Learning Mathematics: A Change in Focus

P Janelle McFeetors

Over the last several decades, reforms made to classroom practice have significantly shifted teaching methods from teacher-centred to student-centred instruction (Chazan 2000; National Council of Teachers of Mathematics 2000). These reforms have brought about changes from direct instruction to inquiry models of teaching (Boldt and Levine 1999; Borasi 1992). Teachers have focused on transforming their teaching practice, noticing the shift in their role from delivering content to guiding students' exploration (Brown and Smith 1997; Verkaik and Ritsema 2006). Teachers take note of their effectiveness in the classroom by recognizing their students' decreased dependence on them during the learning process.

The shift in teaching focus has kept the content of mathematics in direct view. In exploring better teaching practice, reforms in mathematics education have focused on different methods of delivering or exploring mathematical content (Simon 1995; Ward 2001). Many mathematics courses, especially at the high school level, are overflowing with content; there seems to be an enormous challenge to teach all the outcomes in a course. Although teachers have shifted their teaching practice, they remain focused on getting through heavily weighted courses by addressing the content.

What if the reforms to mathematics education were intended to support more than just instructional change? What other types of change could improve mathematics education?

Mathematics Instruction: Making Space for Conversation

Three scenarios familiar to junior high and high school mathematics teachers follow. While reading the scenarios, consider the commonalities between the teachers' orientations toward the learning of mathematics.

In the first scenario, a mathematics student approaches a teacher at lunchtime for some extra help. The teacher willingly agrees, and sits down with the student. He asks the student what topic is troublesome and asks to see some of the student's individual practice. The teacher looks through the student's steps, asking probing questions. Carefully and thoughtfully, the teacher determines which step the student has completed incorrectly in each question, diagnosing the problem. Patiently, the teacher explains (perhaps in a different way from his explanation that day in class) how to perform the step, and he demonstrates the correct method for the student. The teacher encourages the student to perform the step several times, scaffolding each attempt, until the student begins to feel confident and the teacher feels that he has addressed the problem. The student leaves knowing how to correctly complete the step and finishes the individual practice that evening for homework.

In the second scenario, a mathematics teacher sits down to plan the next unit of instruction. She carefully reads the curriculum document and considers each specific learning outcome, breaking down each individual skill and concept the students are expected to learn. Considering the time allocated for the unit, she begins to sequence the learning outcomes. She notices that each day the students will be required to learn a new skill or concept. The pace seems fast, with so much content to cover, so she designs each lesson to include a large segment of direct instruction and some individual practice time in order to reach all the specific learning outcomes in a short amount of time. She feels confident that with the ordering of the learning outcomes and her ability to explain the connections between each lesson, in addition to the students' practice of the skills, the students will be able to perform the necessary skills by the end of the unit.

In the third scenario, the time for a reporting period has arrived. A mathematics teacher is preparing for parent–teacher interviews after providing marks and comments on each student's report card. The comments have been selected from a collection of prewritten phrases. For each student, the teacher considers thoroughly each assessment task that has been collected. He notes the mathematics skills each student has developed during the term, as well as skills that

need improvement. The comment "Needs to improve basic fraction calculations" seems appropriate for one student. In approaching the parent–teacher interview, the teacher creates a plan to help the student get better at using fractions that includes a weekly tutorial in the mathematics lab and extra practice. The interview is successful, and the student and her parents appreciate the teacher's suggestions and are willing to implement the plan to see improvement.

What do these three scenarios have in common? Perhaps you noted the positive tone of each situation, with a resolution that gives the teacher and the student confidence in the experiences in the mathematics classroom. Perhaps you noted that each student attends a mathematics class in which every day offers opportunities to learn new mathematical skills and concepts with a teacher who is thoughtful about her or his practice. Perhaps you noted that each teacher is concerned with the student as an individual mathematics student. Finally, perhaps you noted that scenarios like these often occur in the mathematics classroom.

However, there is an additional commonality between these three scenarios that, when explored, could lead to further reform in the mathematics classroom. Perhaps asking the question in a different way will uncover this similarity. In each scenario, what is the *focus* of the teacher's efforts? In the first scenario, the teacher focuses on the mathematics content with which the student is having difficulty; the extra help session focuses on the individual step the student missed and corrects only that step. In the second scenario, the teacher focuses on the mathematical concepts in the unit and the mathematical skills the students should acquire during that unit. In the third scenario, the comment the teacher selects for the report card focuses on a mathematical skill the student needs, and the conversation at the parent–teacher interview is concerned with that mathematical content.

In each scenario, the teacher is focusing on the mathematical content that is in view. However, could each student's experiences in mathematics class be enhanced through a change in focus—a focus on the student's acts of learning? During the extra help session, how could the student have benefited from a conversation about how he was learning during the teacher's explanation in class, or how he was learning from his individual practice? Within the unit of instruction, how could a student's learning be improved by conversations through assessment tasks that focus on how the student learned a particular skill? How could the discourse at the parent–teacher interview have been more effective for the student if it had included a conversation about how to learn to perform arithmetic operations on fractions, or the general learning processes best for that student?

Incorporating conversations about how students are learning, including discourse about how to improve learning, is important in supporting students' successful mathematical learning. These learning-based conversations require a shift from a focus solely on mathematics content to a focus on learning that uses the mathematical content as a vehicle for the learning-based conversations.

This article will introduce the concept of metalearning as a focus in the secondary mathematics classroom. Metalearning moves beyond a teacher's focus on mathematics (learning) and promotes student engagement in conversations about their own learning, with the intent of improving their learning (of mathematics). After describing the classroom ethos that encourages teacher–student conversations about learning, I will discuss how assessment practices can incorporate metalearning as an additional purpose for such tasks.

Metalearning: Learning as a Focus of Conversation

Metalearning is a term that describes students' thinking about their learning processes (Jackson 2004). *Learning processes* refers to ways in which students come to know and understand, as well as their positioning with authority, their beliefs about the reception or construction of knowledge, and other related actions (Baxter Magolda 1992; Belenky et al 1986; Chickering and Reisser 1993). Engaging in thinking about learning is a higher level of cognition that invites those in a classroom to analyze and make meaning of the way in which they are students and learners in the classroom. This higher level of cognition would be situated within a higher order of thinking in the classroom, such as Marzano and Pickering's (1997) "habits of mind" or fifth dimension of learning. When students engage in metalearning, they move beyond learning content to critically view their learning.

Metalearning occurs both while students are learning and, more commonly, as they look back on the learning they have done. When teachers invite their students to engage in metalearning, they begin a conversation (Gordon Calvert 2001) with students about what they are learning and how they are learning. This gives teachers opportunities to assess what new concepts and skills students have learned and the way in which they have learned them. An important

element of metalearning is the feedback students receive from teachers. Feedback, often in written form, is given to students when they have completed a metalearning activity. Teachers model, through feedback, how to think in a metalearning way, in an effort to extend students' learning about learning (Norton, Owens and Clark 2004). Thus, the act of metalearning is both assessment *of* learning and assessment *for* learning.

Six purposes can be identified for inviting students to engage in metalearning. First, metalearning brings learning into focus in the classroom setting, rather than focusing on specific content. This shifts the valuation of knowledge and understanding to encompass goals broader than merely learning specific mathematical outcomes.

Second, because metalearning seeks to help teachers and students understand how and what students learn, it addresses the multiple forms of assessment (assessment *of* learning, assessment *for* learning and assessment *as* learning) recently incorporated into provincial assessment frameworks (Alberta Assessment Consortium 2005; Manitoba Education, Citizenship and Youth 2006).

Third, when individual students become analytic about their learning, they can learn how to get better at their learning processes. They are encouraged not only to describe their learning processes but also to consider how they might make those processes more effective. The development of effective learning processes is critical to lifelong learning.

Fourth, metalearning focuses on the learning processes of the individual, allowing for differentiation of thinking and learning that is appropriate and effective for each student in the classroom (Manitoba Education and Youth 1996; Tomlinson 1999).

Fifth, if students become aware of how they learn, especially in different settings and with different focuses (for example, conceptual understanding or skill development), they can improve their learning of specific mathematical content.

Sixth, metalearning changes the didactic contract (Herbst and Kilpatrick 1999) and the asymmetrical power relationship inherent in many classrooms. The shift in power relations occurs within the context of metalearning because the learners become experts on their own learning, and the teacher acts as a guide to prompt metalearning awareness and the growth of learning processes. The asymmetrical power relationship between students and the teacher is minimized because the teacher is learning about the students' metalearning alongside the students (Freire 2000). Together, in mutuality, they are engaging in discourse about each student's learning.

Some similarities can be seen between metacognition and metalearning. Both occur on a higher level of cognition within the classroom, and both invite individuals to be aware of and analytical about the processes in which they engage daily in the classroom. As they engage in both metacognitive and metalearning thought, they have opportunities to get better at related processes. Both also aim at achieving learning and thinking goals that are broader than specific subject content outcomes. However, an important distinction must be drawn between metacognition and metalearning. Metacognition focuses solely on the *thinking* of students in the classroom (Schoenfeld 1987). Metalearning cannot be a subelement of metacognition, because the purposes and stances addressed in metacognition and metalearning are quite different. Rather than considering only cognitive processes, metalearning also takes into account the individual's relationship to others and to school as an institution (McLaren 1994).

Listening: The Foundation for Conversation

Conversations about student learning and general learning processes can take place in any mathematics classroom, but a certain classroom dynamic must be established. In a student-centred classroom, students and their teacher have already developed power relationships that encourage mutual exploration of mathematical content. In this classroom, learning about mathematics alongside one another is a common experience; space for conversation about mathematical ideas already exists. Mathematical experiences of this type can be extended to create similar metalearning experiences.

Engaging students in metalearning takes place within a community that has cultivated authentic discourse between students and the teacher. The community of learners in the classroom is built on respect and mutuality. Metalearning situates itself within a pedagogical relationship characterized as teacher-with-learner and learner-with-teacher. The teacher is "as much a participant as a person who leads the students, yet retains the responsibility for the learning, the teaching, and the environment in the classroom" (Romano 2000, 59). The community of learners forms because of the members' willingness to learn something together, affecting each other's sense making in a particular context (Craig 1995). The community is forged through caring relationships (Noddings 1984) and through directed interactions between the teacher and each learner that encourage dialogue about metacognition, learning and self-awareness.

Forging a community of learners is challenging. Although it is not dependent on methodology or strategy, listening to students is central. Listening can be enacted in several ways in the classroom, depending on the roles and the relationship of the students to the teacher and the school system. At times, students are listened to as students; the listening focuses on how students interact with the schooling system, but they are not seen as particular individuals and learners. At times, students are listened to as cognizers; the listening focuses on the way in which students are thinking about mathematical content. However, the listening central to metalearning can be referred to as *authentic listening*, where each student is listened to as a particular learner in the classroom. The teacher forges a pedagogical relationship with each student; listening to the whole individual, the teacher comes to know each as a student, a learner and a human being. Van Manen (1986, 17) describes this listening as hearing the student "as a whole human being involved in self-formative growth."

Authentic listening is critical in conversations about learning. These conversations can take place in a variety of contexts in a mathematics classroom—through classroom observations, instructional moments, classroom interactions and specific assessment tasks. An informed conversation begins with the teacher's classroom observations (one method of listening) of each student's learning processes. The conversations can be supported, and often prompted, by instructional moments—where the teacher takes time in class to discuss a particular learning strategy and why it is effective. In initiating a learning-based conversation, the teacher signifies to the students a change from a focus on mathematical content to a focus that encompasses learning processes. Whole-class discussions can lead to conversations with individual students, and the strategy can be differentiated. Through one-on-one conversations in class or in assessment items collected from each student, the teacher can authentically listen to each student.

The following section explores how teachers can incorporate metalearning in existing assessment tasks.

Assessment: The Opportunities for Conversation

Listening to students not only fosters the success of all learners but also is an effective way to assess student learning. A change in focus allows teachers to attend to the learning students have done and the ways in which they learn. Teachers can gain a much richer picture of student learning and can assess what has been learned, what areas need improvement and how to support improvement. Through thinking and writing about their learning, students engage in self-assessment of learning and learning processes (not just self-assessment of content). In conversations with students, teachers can model how to assess learning and how to build on previous learning.

Assessment tasks that incorporate a written element can be effective for engaging students in conversations about their learning. The writing occurs in a conversational style between the teacher and the student. This can be considered a conversation because sustained interactions are encouraged through the assessment tasks. The focus is on how the students are learning and what the students are learning; students respond to prompts that support their thinking and writing about their learning. Metalearning is part of assessment in a classroom because both the students and the teacher are observing what the students have learned. Additionally, incorporating metalearning elements into existing assessment items, instead of increasing the number of assignments taken in by a teacher, makes the task less onerous for the teacher.

Metalearning developed in my practice through my use of learning-based prompts in students' assessment pieces in a variety of secondary mathematics courses (including pure math, applied math, and Math 14 and 24). I conducted a research study (McFeetors 2003) in a Grade 10 consumer mathematics course (for course information, see Manitoba Education, Training and Youth 2002), a course similar to Math 14. I found that written assessment tasks helped me learn more about my students' learning processes, and my students became increasingly adept at writing about their learning. I used a variety of assessment forms to encourage a focus on learning; however, I found that a simple adaptation of journal writing became a foundational element for engaging in metalearning with my students.

The role of journal writing can be expanded from merely explaining mathematical skills and concepts to prompting students to write about what they have learned and their learning processes. This shift signifies a change in focus and intention for student writing, bringing each student's learning into direct view. Student writing about learning, with responses from the teacher, is interpersonal in nature because it allows the learner and the teacher to come to understand each other's views—listening and relating. The student and the teacher can have a dialogue about the student's progress, creating opportunities to recognize and celebrate successful learning. Further, student writing about learning helps the teacher recognize what can be done to promote each student's success

in the mathematics classroom. Recognizing each learner as a person builds an environment that invites each to become the best learner, student and human being he or she can be.

Engaging in conversations about learning is a new focus for many students in the mathematics classroom. Because this is an emergent process that students will not initially engage in independently, teachers should scaffold opportunities for students to think about their learning and their learning processes. Let's further explore journal writing as an example. When students submit their journals, the teacher can write back to each student, instead of marking each journal with a numerical score. In the written response, the teacher can interact with the student's ideas, model metacognitive and metalearning thinking, and encourage the student to think more deeply about her or his learning. This is called interactive writing (Mason and McFeetors 2002). Interactive writing allows the teacher to have a conversation with each student, at the most appropriate place in that student's learning and thinking. It also allows the teacher to come to understand what and how each student is learning, supporting the change in focus from mathematics to learning. See Figure 1 for suggested prompts focusing on student learning.

Interactive writing is only one of a variety of activities and assessment tasks that can be used to engage students in metalearning in the mathematics classroom. Consider assessment tasks that you already use

Figure 1

Learning-Focused Prompts

General Prompts Focused on Learning

- What do you want to learn in this course? Describe two things you will do to be successful in your learning goals.
- Think back to math class last year. What were two things you did that supported your learning?
- Again, think back to math class last year. What were two things you did that did not support your learning? How are you going to improve this year?
- How did you study for the math test yesterday? (Be specific.)
- Describe how you do your math homework every evening (how often, what you do and so on).
- Pick two items that can be shared with your parents at parent–teacher interviews. Describe why you picked those particular items. (In other words, what do they show about your learning?)
- Describe your day-to-day study habits for math during this last unit (include actions in class and at home). Can you see a connection between your study habits and your learning and test mark? What can you do to improve?
- Tell me about the hardest test question that you did well on. What made the question challenging? How did you get it in the end?
- Look back at your goals and strategies. Then take a look at your report card mark. Tell me about your progress. Talk about whether you are using your strategies. Do you need to set a new goal or use different strategies?
- Check off what you have completed from the list of assignments. How does the completion match up to how you did on the test? Which topic(s) do you need to work on? How will you improve?
- Create two report card comments for yourself. Explain why they are appropriate.

Homework Prompts Focused on Learning

- One thing I now know how to do because I did my homework is ...
- One thing I learned from doing my homework was ...
- I got stuck on question __. To get unstuck, I ...
- One thing I still do not understand how to do is ... To improve, I will ...
- A question I now understand after homework question time is ... What I now understand is ...
- For me, the purpose of homework is to ...

in your classroom that could be adapted or amended to encourage students to intentionally think about their learning processes. A change in focus, from considering mathematics content to incorporating conversations about learning, will enable students to become better learners of mathematics and lifelong learners.

References

Alberta Assessment Consortium (AAC). 2005. *A Framework for Student Assessment.* 2nd ed. Edmonton, Alta: AAC.

Baxter Magolda, M B. 1992. *Knowing and Reasoning in College: Gender-Related Patterns in Students' Intellectual Development.* San Francisco: Jossey-Bass.

Belenky, M F, B M Clinchy, N R Goldberger and J M Tarule. 1986. *Women's Ways of Knowing: The Development of Self, Voice, and Mind.* New York: Basic Books.

Boldt, G, and A Levine. 1999. "Adventures in Mathematical Inquiry." In *Developing Mathematical Reasoning in Grades K–12,* 1999 yearbook, ed L V Stiff and F R Curcio, 234–46. Reston, Va: National Council of Teachers of Mathematics.

Borasi, R. 1992. *Learning Mathematics Through Inquiry.* Portsmouth, NH: Heinemann.

Brown, C A, and M S Smith. 1997. "Supporting the Development of Mathematical Pedagogy." *Mathematics Teacher* 90, no 2 (February): 138–43.

Chazan, D. 2000. *Beyond Formulas in Mathematics and Teaching: Dynamics of the High School Algebra Classroom.* New York: Teachers College Press.

Chickering, A W, and L Reisser. 1993. *Education and Identity.* 2nd ed. San Francisco: Jossey-Bass.

Craig, C J. 1995. "Knowledge Communities: A Way of Making Sense of How Beginning Teachers Come to Know in Their Professional Knowledge Contexts." *Curriculum Inquiry* 25, no 2 (Summer): 151–75.

Freire, P. 2000. *Pedagogy of the Oppressed.* 30th anniversary ed, with an introduction by D Macedo. Trans M B Ramos. New York: Continuum.

Gordon Calvert, L M. 2001. *Mathematical Conversations Within the Practice of Mathematics.* New York: Lang.

Herbst, P, and J Kilpatrick. 1999. "Pour lire Brousseau." *For the Learning of Mathematics* 19, no 1 (March): 3–10.

Jackson, N. 2004. "Developing the Concept of Metalearning." *Innovations in Education and Teaching International* 41, no 4 (November): 391–403.

Manitoba Education and Youth. 1996. *Success for All Learners: A Handbook on Differentiating Instruction.* Winnipeg, Man: Manitoba Education and Youth.

Manitoba Education, Citizenship and Youth. 2006. *Rethinking Classroom Assessment with Purpose in Mind: Assessment for Learning, Assessment as Learning, Assessment of Learning.* Winnipeg, Man: Manitoba Education, Citizenship and Youth. Also available at www.edu.gov.mb.ca/k12/assess/wncp/index.html (accessed January 2, 2008).

Manitoba Education, Training and Youth. 2002. *Senior 2 Consumer Mathematics: A Foundation for Implementation.* Winnipeg, Man: Manitoba Education, Training and Youth. Also available at www.edu.gov.mb.ca/k12/cur/math/s2_cons_found/index.html (accessed January 2, 2008).

Marzano, R J, and D J Pickering. 1997. *Dimensions of Learning Teacher's Manual.* 2nd ed. Alexandria, Va: Association for Supervision and Curriculum Development.

Mason, R T, and P J McFeetors. 2002. "Interactive Writing in Mathematics Class: Getting Started." *Mathematics Teacher* 95, no 7 (October): 532–36.

McFeetors, P J. 2003. "Voices Inside the Classroom: Stories of Becoming in Mathematics." Master's thesis, University of Manitoba.

McLaren, P. 1994. *Life in Schools: An Introduction to Critical Pedagogy in the Foundations of Education.* 2nd ed. Toronto: Irwin.

National Council of Teachers of Mathematics (NCTM). 2000. *Principles and Standards for School Mathematics.* Reston, Va: NCTM.

Noddings, N. 1984. *Caring: A Feminine Approach to Ethics and Moral Education.* Berkeley, Calif: University of California Press.

Norton, L S, T Owens and L Clark. 2004. "Analysing Metalearning in First-Year Undergraduates Through Their Reflective Discussions and Writing." *Innovations in Education and Teaching International* 41, no 4 (November): 423–41.

Romano, R M. 2000. *Forging an Educative Community: The Wisdom of Love, the Power of Understanding, and the Terror of It All.* New York: Lang.

Schoenfeld, A H. 1987. "What's All the Fuss About Metacognition?" In *Cognitive Science and Mathematics Education,* ed A H Schoenfeld, 189–215. Hillsdale, NJ: Lawrence Erlbaum Associates.

Simon, M A. 1995. "Reconstructing Mathematics Pedagogy from a Constructivist Perspective." *Journal for Research in Mathematics Education* 26, no 2 (March): 114–45.

Tomlinson, C A. 1999. *The Differentiated Classroom: Responding to the Needs of All Learners.* Alexandria, Va: Association for Supervision and Curriculum Development.

Van Manen, M. 1986. *The Tone of Teaching.* Richmond Hill, Ont: Scholastic.

Verkaik, M, and B Ritsema. 2006. "Professional Development as a Catalyst for Classroom Change." In *Teachers Engaged in Research: Inquiry into Mathematics Classrooms, Grades 9–12,* ed L R Van Zoest, 253–71. Greenwich, Conn : IAP.

Ward, C D. 2001. "Under Construction: On Becoming a Constructivist in View of the Standards." *Mathematics Teacher* 94, no 2 (February): 94–96.

P Janelle McFeetors is a high school mathematics teacher in Winnipeg, Manitoba. She has taught pure, applied and consumer mathematics courses. Her research interests are in the area of success for all students, encouraging students to think about their learning, students' identity in math class and their beliefs about the nature of mathematics, and mathematical communication. She is currently co-conducting a longitudinal research project inquiring into students' choices of high school math and science courses, and the strategies they use to succeed in those courses.