Mathematics Professional Development for Elementary Teachers: A Constructivist Model

Katherine Willson and Roberta McKay

Background

The Western Canadian Protocol framework for mathematics focuses on a constructivist approach to teaching and learning mathematics. One particular area of concern for teachers has been the expectation to increase communication processes in the mathematics classroom through student discussions and writing. According to researchers, such as Deborah Schifter (1996), teacher professional development in mathematics needs to change to reflect constructivist principles. Key ideas from constructivist theory include a recognition that students are active learners who come to classrooms with different knowledge, experiences and backgrounds, and that students learn by attaching meaning to what they do; they must be able to construct their own meaning of mathematics. Students need to read, explore, investigate, listen, discuss, explain ideas in their own language and use manipulatives. This helps students create their own links between their informal understandings of mathematics and the formal language and symbolism of mathematics. Similar constructivist principles are needed to inform teacher professional development in mathematics.

As professors in the Department of Elementary Education at the University of Alberta, we teach in the areas of language arts and mathematics. With funding from Imperial Oil National Centre for Mathematics, Science and Technology Education (IONCMASTE) and Edmonton Catholic Schools, we initiated a long-term professional development project in mathematics. We wanted teachers, district consultants and ourselves to collaboratively construct meanings about the teaching and learning of elementary school mathematics. We also wanted a professional development project that would demonstrate constructivist teaching and learning principles. A key focus was the role of discussion and writing in the construction of meaning. Not only did we recognize the importance of this in all subject areas, but we believed that a focus on discussion and writing in a mathematics professional development project was particularly important because of the emphasis in the Western Canadian Protocol for mathematics on increasing communication to enhance the learning of mathematics.

The Mathematics Professional Development Project: Year One

We began the project by meeting with the language arts and mathematics consultants from Edmonton Catholic Schools to discuss constructivist professional development. We agreed that the sessions for teachers should be held during the school day to demonstrate the value of teachers' time and the activities in which we would be involved. We planned to meet one half-day per month during the school year. Ten teachers were chosen in consultation with the school district consultants and invited to participate. The mathematics and language arts consultants also participated in the professional development sessions.

The format of our sessions required much thought and a willingness to take risks on our part and on the part of the teachers. We needed to think about what a social constructivist model of professional development in mathematics might look like. This mirrored the teacher's process of considering what the constructivist teaching of mathematics might look like. We knew that we would not be giving inservices or conducting workshops. Although these traditional professional development structures have a purpose, they would not allow us and the teacher to construct meanings about the teaching and learning of mathematics. For this reason, teacher dialogue and journal

writing about experiences teaching mathematics would be the main focus of the professional development sessions. In order to reinforce our own role as learners and group members rather than outside experts, we decided to participate in the dialogue and journal writing as well.

The Professional Development Sessions

Participants were given a journal at the first session, and each session had the following format. Participants reflected and wrote in their journals about the mathematical issues (successes and concerns) that had been a part of their teaching experiences over the past month. A sharing session followed, which led to rich discussion—something that usually does not happen during the typical one-shot inservice model of professional development. The teachers told us that because they met on a regular basis over an extended period of time, a feeling of trust was created among the group members that enabled them to share mathematics stories that normally they would not have shared. During each session, teachers were also given an article from a professional journal to read and discuss. This was originally planned as a back-up activity in case there was a lack of discussion, but the current articles written for a professional audience were excellent for provoking lively discussion. In fact, most of the teachers continued to mention these articles throughout the year. At the beginning of the year, teachers were also given a professional book called *What's Happening in Math Class*? by Deborah Schifter, which addresses current teaching and learning issues in elementary mathematics classrooms. The professional development sessions culminated with teachers writing vignettes about the major issues that had surfaced for them through the discussions, readings and journal writing. Many of the teachers were not confident about their writing and wondered if they had anything to say about teaching mathematics that would be of interest to anyone else. They wrote the vignettes, then read each other's and provided feedback. Through the questions and comments they provided to each other, they realized that they were writing about topics of interest to other teachers. We also provided oral and written feedback throughout several drafts. The teachers expressed many interesting insights about the teaching and learning of mathematics. Writing vignettes was a powerful tool for stimulating mathematical dialogue among teachers and promoting reflection on their own practice.

The Mathematics Professional Development Project: Year Two

As a result of the positive feedback from the teachers and consultants, the project was funded for a second year. The format remained the same, although the process for selecting teachers was slightly different. Five teachers from year one expressed an interest in continuing the project, and they were joined by five new teachers. The professional book provided to the teachers in year two was entitled *Math Is Language Too*, by Phyllis Whitin and David Whitin. The key components for each of the sessions remained the same: professional readings, journal writing, and discussions and reflection about the teaching and learning of mathematics in the classrooms. The year once again culminated with the teachers writing vignettes.

The Vignettes

The following are two vignettes written by participants that illustrate the power of this long-term reflective professional development model. In the first vignette, "Drill-and-Practice to Constructivism: My Math Journey," an experienced teacher reflects on her years of teaching mathematics primarily through drill-and-practice, and her frustrations with the number of students who did not succeed in mathematics. She describes being intimidated by shifting to a constructivist orientation for the new mathematics curriculum. However, students' responses to an activity that had several constructivist elements convinced her to switch to a constructivist approach in teaching and learning mathematics.

Drill-and-Practice to Constructivism: My Math Journey

How did teaching math become so complex? Twenty years ago or so, teaching basic facts required exactly one strategy, one teaching method and one method of evaluation. Drill-and-practice was the norm. Now the teaching of mathematics requires a more inclusive approach—an approach that asks the students to be active participants in constructing their own knowledge. Within this approach, the teacher is no less important in her role as educator. However, the nature of her role has changed. She is now asked to facilitate the learning and she is given many more open-ended ways to achieve this end. This is not an easy road; it is very hard to be a learner. This story is about my journey and the best learning I have done in a very long time.

I have been a teacher for almost 20 years. I began teaching in a special education classroom in an inner-city school. I taught 10 to 12 students in a segregated room who, at that time, were classified as educable mentally handicapped (EMH) students. Teaching math was the biggest challenge. Not only were many of the grade-specific math concepts difficult for most of the students, but the students had difficulties retaining what was taught. We had at least three math groups each day in an attempt to individualize instruction as much as possible. Practice through drill was the means to learning.

After my first seven years, I moved to a school on the south side that also ran the district EMH program, later renamed Educational Experiences 3 (EE3). The curriculum in special education had undergone changes. A living and vocational skills component was added. In math, each student now used an appropriate grade-level textbook and there was a focus on preparing students for real life. A huge addition to the program was involving children in hands-on activities to enhance the drill-and-practice. However, my guess is that many teachers' lessons continued to be teacher-directed.

After three years at that school, I left the special education classroom. Over the next four years, I taught Grades 3, 4 and 4/5. I then moved to my new school, where I have taught a combined Grade 4/5 class for the past two years.

Like most teachers, I taught the mathematics concepts, did the drill-and-practice and tested the students for retention of the material. I used current curriculum, followed the program of studies, taught the mathematics guide page-by-page and corrected the daily assignments promptly. Like many teachers, I felt that students' problems with mathematics had more to do with faults in learning than in teaching. Surely it had nothing to do with my teaching strategies or the curriculum.

After much thought and discussion with colleagues, I decided that the way to help my students who were having difficulties was more drill-and-practice. That had to be the answer. They didn't understand math because they did not have enough practice. So I gave them lots of drill—directed drill, timed drill, drill in groups, drill in workbooks, drill from the board and, most recently, computer-generated drill. After the chapter-end tests, several students still did not do as well as I had expected. What should I do next? What was causing a lack of success for some of the students?

It never occurred to me during these years of my career that the students were not *learning* math; they were simply *doing* math. Math was a school subject taught to them. Concepts were explained, drawn on the board, repeated as necessary and, of course, practised frequently. I planned carefully how to introduce the concepts. I used a clock, a thermometer, play money, metre sticks and rulers, fraction pieces, and bundles of 10s and 100s. I do not know if what I said or what I did ever became meaningful to the students. I do not recall using manipulatives often and, certainly, I do not recall students writing, discussing or asking questions other than "What page number do we do?" That was the way of sound teaching.

As the department of learning and the publishers became more progressive, the content of math programs and math textbooks became more relevant and more interesting to the students. Large, colourful pictures of children doing activities were placed in the math textbook to grab the students' attention and make the concepts more meaningful and relevant. However, students were still not expected to be active participants in their own learning, and some students still did not succeed in math. The pedagogy was starting to change but we were not there yet. Math was still something teachers taught to students.

Three years ago, I was handed a new mathematics curriculum along with new mathematics materials, both with a constructivist focus. It was the program of the '90s and it was scary. The students still had some practice exercises, but oh, how the lessons had changed! Even the look of the teacher's guidebook had changed! The student book was almost unrecognizable. Where were the rows and rows of practice exercises? The students were now expected to do something to generate their own learning. They were asked to explain, question, think about and talk about mathematics during math class. More importantly, the new program offered students ways to relate math learning to their own lives. The teacher would be more of a facilitator of learning rather than a deliverer. Both the students and the teacher had to learn to think in new ways. No longer were there pages of isolated drill-and-practice exercises. The practice was included in a problem-solving context so that the students could apply the learning to their everyday lives.

I recall one lesson that I taught in the spring. I was using the Quest 2000 math program with my Grade 4 class, and I had the students make kites to apply their understanding of perimeter and area. The math unit had begun with several classes that developed ideas of area and perimeter, and then explored the relationship between them. The students were drawing and cutting while questioning, comparing and problem solving. Through these activities, they developed an understanding of how area and perimeter are related.

The culminating lesson---constructing a kite—was wonderful. The students were asked to design the largest kite they could with a one-by-one-metre sheet of white paper. The only condition was that the area had to be larger than the perimeter. What fun that was! All of us were on the floor—measuring, cutting and, perhaps most important, discussing. Mistakes were made and some kites had to be remeasured and redone, but that became a critical part of the learning and our discussion. The students decorated the kites however they chose and we attached string tails and string guides. The best part was trying to fly the kites. They never did fly, but the students learned more about perimeter and area than they would have from 30 drill-and-practice worksheets. Could this really be the way to learn math? Was math really meant to be fun?

This new approach caught me off guard. Until then, I had to plan well for math out of fear that something would happen that I could not control. The students were now more involved in the lessons and added their own ideas, understanding and direction to our math classes. Math class involved more discussion and became less teacher directed. I had no idea at that time how valuable and educationally sound this type of teaching could be. I also had no idea that making a kite could be a form of assessment—a test that allowed everyone to succeed. Now my students loved math, and that became a more meaningful measuring stick of my program than could any number of test scores.

As the year finished and I became more confident with my math program, I realized that, for me, using a constructivist approach was how math should be taught and learned. My Grade 4 class still had an average performance on their formal assessment, but they had discovered that math belonged in their lives and they were confident in their approaches to problem solving. With this type of math instruction, their learning and skills would grow. I discovered that learners must be active in their learning if it is to be meaningful and retained. Students must be allowed to construct their knowledge and then apply it to real-life situations. If those situations happen to be fun, it's a bonus!

I now try hard to plan constructivist strategies into my math lessons, even though I have a combined class in which the expectation to complete two math programs is stressful. Whether they bring in objects to illustrate a concept, read math-related literature or use their bodies to create place-value situations, students are encouraged to be active in their learning. We now discuss and share strategies, construct models, write in math journals, write our own problems to apply our knowledge and do drill-and-practice exercises. Drill-and-practice still has a place in math—just not first place anymore. This has been my math journey and the best learning I have done in a long time.

The second vignette, "Walking the Talk: Lessons Learned About Effective Professional Development," illustrates the experience of a teacher in her new role as a district mathematics consultant. She explains that the most challenging part of her role is helping teachers understand and implement constructivist principles of teaching and learning. She recognizes that, in order to implement constructivist teaching, professional development must model constructivist principles. She highlights four key insights that have influenced her planning of professional development for teachers.

Walking the Talk: Lessons Learned About Effective Professional Development

Many educators are asking why the constructivist movement hasn't had more of an influence on classroom instruction in mathematics. Studies document the gains children can make when we apply constructivist principles in our teaching practices. And yet many teachers still tend to teach mathematics in the way they themselves were taught—memorization and drill—even though they readily admit that they never learned much from this type of instruction.

Helping teachers understand and implement constructivist principles in mathematics instruction is the most challenging part of my position as a mathematics consultant. The back-to-the-basics movement has complicated my task even further. But I have learned a lot over the past year about the type of professional development that promotes change in teachers' attitudes and practices in mathematics instruction.

Walking the talk, or practising what you preach, is more difficult than we think. Some teachers request activities, blackline masters and preplanned lessons to assist them with their mathematics instruction. I understand this in my role as a consultant: lack of time for professional development sometimes tempts me to resort to the one-shot, how-to inservices that may do little to change teaching practices and improve student learning. Simply telling someone how to apply constructivist principles is tantamount to telling a child how to compare fractions—neither lead to true understanding. The structure of professional development must also reflect constructivist principles.

I have come to this conclusion through my experiences with the mathematics professional development group—a collaborative project between our district and the University of Alberta. When I joined the group in its second year, I thought that the teachers had been chosen because of their strength in mathematics instruction. I soon learned that the group had been on a journey of discovery that had profoundly changed how they thought about the teaching and learning of mathematics. I also observed first-hand the constructivist principles being demonstrated throughout the professional development sessions. As the year progressed, I began applying this model of professional development to my work with teachers in schools. Although there is still a lot to be learned, I have highlighted below four of my key insights concerning teacher professional development.

1. Concentrate on the big ideas of mathematics instruction and discover them through real experiences

Too often, teachers only consider the specific outcomes of a program, such as multiplying decimals, recognizing number patterns or using the vocabulary of probability. We are professionally obligated to cover these outcomes over the course of a year and may lose sight of the constructivist principles on which the program is based. Teachers must understand these principles to know how to successfully teach these outcomes.

Discussions in our professional development group focused on principles of constructivist learning. The teachers shared stories of their classroom experiences, which were used to illustrate big ideas about learning rather than show how to teach specific skills.

One teacher shared student posters from a colleague's classroom. The colleague had told the students that aliens had invaded the earth and one of the first changes they wanted to make on the planet was eliminating multiplication. The students were asked to create posters for a campaign to save multiplication from worldwide obliteration. The posters included pictures and ideas, such as multiplication being a more efficient way to add a series of the same number and finding the area of a room. Another poster argued that figuring out the cost of 12 chocolate bars would be more difficult without multiplication. The teacher shared the activity with the professional development group to illustrate how communication in mathematics is not just a way of assessing understanding but also a way of helping students refine their thinking and make sense of mathematics.

Teachers also distinguished between learning *about* problem solving and learning *through* problem solving. Introducing new mathematical concepts in problem solving contexts was modelled and discussed in the professional development group, and applied in all of our sessions. We discussed solutions to real problems that we face in our schools, such as homework issues and the role of the Kumon mathematics program. After being involved in this approach, teachers realized how powerful a model it was and why their students were enthusiastic when solving real-life problems in cooperative groups.

There were many questions about teaching basic facts, such as the multiplication tables. The discussion on teaching basic facts went beyond drill to explore the developing of metacognitive strategies, which help children become proficient in mental mathematics and to see the connection between numbers.

By focusing on these constructivist principles rather than on a mandated document, teachers become resource-free. They use classroom resources as tools rather than instruction books, and they implement programs as intended.

2. Allow for time for reflection

Each session of our professional development group began with time—precious time—for writing in our journals. We wrote about what was happening in our mathematics classes, our successes and our concerns. We could then share what we had written. I often asked myself if everything I had been so busy doing was actually accomplishing something.

Imagine if our children did this as well. Before asking them what they learned that day at school, we could ask them to write down their thoughts and questions about what they had done that day. Instead of just giving the usual reply, "Oh, nothing," children might be surprised at what they had learned.

I am beginning to understand that we don't really learn anything until we reflect on it.

3. Encourage teachers to discuss with, collaborate with and learn from each other

As the year progressed, the professional development group became more comfortable talking about difficult issues and successes. We rarely have the opportunity to collaborate with other teachers in our profession. We are isolated in our classrooms for most of the day and we often spend staff meetings discussing business matters. Even professional development seminars that may capture our attention do not often include time for collaboration.

I learned a lot from my colleagues. We left each session with a new idea or a new question to ponder. Discussions about the tough issues we face gave me

insight into what is on teachers' minds. We were given time to discuss and refine our thoughts, organize our understanding of mathematics and share our wisdom about practice.

When I first started working as a consultant with school staffs, I found that many of them were reluctant to talk. Perhaps the teachers expected to listen to an expert tell them how to teach mathematics, even when many of them had their own expertise. Now, I often begin my workshops by stating an idea or concern raised in our professional development group. After a short pause, teachers start talking—to each other. It is as if they need permission to express their own thoughts about effective mathematics instruction. Teachers who spend all day next door to each other find out that their colleagues have wonderful ideas to share. The Grade 2 teacher finds out that her concerns are not so different from the concerns of the Grade 6 teacher. As they begin to search for solutions together, teachers are eager to discuss math and collaborate to make changes for their students. A knowledge-building community is created within the school.

4. If you value something, give it time

Our professional development group met for a half day, once a month, over the course of a school year. Teachers were released during class time to meet. We truly valued our time together.

This type of ongoing professional development is very effective. We felt more accountable for our journey during the year. Teachers were encouraged to become researchers in their own classrooms, constructing their own understanding of why certain practices were more effective than others. Nothing transforms a teacher more than putting theory into practice and then evaluating the results.

We also took the time to investigate some of the best theory. During each session we read a chapter from our professional reading book or an article from recent National Council of Teachers' of Mathematics (NCTM) journal or another professional publication. Professional reading was valued and time was provided during each session to read an article. It is amazing how one well-chosen article can change how you think about teaching and learning. Reading articles during the session alleviated the pressure to prepare for each session.

I have used many of the great articles that were shared within our professional development group in my work with the schools in our district. Teachers appreciate the time to just sit and read during an in-service. I have also learned to be more patient. Real change takes careful planning and time.

Conclusion

As I reflect on the past year and start making plans for my work with schools in the fall, I am encouraged by what I have learned yet also anxious about some of the challenges I face.

With all the pressures and new initiatives that teachers face, how can I help them find the time for ongoing professional development with needed follow-up and self-reflection? How do I avoid becoming the "guest speaker" at school professional development sessions and instead shift the responsibility for improving mathematics instruction to the classroom teacher? Do teachers who may never have had the opportunity to construct a deeper understanding of mathematics have the confidence and knowledge to guide children in their learning? What can I do to assist teachers in gaining this knowledge? Perhaps some teachers will learn with their students. Finally, I wonder what other professional development experiences will help teachers, parents and students make the paradigm shift that this constructivist movement in mathematics requires?

I am left with many questions that need to be answered. Yet, learning how to "walk the talk" has been a fulfilling journey. I still have much to learn about the constructivist model in mathematics professional development. My experiences this year have given me a direction to follow that can make a difference for teachers and their students. I look forward to the challenges and will be forever grateful for this learning experience.

Concluding Comments

Feedback from teachers about the professional development project was overwhelmingly positive. They stated that reflecting on their practice over time affected their thinking about the teaching and learning of mathematics. They also found the writing of vignettes to be a powerful tool to stimulate mathematical dialogue and promote reflection on their practice.

Vignettes from both years of the project have been compiled into a monograph entitled *Teacher Vignettes: Elementary Teachers Reflect on the Teaching and Learning of Mathematics* (Willson and McKay 2003). Vignettes from the monograph have been shared with graduate and undergraduate students as well as in-service teachers and professional development providers. They are an excellent springboard for discussing the teaching and learning of mathematics. Teachers have told us that they readily identify with the issues that their colleagues have grappled with regarding the implementation of a constructivist philosophy in the teaching and learning of mathematics.

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Katherine Willson and Roberta McKay are professors in the Department of Elementary Education at the University of Alberta. Wilson's expertise is in mathematics education and McKay's expertise is in language arts education. They have worked extensively in teacher education with both preservice and inservice teachers, integrating language arts and mathematics. Their recent work has focused on long-term collaborative professional development with Edmonton Catholic Schools. This year-long project involved analyzing student thinking on mathematical tasks.