

## **Developing content knowledge through professional development grounded in the practice of teaching**

### **Summary**

Professional development is at the heart of improving mathematics education. Research suggests that a set of general principles should guide professional development if it is to work. Key is that teacher growth is enhanced when professional development is grounded in specific classroom practices. Since many K-8 teachers' own knowledge of mathematics is fragile, they need to engage in the study and doing of mathematics they are expected to teach, to deepen their own content knowledge, and to see how mathematical ideas develop and connect within and outside mathematics. This can be done effectively through content-based professional development that integrates the enhancement of teachers' knowledge of the content they teach with pedagogy of effective instruction.

### **The strategy**

- focuses on an area of mathematics that teachers self-identify or recognize as a weakness in their preparation to teach (buy in)
- uses mathematical tasks that teachers can try in their own classroom (relevance)
- uses tasks that have the potential to deepen teachers' subject matter knowledge through extensions or investigations beyond what students would be expected to do (more on the mathematics)
- uses a range of tasks that collectively provide balance over mathematical processes
- involves teachers working independently and together, discussing ways of reasoning about and approaches to solving a problem, justifying approaches and solutions (mathematics learning community)
- uses carefully chosen student work on rich tasks to push at teachers' subject matter knowledge

This strategy draws upon a type of professional development that employs case studies. Cases that are situated in real classrooms, with all the complexity that implies, provide a site for teacher investigation and learning. The tools recommended are casebooks that have grown out of several research projects including the QUASAR Project, the COMET Project, and the Mathematics Case Method Project.

While individual teachers can benefit from reading cases, the maximum use can be made by engaging groups of teachers in the cases with the guidance of a facilitator. The tools recommended provide a facilitation guide as part of the casebook.

### **Background**

Deborah Lowenberg Ball, in her introduction to *Implementing Standards-Based Mathematics Instruction: A Casebook for Professional Development* (Stein et al., 2000) argues that professional development should involve not only teachers having an experience, but also learning from that experience. The expectation for teachers leaving a workshop should be that they are taking more than a fun task to try in their classroom. Therefore, professional development facilitators have a critical role to play in mediating teachers' learning from the experience.

Teachers at all grades typically have a deep-seated set of beliefs about the nature of mathematical knowledge that grows out of their own experiences in traditional mathematics classrooms. Professional development needs to engage teachers in a different kind of experience if they are to value and build practices around problem solving and reasoning. They need opportunities to construct their own meaning and understanding of mathematical processes and content.

Ball suggests that learning mathematics in the context of practice can be powerful, since it engages teachers in the work of teaching: working on and analyzing tasks, interpreting students' work on the tasks to better understand their reasoning and sense-making, framing questions to engage students in further conversation about how they are coming to understand the mathematics embedded in the task.

## **Tools**

*Children's Mathematics: A Workshop Leader's Kit: Cognitively Guided Instruction* by Thomas Carpenter and Elizabeth Fennema. Published by Heinemann, 2000.

CGI is a problem-solving mathematics program for grades K-3 that takes children's knowledge as central to instructional decision-making. Teachers use research-based knowledge about children's mathematical thinking to help them learn how to build on this knowledge in classroom instruction. The materials include videotapes, a book of readings with an accompanying CD, and a guide for workshop leaders.

*Connecting Mathematical Ideas: Middle School Video Cases to Support Teaching and Learning* by Jo Boaler and Cathy Humphreys. Published by Heinemann, 2005.

The video cases in this collection are extracted from the videotaping of a yearlong course taught by Humphreys. They have been selected to highlight connections in various forms: between students' ideas; between student and teacher ideas; between different mathematical ideas, different mathematical representations, and between different mathematical domains. The set consists of two CDs and an accompanying book in which Humphreys writes about and reflects on each case. In addition, Boaler provides case commentaries.

*Developing Mathematical Ideas: Seminars on Number and Operation, Geometry, and Data Analysis* by Deborah Schifter, Virginia Bastable and Susan Jo Russell. Published by Dale Seymour Publications, 1999; 2002.

DMI is a series of seminars designed to help teachers think through the big ideas of K-7 mathematics. The collection includes three casebooks accompanied by facilitator guides and videos. The materials include cases from classrooms that illustrate students' thinking as described by their teachers. In seminars teachers explore mathematics, examine student work, analyze interviews of students, read and discuss relevant research, and engage in writing cases of episodes from their own classrooms

*Fostering Algebraic Thinking Toolkit: A Guide for Staff Development* by Mark Driscoll in collaboration with Judith Zawojewski, Andrea Humez, Johannah Nikula, Lynn Goldsmith, and James Hammerman. Published by Heinemann, 2001.

This Toolkit is composed of four modules designed around analyzing student work; listening to students; documenting patterns of student thinking; and asking questions of students. The goal of the Toolkit is to “help mathematics teachers in grades 6-10 learn to identify, describe, and foster algebraic thinking in their students...and understand students’ thinking through the analysis of different kinds of data, such as student work and classroom observations.” The Toolkit materials include Facilitator Notes and blackline masters for each module and are built around rich problem solving tasks.

*Fractions, Decimals, Ratios and Percents: Hard to Teach and Hard to Learn* by Carne Barnett, Donna Goldenstein, and Babette Jackson. Published by Heinemann, 1994.

This set of materials is composed of 29 narrative cases written by teachers in grades 4-8 who participated in the Far West Laboratory’s Institute for Case Development. The casebook is accompanied by a Facilitator’s Discussion Guide that provides teaching notes for each case. The cases are centered in the domain of rational numbers and each is linked to a particular set of issues (e.g., building concepts, relationships, classroom discourse, manipulatives, invented algorithms, proportional reasoning).

*Implementing Standards-Based Mathematics Instruction: A Casebook for Professional Development* by Mary Kay Stein, Margaret Schwan Smith, Marjorie A. Henningsen, and Edward A. Silver. Published by Teachers College Press, 2000.

The centerpiece of these materials is a set of narrative cases drawn from the QUASAR Project and viewed through the lens of the Mathematical Tasks Framework – a characterization of how mathematical tasks unfold during classroom instruction. The cases portray the enactment of cognitively challenging tasks in middle grades classrooms. The Framework provides a tool for guiding a discussion of cases and the challenges of using high-level tasks for instruction.

*Using Cases to Transform Mathematics Teaching and Learning: Improving Instruction in Rational Numbers and Proportionality; Improving Instruction in Algebra; Improving Instruction in Geometry and Measurement* by Margaret Schwan Smith, Edward A. Silver and Mary Kay Stein. Published by Teachers College Press, 2005.

The centerpiece of these materials is a set of narrative cases of mathematics lessons from urban middle school classrooms that grew out of the NSF-funded COMET Project. Cases provide an opportunity for participants to wrestle with issues of practice that arise when teachers use cognitively challenging tasks in classrooms. The materials provide guides to the leader about facilitating analysis and discussion of the cases and designing follow-up activities that help teachers connect case experiences to their own practice.

## **Challenges addressed**

*Our teachers need a deeper knowledge of the mathematics they are teaching.* The visions of mathematics teaching portrayed in Principles and Standards of School Mathematics (NCTM, 2000) and Professional Teaching Standards (NCTM, 1991) are premised on teachers having a deep understanding of the mathematics they teach. Yet many teachers in the elementary and middle grades have not had the kinds of

learning experiences that could help them develop this knowledge. How can teachers broaden and deepen their knowledge of mathematics for teaching?