▲ Mathematics Improvement Process: A Principal's Perspective

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> *"A broad consensus now exists among researchers and educators on the knowledge and skills children need in mathematics, the experiences that advance the development of mathematical skills and understanding, and the basic components of an effective mathematics program. But for many teachers, both new and experienced, there continues to be a gap between theory and practice. How can current research about teaching and learning mathematics be brought to life in the classroom? What skills and knowledge can best help teachers meet their commitment to help every child become mathematically proficient?"*
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> (Ontario Ministry of Education, 2006, p. v)

Despite the best intentions and hard work by mathematics associations and consultants, wide-spread attention to what we know constitutes good mathematics instruction is not as evident as one would hope. As an elementary school principal, several key moments highlighted this "gap" in practice. The first was two years ago as I started the process of school-wide math improvement in my new assignment. In one of my first meetings with the staff, we undertook a data-analysis activity to determine the direction for our school-improvement plans. It was felt by the staff that we should continue our literacy goal, as we had not yet achieved our targets. We had many literacy data markers to analyze and there was certainly some merit in continuing the goal. What stood out to me, however, was the need to improve mathematics scores; yet the only data source I could find was the current EQAO data.

The staff was by no means resistant, but they had no experience dealing with a math goal. They had always worked on literacy; the Board and Provincial mandate was focused solely on literacy, and all of the previous in-service had been on literacy. At the same time, I had spent a lot of time in classrooms observing excellent teachers conducting math lessons that were not reflective of current practice. I had also consulted my colleagues and asked them about their school goals and how they relate to school improvement. Each one I consulted had a progressive plan for their ongoing improvement and initiatives to improve literacy. When asked about mathematics, most did not have math goals; therefore, the discussion ended abruptly, and others, when I persisted, would list the top three answers such as more "hands-on," problem solving, or manipulatives. The discussion was completely opposite to the well-developed scope of their literacy-improvement efforts.

The same scenario occurred when I was hiring for an open teaching position. When I asked the candidates to describe their literacy program, to a person, the answers were involved, thorough, and included all the parts of a good balanced literacy program—including what an exemplary lesson would include. Similarly, when I asked the candidates to describe their math program, the responses were often tangential and most had no idea where to begin. Frequently the same phrases—"hands-on," problem solving, or manipulatives—were offered as words that needed to be mentioned, but with no specific connection to student achievement. "What is your path through your program?"

This basic depth, breadth, and scope, planning question had no prepared approach. "Describe your mathematics program" remains a difficult question for teachers to articulate because the work on numeracy has been so compartmentalized.

Finding a Place to Start

In order to make change pervasive in a school, it seems that changing the culture is a critical factor. Staff and students have to realize that mathematics instruction is important and has to be a part of what makes the school successful. All schools have some area that they are known for, whether it is literacy, sports, music, or safe schools. My job was to connect mathematics to this existing culture and market the new focus of Literacy, Numeracy, and Technology. This triumvirate became the

driving force at staff meetings, parent nights, newsletters, and school council meetings. Because the Board and Ministry were continuing to move forward the literacy agenda, mathematics became the school's domain, and technology would be a means to support teachers and engage students in math curriculum instruction. In short, I needed some math champions.

Creating the Role of the Math Coach/Champion – Numeracy Prep Time

In schools in Ontario, there are numerous strategies to cover preparation time. In most contracts, preparation time for staff has to be covered by another teacher in the school or a teacher who is designated as a "prep teacher." Often these teachers delivering preparation time would provide "coverage" in areas of the curriculum that can be easily separated and reported on, such as drama, media, or technology. Instead of this compartmentalization, in our timetable, I created a "Numeracy Prep" teacher. These teachers were instrumental in building the new culture and they would become the champions of math curriculum and instruction. The vision for these teachers was for each to be a math coach for students in numeration. Their mandate was to build primary students' number sense through a focus on the mathematical processes. There was no fragmentation of the math curriculum because the numeracy teachers would reinforce the number concepts connected to whatever strand the classroom teacher was instructing—for example, connecting place value to linear measurement.

The first step was to support these teachers to be able to provide high-quality support for students. There was willingness by these teachers to extend their knowledge in mathematics education. They attended summer institutes, Board/Ministry sessions on effectiveness guides, and PRIME (Small, 2005) training. As well, they became involved in Board writing and coaching teams wherever possible. I was able to gain release time for these teachers to spend time early in the school year with our Board coaches and consultants in order to outline their plans for the year, to review resources, and analyze their early data collection. With this training, the numeracy prep teachers were able to plan a course of study that supported students in strengthening primary number concepts as they were applied to what was happening in the regular classroom, for example, skip counting by five and telling time, linear patterning and early proportional reasoning, money, and perimeter and operation meanings.

The regular classroom teachers became completely supportive of the initiative when they saw the benefits of the programming. Many primary math teachers believe that there is too much to cover in the number strand and little time to provide students with the constant reinforcement with new number concepts they need. As well, they have little time to provide the differentiation that would support the needs of all of their students. All of these challenges became part of the numeracy prep teachers' instruction. With this ongoing support, the classroom teacher could continue to focus on the big ideas in the mathematics curriculum without spending all their time on review and practice of number and operational skills. Regular class teachers could concentrate on providing three-part problem-solving-based lessons that exposed the big ideas in the curriculum.

Mathematics Professional Learning Communities – PLCs

The classroom teachers were becoming interested in the mathematics movement in the school and decided to meet as a primary team to discuss math growth in the school, review professional articles, and learn about new approaches. As the team and expertise evolved, we began to delve deeper. Concepts such as regrouping, skip counting, composing/decomposing of numbers, or the difference between the quotative and partitive interpretations of division are both sophisticated and challenging mathematically (Ma, 1999), and teachers benefited from collegial discussions about them.

Being careful not to overlook the importance of all the strands, we started our primary team PLC sessions with patterning and, in particular, the connection between assessment and instruction. Often in mathematics, we just teach a concept or topic without comprehending what constitutes understanding. In mathematics, we have them "do" or "finish" the question. If it is correct, the student understands; if it is not, we reteach. When planning for a math lesson, the team was challenged to focus on the intention of the lesson(s) and the evidence instead of merely "covering" a topic.

When we are concerned with what constitutes evidence of understanding, instruction and assessment are connected (Figure 1). As we built our background knowledge through reading, in-service, talking, and experience, we were able to identify and categorize the indicators of understanding and use them to better teach, assess, and differentiate instruction.

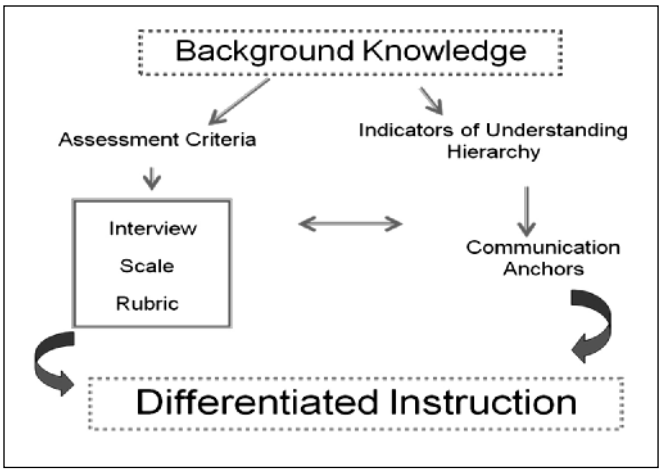

Figure 1: Indicators of Understanding/Assessment Criteria

We became better able to recognize understanding when we saw it or realized what questions still needed to be asked. We focused on building communication anchors and exemplars and through examining learning trajectories, building open and parallel questions to differentiate instruction. For example, one way to describe development in primary students' development of sorting concept is as follows:

- Sorting using a single attribute
- Inferring a sorting rule based on a single attribute
- Sorting and inferring a sorting rule, using more than one attribute when the attributes are related
- Sorting and inferring a sorting rule, using independent attributes (Small, PRIME 2005)

Working with this continuum, we provided learning situations that moved students along the sorting continuum, constantly moving toward a more sophisticated indicator.

Instrumental in these sessions were the use of resource materials such as the *Guides to Effective Instruction in Mathematics* (Ontario Ministry of Education, 2006), *PRIME Phases and Indicator Maps* (Small, 2005), and *Making Math Meaningful* (Small, 2009).

The capacity building resulting from these PLCs was instrumental in broadening the teachers' and students' comprehension of big ideas in elementary mathematics. The original math improvement team has now multiplied from two prep teachers and the principal to the whole primary team. As Ministry release time was introduced for various improvement cycles, we were ready to formalize the learning process with our primary team and prepare for phase two with the junior and intermediate teachers. Teacher collaboration was becoming more evident as a result of the growing commitment toward a goal and the connection with the Ministry's improvement models.

Role of Technology

Another important factor in improving math education and in enhancing collaboration was the introduction of technology to all classes in the school, beginning with the Primary division. Paired with the acquisition of more manipulatives, interactive whiteboards were purchased to give teachers access to instant manipulation of data, questions, graphics and models for students to consider. The greatest immediate effect was the enthusiasm to learn and discover new concepts that the technology delivered. With the help of the math champions and our technology leaders, interactive whiteboard sessions were being offered at lunch hour and after school on a drop-in and invitational basis.

It is crucial that the technology is introduced strategically in coordination with a mathematics goal. Instead of the orientation workshops being "how to use" or "which button to press," the technology was introduced as part of the three-part lesson structure, complete with virtual manipulatives, lesson construction, and problem modelling. The in-service allowed us to build upon the PLCs to promote conceptual reasoning and translate theory into practice. As well, we could model digital data walls and post them on our school conference so that teachers could participate immediately. Lessons, activities, models, and applets were posted to our intranet. The enthusiasm was infectious and it created a positive momentum for informal sharing among the staff.

As a second phase and to sustain the momentum, overhead document cameras, affectionately known as ELMOs (Electricity Light Machine Organization), were purchased to help with immediate sharing of solutions and models, both from students and teachers. Teachers and students could display printed material or handwritten items in colour for the whole class to see on the screen. As well, a textbook, graphing calculator, or resource guide could be placed under the camera. Students shared their mathematical ideas on the document camera to justify and defend their thinking. Some of the standard lines in the classroom that have come out of this implementation are: "ELMO will like that one," "ELMO needs to see that one," "Can you justify that with ELMO?" Students are constantly asking if their model or solution can be shared on ELMO. Teacher questioning shifted to focus on mathematical processes,

including connecting, reflecting, reasoning, and communicating, when explaining strategies or answers. The student models and solutions could be saved and downloaded to create an instant "bansho" (a method of organizing and displaying students' work that is connected to each other conceptually and highlighting the common ideas). Student engagement was also fostered when using technology. The document camera often eased the reluctance of students to share responses.

Lastly, to reinforce the importance of doing mathematics at home, largely the domain of literacy, school-wide licences were purchased for each student for an online math program. This online system enables students to reinforce hundreds of Ontario curriculum math topics. There is also a real-time competitive section where students can compete against students from all over the world. Classes and students are ranked in the world and Canada. Most importantly for us, mathematics became a focus for the whole school beyond the classroom. The energy and competition are engaging and add to the positive culture of mathematics, but also connects parents to the school's initiative.

Conclusion, Reflection, and Next Steps

What is reassuring and motivating is the notion that when you focus and set targets toward a goal, change will occur. Measurable increases in all data sets were realized through the PLC process. Students' flexibility with numbers has improved dramatically on all markers. After the first year of implementation, teachers were quick to credit the numeracy prep teachers for the massive gains in EQAO scores in Primary mathematics. The school went from 57% Levels 3 and 4 to a staggering 91% over the course of the year. Further analysis did not suggest that the cohort significantly affected the high score; however, the pressure was firmly in place for the following year. Again in the second year of implementation, all data markers validated that growth had continued across the division, as progressive teaching methods and use of technology were refined. In the second year, EQAO percentage was sustained at 87%, and improvements were also noted in literacy.

In summary, we were attempting to mimic the literacy movement and create common messaging and pedagogical strategies that became part of the regular routine at the school, instead of an event that ended following the PLC. The new curricular culture had its roots and needed to be constantly nurtured. Hiring practices also had to be considered as a key factor in continuing the improvement. Any time teaching positions became open, numeracy background became part of the advertised skill set and played an important role in the interview.

Change, no matter how positive, doesn't come without its problems. The corollary for us was also true; what you don't focus on suffers. In the second year of implementation, our Grade 6 mathematics scores dropped significantly. Instead of making excuses or questioning our practice, we knew it was time to begin the next phase of the mathematics plan formally with our Junior division. This decision came directly from the Junior teachers, as they had seen the work by the Primary team and understood that they were receiving higher-achieving students. Both the pressure and support are in place, and the Junior phase will pick up from the Primary teachers, without the growing pains and stumbling blocks. The resources, technology, and systems are in place, and we are cautiously optimistic that the gains will be translated across the school.

We are now in the third year of implementation and all of this work does not happen at once. There were no course outlines to follow and our team had to develop new approaches to ensure conceptual understanding. The process continues to evolve with more grades and more training. Instilling a culture of mathematics in a school cannot be willed into existence or demanded by the leader. Instead, it is a strategic mission that builds upon small successes and a few champions.

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