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Research into Practice

Facilitating Meaningful Discourse

by Christine Thomas, Ph.D.

Introduction

The math achievement of U.S. students, especially secondary students, has been the focus of concern and even angst among math educators and school administrators for many years. Not only were U.S. students' scores on internationally benchmarked assessment lower than those of students in other industrialized or even emerging countries, but U.S. businesses chronically complained that high school and even college graduates were ill-prepared for career expectations.

Research findings suggest that the under performance of U.S. students on international assessment can be attributed to, among other factors, students' superficial and primarily procedural understanding of key math concepts. Students know how to carry out an operation or a procedure, for example, how to factor a quadratic equation or calculate measure of center and spread, but are not always able to articulate when completing the square is a more useful process than using the quadratic formula.

The National Council for Teachers of Mathematics (NCTM) leadership has been at the forefront in looking to bring about a change in focus in the high school mathematics classroom, to emphasize conceptual understanding and reasoning over skill practice. This shift away from procedural fluency—what to do—reflects the belief that students need a deep understanding of mathematics—how to do it and why—in order to make use of their mathematical knowledge and skill to solve unfamiliar problems in new settings or context; that is, to be effective problem solvers. In its 2009 publication, *Focus in High School Mathematics: Reason and Sense Making*, the NCTM leadership argued that high school mathematics curricula and instruction should be grounded in reasoning and sense-making. Arguing that reasoning and sense-making are the "foundations for the process of mathematics—problem solving, reasoning and proof, connections, communication, and representation,"[1] the authors of the publication maintain that these processes should be pervasive through the high school mathematics curriculum. With such an emphasis, they insist, students are able to develop deep conceptual understanding of math content, allowing them to succeed in college and career endeavors.

Christine Thomas

Christine Thomas's scholarly expertise is in developing teacher learning communities. Dr. Thomas also focuses on ways to help teachers implement NCTM's Effective Teaching Practices in the high school math classroom.

Acknowledgments

[1] National Council of Teachers of Mathematics (2009). Focus in High School Mathematics: Reasoning and Sense Making. Reston, VA, p. 3.

Why Discourse in the Mathematics Classroom?

What then is the connection between discourse in the mathematics classroom and student achievement in mathematics? Mathematical discourse is foundational to student learning and is related to student achievement. It is anchored in communication that promotes students' understanding of key ideas. While engaging in mathematical discourse, students share ideas, which then helps them clarify their understanding of concepts; as they construct convincing arguments, they develop precision of language for expressing mathematical ideas. Through listening to the ideas and arguments of their classmates, they learn to see things from other perspectives. In short it is through these mathematical conversations that deep understanding emerges. (NCTM 1991, 2000).

Just as important is the nature of the tasks that students encounter and about which they engage in mathematical discourse. These tasks need to focus on cognitively challenging tasks that encourage multiple entries to the problem and allow for multiple approaches to its solution. When tasks present interesting challenges and potential missteps, students benefit from working their way out of the missteps, leading to real understanding. (Hatano & Inagaki, 1991; Michaels, O'Connor, & Resnick, 2008).

Defining Meaningful Discourse

This message of reasoning and sense making was integral to the development of the Common Core State Standards for Mathematics (CCSS-M), in particular the Standards for Mathematical Practice (SMP)—the eight habits of mind found in every grade from kindergarten through high school. These standards call for students to engage in communicating, explaining, analyzing, justifying, making conjectures, representing, sharing ideas, and critiquing the reasoning of others. The first four practices explicitly include language related to reasoning, sense making, and communication. SMP 1 exemplifies the importance of classroom discourse, while SMP 2 describes the importance of student representation. SMP 3 and 4 reveal direct connections to discourse and communication, with the former emphasizing argumentation and the latter communication. Nevertheless, it is clear that all eight of the practices require that students engage in meaningful conversation within the math classroom. Further, the authors of the CCSS-M explicitly state that "the practices rest on important processes and proficiencies with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation and connections." While all five of the process standards are integral to mathematical discourse, three of the process standards are inextricably linked to discourse in terms of the language used to define them. They are reasoning and proof, communication, and representations are described in terms of classroom discourse. NCTM defines these processes as:

- **Reasoning and proof:**
  Mathematical reasoning and proof offer powerful ways of developing and expressing insights about a wide range of phenomena.
- **Communication:**
  Mathematical communication is a way of sharing ideas and clarifying understanding.
- **Representations:**
  Mathematical ideas can be represented in a variety of ways: pictures, concrete materials, tables, graphs, number and letter symbols, spreadsheet displays, and so on.

In 2013, Koestler, Felton, and Bieda published an alignment of the NCTM Process Standards to the SMPs. For each SMP at least one of the process standards: reasoning and proof, communication, and representations is directly linked. This further corroborates the importance of mathematical discourse to effective mathematics teaching and specifically describes how engaging students in meaningful discourse is central to developing students' expertise in the SMPs.

Facilitating and Promoting Meaningful Mathematical Discourse

The challenge that many teachers face is not with defining mathematical discourse or describing what it should look like in the classroom; rather it is in successfully establishing an environment to foster that discourse, and in providing for students the cognitively rich tasks that encourage the kind of discourse that leads students to deep conceptual understanding. Once again, NCTM has been a leader in offering guidance to teachers to help them achieve a mathematics classroom that fosters mathematical discourse. In 2014, NCTM published *Principles to Actions: Ensuring Mathematical Success for All*, a "framework for strengthening the teaching and learning of mathematics." The authors identified eight effective teaching practices for mathematics. They are as follows:

1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem solving.

3. Use and connect mathematical representations.
4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.

The instructional design of *enVision A|G|A* is structured in a way to provide mathematical discourse throughout the program. Each lesson opens with a learning activity that is designed to promote reasoning and problem solving, to give students opportunities to engage in productive struggle and in mathematical discourse. In the Teacher's Edition there are questions to facilitate discussion after students have worked on these activities, to draw out their thinking about the problem and to help them connect the new concepts of the lesson to the activities.

During Step 2, students are introduced to new concepts in the examples. The questions found in the Teacher's Edition are purposefully geared towards helping students develop understanding of the core concepts that underline the mathematical procedures. The Math Practices side column boxes focus students' attention on particular aspects of the concepts.

At the topic level, two special features emphasize mathematical discourse: the *Mathematical Modeling in 3 Acts* tasks and *enVision*® STEM projects. Both of these tasks present high-interest, low-entry tasks that require student interaction and discourse. They both allow students at all levels of mathematical proficiency to engage in the tasks and through the rich classroom discussion, to grow in their understanding of the key concepts used in these tasks.

In *enVision A|G|A*, throughout each topic, lesson, and project, teachers are provided questions that focus on each of the eight teaching practices. These are highlighted by an icon "ETP." The development of *enVision A|G|A* was guided by these Effective Mathematics Teaching Practices and the teacher support will help bring purposeful and meaningful discourse into classrooms.

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