teacher can productively move the discussion forward. Another strategy involves allowing the students to share their ideas as the basis of the discussion. Sometimes even incorrect strategies are worth exploring.

Explore Incorrect Solutions

Rather than only allowing correct solutions and strategies to surface in discussions, many teachers have taken steps to reduce the stigma attached to being wrong, thus communicating to students that mistakes are part of the learning process (Staples & Colonis, 2007). Some researchers have found that exploring incorrect solutions can serve as a springboard for each other (e.g., Asking Students to Revoice after Probing a Students' Thinking). These moves can be used in conjunction with the Five Practices introduced above.

Draw Connections and Summarize the Discussion

The first four of the five practices mentioned above (Anticipating, Monitoring, Selecting, and Sequencing) work to set up the discussion, whereas Connecting is primarily meant to occur during the discussion. Rather than having mathematical discussions that consist of separate presentations of different strategies and solutions, the goal is "to have student presentations build on one another to develop powerful mathematical ideas" (Smith & Stein, 2011, p. 11). The teacher supports students in drawing connections between their solutions and other solutions in the lesson. The discussion should come to an end with some kind of summary of the key mathematical ideas. The students ideally leave with "residue" from the lesson, which provides a way of talking about the understandings that remain when the activity is over (Hiebert et al., 1997).

Concluding Thoughts

In this brief summary, various guidelines and tools were presented to support teachers' efforts to facilitate productive discussions. It is important to recognize that this review only scratches the surface of a growing body of work. Several important areas of this research could not be included here due to space. Some examples include: the teacher's role in classroom discourse (Walshaw & Anthony, 2008); the role of students (Hiebert et al., 1997); the development of mathematical language (see, e.g., Herbel-Eisenmann, 2002; Pimm, 1987); developing lesson goals and planning for productive discussions (Smith & Stein, 2011); using discussion as a formative assessment tool (Lee, 2006); types of questions (e.g., Boaler & Humphreys, 2005) and patterns of questioning (Herbel-Eisenmann & Breyfogle, 2005); equitable participation in classroom discussions (Esmonde, 2009); student motivation to participate in discussions (Jansen, 2006), and so on. There is still much to learn about the conditions under which discussions are productive toward reaching learning goals in mathematics classrooms. The guidelines and tools presented here, however, are intended to provide teachers with a place to begin working on their own goals of facilitating productive and powerful mathematics discussions.

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