Lessons learned from research

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My research focuses on the complex task of teaching mathematics and assessing mathematics learning. This research also intersects with the development, understanding, and implementation of mathematics curricula and with research on teacher learning. In the following I will make some assertions based on my research followed by a brief discussion of each assertion.

The Ontario mathematics curriculum reflects current thinking and research in mathematics education.

The Ontario mathematics curriculum reflects current thinking in mathematics education. I have headed the research teams that have provided the Ontario Ministry of Education with a background research report for the curriculum review resulting in the 2005 mathematics curriculum and have just finished a report to review the curriculum for the upcoming mathematics curriculum review (Suurtamm & Vézina, 2003; Suurtamm & Koch, 2013). In both cases, the results of the review demonstrate that the Ontario curriculum represents current thinking in mathematics education and is well aligned with mathematics curricula from other jurisdictions, including those jurisdictions that are considered high performing in international assessments. The curriculum follows other curricula by providing a balance between problem solving approaches and the integration of mathematical skill development.

In terms of current trends in curriculum development, there is a great deal of research focused on learning progressions. Learning progressions help to describe the possible paths that student learning can take and the types of connections that can be made between different mathematical concepts. Learning progressions are hypotheses, ideally supported by empirical research, about the stages of thinking, knowledge, or skills that students are likely to go through as they develop an understanding of mathematical ideas. They are also context sensitive. In other words, a learning progression developed with evidence of student learning in one setting cannot necessarily be applied in another setting. Current work in curriculum development warrants an examination of the research on learning progressions and this is a potential consideration when moving forward with curriculum reviews and revisions.

The teacher plays the critical role in enhancing student learning.

Much of my research focuses on the complex process that teachers undertake to develop students' mathematical thinking. Current thinking and research in mathematics education promote classrooms where students investigate, represent, and connect mathematical ideas and develop mathematical procedures within the context of problem posing and problem solving (NCTM, 2000). In such classrooms students develop fluency with mathematics that moves beyond viewing mathematics merely as a set of rules and procedures. Rather they see it as a set of connected ideas and procedures that they use to reason, argue, and engage in mathematical sense making. The emphasis is on developing conceptual understanding along with procedural fluency.

The role of the teacher is the critical element in the development of learners' mathematical understanding (Ball & Bass, 2002; Boaler, 2002). As students learn mathematics, both students and teachers are engaged in using and doing mathematics. They are representing ideas, developing and using definitions, interpreting and introducing notation, determining whether a solution is valid, and recognizing and consolidating patterns. Teachers provide stimulating problems to students that challenge their mathematical understanding and help them develop new understandings. They help students see the connections between mathematical ideas and provide students with the tools to develop representations of their ideas and the ideas of others

However, while we know a great deal about what good teaching looks like, there is no precise recipe that can be applied to all situations. The most important tasks that teachers have before them involve purposeful questioning, attentive listening, and responding in ways that elicit and extend student thinking and mathematical understanding. These are complex tasks that do not necessarily have a script as questions and responses depend on the interaction with the student and seeing the ways in which the students understand the mathematical ideas.

Teachers' "mathematics knowledge for teaching" requires support

While teaching mathematics can be seen as enhancing students' mathematical power, it may pose challenges for teachers. The posing of problems, the facilitation of discussion, and the consolidation of mathematical concepts and processes are teacher practices that require a great deal of knowledge and attention. In many cases, teachers, themselves, have not learned mathematics in this way, nor have they had opportunities to develop their own mathematical understanding and procedural fluency. In our research with over 400 prospective primary and junior teachers in a summer math program (Graves & Suurtamm, 2009; Suurtamm & Graves, 2006), our analysis of their mathematics narratives provides evidence that beginning teachers do not necessarily see themselves as "math people". They often feel anxious about the prospect of teaching mathematics. Further, their narratives often describe the practices of a particular teacher who was seen as causing this mathematical self-doubt and anxiety. These stories thus point to a double-edged sword. On the one hand, they show us that beginning teachers are anxious about teaching mathematics and on the other hand, they show the power that a teacher has in how students view mathematics.

Fortunately, there are many experiences that help teachers to develop positive perspectives and understandings of mathematics. Some studies suggest that once teachers have experienced learning new mathematics through approaches that deepen their understanding, they more easily facilitate and promote student understanding (Makar & Confrey, 2007). We have seen that in our own work with the beginning teachers in the summer math program. The data that we collect at the end of the program suggests that they have developed some new perspectives on mathematics and mathematics teaching and learning, and new mathematical understandings. Data from questionnaires administered after their fall and spring practica show that they have tended to incorporate these ideas in their own beginning teaching and had more confidence in their own approach to math.

In addition, it is possible for teachers to deepen their understanding of mathematics and mathematics teaching through the activity of teaching itself (Hill & Ball, 2004). Research projects with teachers in the field show that supporting teachers as they work on developing new

strategies that attend to students' mathematical thinking helps them develop both new pedagogical and mathematical understandings (Suurtamm & Vézina, 2011; Suurtamm, Koch, & Arden, 2010).

Communities of learning and practice provide student and teacher support.

Communities of learning need to exist on several levels – in the classroom to support student learning, in the school to support teacher learning, and in the district to support teacher leader and administrator learning. Research suggests that when teachers add meaningful collaboration with other teaching colleagues to their actions in their own classroom, teachers demonstrate increased mathematical knowledge and more effective mathematics teaching (Lachance & Confrey, 2003). The Curriculum Implementation in Intermediate Math (CIIM) research project in Ontario demonstrated that collaboration with colleagues was the second most frequent response (after textbooks) reported by teachers as the resource that supported them in learning new ways of teaching mathematics and implementing the curriculum (Suurtamm & Graves, 2007). The data also showed that teachers had few opportunities for such collaboration to occur.

In recent work with teachers examining and enhancing their assessment practices, we used a community of practice approach (Suurtamm & Koch, 2011, under review). The community of practice provided a forum for sustained professional development and dialogue as well as a rich research setting. We were able to identify certain components that facilitated this, such as connections to practice, and a non-evaluative stance. We tend to use the phrase "inquiry as stance" (Cochran-Smith & Lytle, 2009) to place value on the work that teachers do as they inquire into their own practice. This inquiry is ideally in collaboration with other teachers and oftentimes, alongside researchers, coaches, or other supportive individuals. Ideally, professional development initiatives should support teacher inquiry in the same ways that teacher practices in the classroom support mathematical inquiry. This means engaging teachers in new mathematical tasks and pedagogical practices, providing space for risk-taking in trying out new ideas, and encouraging meaningful discussion among colleagues as they experience new ways of teaching and learning. This, in turn, encourages and supports new pedagogical and mathematical understandings to emerge.

Teachers face a variety of dilemmas as they work on shifting practice.

It is evident in my research that as teachers work on shifting practice, they may face a variety of dilemmas. In a two-year study of the assessment practices and understandings of 42 teachers of mathematics, we found that we were able to use an analytic framework developed by Windschitl (2002) which helped us to parse out, understand, and think about how to assist with dilemmas in shifting assessment practices (Suurtamm & Koch, 2011, under review). The framework talks about four types of dilemmas: conceptual, pedagogical, cultural, and political. We saw conceptual dilemmas in assessment arising as teachers attempt to understand the conceptual underpinnings of current views of assessment and of mathematics teaching and learning. For instance, teachers often are not presented with the rationale for making changes in assessment practice and they question whether the changes will improve student learning. They grapple with such things as the different purposes of assessment, the role of formative assessment, the value of aligning instruction and assessment, or what it means to understand mathematics. Pedagogical dilemmas arise as teachers create and enact new assessment opportunities. These dilemmas are often connected to how to create assessment tasks, strategies, and tools and they may occur as

teachers design mathematics activities, determine ways of recording, or work to find time for meeting with students and providing feedback. Cultural dilemmas focus on changes in classroom and school culture with regard to assessment practice. We also see cultural dilemmas as those that arise within the broader school culture including administrators, parents and other stakeholders. Teachers may face dilemmas when their new assessment practices threaten existing cultural practices within a school or department setting, or challenge parents' notions of assessment. Political dilemmas arise when teachers try to align their thinking and practice with provincial, district and school policies around assessment, particularly with regard to accountability. For instance, teachers may be trying to make sense of a new assessment policy that may conflict with the way they were thinking about assessment.

We found the dilemmas framework useful. It helped to identify dilemmas, to determine how the dilemmas interact, and to examine how teachers are supported in negotiating dilemmas. We recognize that different types of dilemmas need to be supported in different ways. While pedagogical dilemmas may benefit from professional development, cultural dilemmas may require discussions among colleagues, or stronger communication with parents and students. Hence, a multi-faceted approach to supporting new initiatives is critical.

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