Thoughts about Professional Development
from a Mathematics Education Perspective

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Why do professional development? A quick response to this rarely posed question might argue that all professions require life-long learning, and professional development provides a way to formalize that learning. If pushed to be more specific, one might claim that professionals need to acquire a specific body of knowledge that helps them to do their work well, and professional development should help them gain that knowledge and keep it current. In the teaching profession, there is an added layer of expectation since a teacher must know the concepts, skills, procedures, and dispositions that are related to their field, but they must also know how to help someone else learn that knowledge.

Mathematics Education Perspective

In mathematics education, there is a responsibility to help all students learn enough mathematics to enhance their lives and help them achieve their goals. While some students need mathematics to push forward the frontiers of mathematics, most students need mathematics to apply it to some other endeavor. The responsibility to help all students understand and be able to use mathematics is assigned to teachers, and they must rely on the knowledge they have gained through their education, life experiences, and professional development. When students do not exhibit the mathematical knowledge that is expected, teachers try to improve student learning by improving the curriculum and students’ opportunities to learn. The teacher is key to both areas of
improvement, because teachers must interpret the curricula and create effective learning experiences for all of their students. We hold teachers responsible for this work, but often send mixed messages about how we define this work. Are we asking teachers to raise scores on tests of skills and isolated procedures, or are we asking teachers to help students acquire the ability to reason and apply mathematical knowledge? Are we asking teachers to work with the most promising students, or to provide high quality instruction for all students? Do we expect teachers to work as a lone practitioner or be part of a faculty, school, and community? It is reasonable to say that we expect all of this from teachers, but our actions, incentives, and support may favor specific goals, implicitly excluding others. Professional developers are caught in the same quagmire. Are we doing professional development to prepare teachers for a specific, measurable goal (e.g. improve students’ mathematical test scores) or are we investing in the long-term goal of professional development that prepares teachers to tackle broad goals (e.g., help all students acquire the mathematics that will enrich their lives)? Arguably, specific goals can be important stepping stones for broader goals, but they can also be seductive goals that offer false success or even derail efforts toward the main goal. It is critical to be clear about the goals of any specific professional development activity.

Professional development in mathematics education has been heavily influenced by the disappointing student scores on international and national mathematics tests (e.g., TIMSS, PISA, NAEP), large achievement gaps between groups of students (U.S. Department of Education, 2005), high numbers of uncertified mathematics teachers in classrooms (U.S. Department of Education, 2005), reform curricula, and new standards from states and professional organizations such as Principles and Standards for School
Mathematics (NCTM, 2000) and the Mathematical Education of Teachers (CBMS, 2001). The main purposes of professional development for teachers of mathematics is to improve their content knowledge, and to improve their teaching of that content so that their students can learn mathematics. While the first purpose is deceptively simple and the second is so broad that it defies parameters much less definition, the following discussion will describe professional development that wrestles with these goals. I will offer characteristics that research has identified as important to the success of professional development and analyze models from professional development in mathematics education.

Characteristics of Professional Development

Focuses on Student Learning

Good professional development focuses on student learning (Franke, Carpenter, Levi, and Fennema, 2001; Hiebert, Gallimore, and Stigler, 2002; Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003; Stein, Smith, and Silver, 1999). It is tempting to focus professional development on teaching, but several studies provide evidence that focusing on student learning is more successful. Helping teachers to recognize and analyze student learning provides teachers with valuable information on which to base teaching decisions. There is a rich literature base on student learning in mathematics that can not only inform teachers about student learning, but also offer informative student tasks and models of student learning of specific mathematical topics. An example of professional development that was centered on student learning is the Cognitively Guided Instruction (CGI) project working with elementary teachers (Franke et al., 2001). They worked to establish generative learning in teachers so that teachers would move beyond the ideas
about student learning presented in the professional development project and begin to build ideas about their own students’ learning. Successful teachers were empowered to teach mathematics by connecting and reorganizing the mathematical structures of their students. The CGI researchers noted a role that teachers must play in focusing on student learning:

From these observations we speculate that organized knowledge about children's mathematical thinking is not enough to engage teachers in generative change. Rather, for change to be generative, teachers need to develop a view that the knowledge of children’s mathematical thinking is their own to create, adapt, and investigate. (p. 683)

Incorporating student learning into professional development can take many different forms, but it needs to play a major role in the design and goals of any professional development for practicing teachers.

Focus on Content

Good professional development focuses on content knowledge (Garet, Porter, Desimone, Birman, and Yoon, 2001; Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003; Stein, Smith, and Silver, 1999). It is frequently argued that teachers need to understand the content that they are teaching (CBMS, 2001), but it is not always clear the nature of that content knowledge. There is a mathematical knowledge for teaching that includes not only being able to do mathematics but also knowing mathematics in a way that you are able to assist someone else to do mathematics. This knowledge is distinct from pedagogical knowledge or pedagogical content knowledge (Shulman, 1986) that allows a teacher to use appropriate pedagogies to teach mathematics. Mathematical knowledge for teaching is a deep understanding of the mathematics that is to be taught. In order to understand the construct of mathematical knowledge for teaching, consider the daily
activities of a mathematics teacher. Teaching mathematics includes asking good questions, probing student understanding, offering examples and counterexamples, providing multiple representations of mathematical ideas (e.g. graphs, tables, formulas), connecting ideas, defining terms and conventions, and stimulating student interest.

Mathematical knowledge for teaching is what is necessary in order to meet these responsibilities. Engineers, accountants, physicists, architects, or research mathematicians use mathematics in different ways and require different types of understanding. Teachers require a special type of understanding. Teachers must be able to look at a mathematical idea from a variety of perspectives and be flexible enough in their thinking to understand their students’ thinking. Professional development that can help teachers to acquire this deep understanding of mathematics has been successful in improving students mathematics achievement (Hill & Ball, 2004). One popular way to address content knowledge is through study of a particular curriculum that teachers are using or planning to adopt. By structuring professional development around curriculum, the content emphasis is relevant to a teacher’s practice and can provide the glue that connects school expectations, student learning and content knowledge.

Incorporates Teacher Knowledge

Good professional development incorporates teacher knowledge (Hiebert, Gallimore, and Stigler, 2002; Little, 1993; Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003; Stein, Smith, and Silver, 1999). Experienced teachers have extensive knowledge about students, teaching strategies, and school culture and expectations that is extremely valuable in teaching mathematics. Researchers explain that craft knowledge has a “correctness and contextualized richness” (Hiebert, Gallimore, & Stigler, 2002, p. 3) that
needs to be integrated into professional development. Professional development needs to not only recognize teachers’ knowledge but also use it as a valuable component of the design. In a series of interviews, high school teachers claimed that although they learned mathematics at the university, they learned the mathematics and teaching strategies they needed for teaching from their practice and from their colleagues (Wilson, Cooney, and Stinson, 2005). There are enormous advantages of building on teacher expertise and connecting to teacher wisdom about students, teaching, and school norms, but there is also the obvious danger of promoting the status quo and allowing current practice to interfere with adopting new ideas. Teachers filter information about new ways of teaching through their practice, and rarely rely on research for ideas to improve their practice. Professional development that bridges the gap between research and practice must build on teacher knowledge.

Embedded in the Work of Teaching

Good professional development is embedded in the work of teaching (Garet, Porter, Desimone, Birman, and Yoon, 2001; Hiebert, Gallimore, and Stigler, 2002; Little, 1993; Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003; Putnam and Borko, 2000; Stein, Smith, and Silver, 1999). Practicing teachers are learning while they are working and students studying to be teachers are focused on being prepared to succeed in the work of teaching. Professional development that uses teachers’ work to build knowledge of students, content, curricula, and teaching is both motivating and relevant. A corollary suggests that professional developers need to be immersed in schools and understand the work of teachers. Although professional development that is school-based has many advantages, using teachers’ work can be done outside of schools. Studying student work,
planning lessons, adapting curricula, creating student assessments, observing and
discussing lessons are all examples of learning through the work of teaching. Embedding
professional development in the work of teaching requires developers to not only
understand the work of teachers but to understand the contexts of their work. Pressures
to adopt reform curricula and standards are part of the everyday life of mathematics
teachers, and the increased emphases on accountability are straining school systems as
well as individual teachers. These realities do not need to be treated as barriers but they
need to be recognized and utilized in professional development. For example, planning
for new curricula or better assessment can serve as an ideal context for focusing on
content knowledge and student learning. Garet et al. (2001) argue for professional
development that is a “coherent part of a wider set of opportunities for teacher learning
and development” (p. 927). They explain that a coherent approach connects with
teachers’ goals and activities, aligns with state and district standards and assessment, and
encourages communication among teachers attempting similar reform efforts. We know
that students learn well when they are involved in the learning process and are active
learners. The same is true for teachers. When they learn within the context of their work,
they are able to be active learners who are learning and accomplishing their work.
Researchers have found that active learning by teachers is an important variable in what
teachers consider good professional development (Garet et al., 2001).

Employs Collaboration

Good professional development employs collaboration (Franke, Carpenter, Levi, and
Fennema, 2001; Garet, Porter, Desimone, Birman, and Yoon, 2001; Hiebert, Gallimore,
and Stigler, 2002; Stein, Smith, and Silver, 1999). Stein et al. (1999) explain that
teachers learn individually and as part of a group and argue that good professional
development both transforms individual teachers and encourages development of a
school culture within which they can grow. Collaborative structures need to be
developed within the school, but also structures need to built that connect teachers and
collaborators outside of school. Professional development can nurture collaborations
among university, community, and school participants with diverse expertise. For
example, university researchers, mathematicians, mathematics teachers, and industry
representatives all bring a specific expertise to the discussion of preparing proficient
mathematics students. Collaborations within a school are important because they allow
new ideas to be discussed daily and can be focused around shared work. There have been
numerous efforts to build and study communities of practice within schools. Although
they differ in purpose, structure, and effectiveness, organizers universally report the
difficulty in establishing a learning community. Despite the difficulty, there is a widely
held belief that communities offer an opportunity for teachers to share their ideas and to
make their practice public. Franke et al (2001) specifically studied collaboration fostered
by the CGI project. They offer a rationale for collaboration as well as a caution:

Professional development that encourages teachers to listen to their
students and to learn from them requires opportunities for the inquiry to be
fostered. Teachers need time to develop relationships with others that they
can talk with in ways that meet their needs and push their thinking.
However, our data suggest that institutionalizing collaborative work or
mandating practical inquiry will not work. (p. 685)

Professional development needs to foster collaborations that are organized around a
shared vision or shared work, developed over time and accommodate induction of new
members.
Long-term Endeavor

Good professional development is a long-term endeavor (Garet, Porter, Desimone, Birman, and Yoon, 2001; Hiebert, Gallimore, and Stigler, 2002; Stein, Smith, and Silver, 1999). After studying the list of characteristics of good professional development, it is easy to see that planning and implementing professional development requires time. Learning is hard and it takes time. The goal of professional development is to improve content knowledge and to improve teaching. Concepts that are learned are not easily or quickly transferred into practice. Professional developers who incorporate teachers’ knowledge and take seriously the call to embed their projects in the work of teachers, have learned that such efforts are long-term endeavors. In a study of mathematics and science professional development projects supported by the federal government, Garet et al. (2001) found that duration of professional development was influential in the success that teachers reported when asked about implementing ideas in their practice. The duration was defined by both the number of hours and the period of involvement.

Models of Professional Development

The following models of professional development in mathematics education are not offered as examples to follow or emulate. Some are still being assessed and all had specific components that were successful and components that were not. They are offered as examples of various attempts to implement the characteristics that were sketched in the discussion above.

Japanese Lesson Study

Japanese lesson study is a collaborative, school-based professional development that is common in elementary schools in Japan (Fernandez and Yoshida, 2004), and is
gaining popularity in the U.S. Teachers jointly plan a lesson. A teacher in the group teaches the lesson and then the group critiques the content and student learning within the lesson. This example illustrates many of the characteristics of good professional development. The process focuses on student learning and content. It clearly takes advantage of teacher knowledge and is embedded in teacher work. Participating in this learning experience requires training and there is a formal protocol for the critiquing procedure. Becoming proficient in this process requires time and the actual study of a lesson is a substantial investment of time, but it is considered to be very effective professional development in Japan. Many professional development efforts in mathematics are adapting this process to promote teacher learning in the U.S. It remains to be seen whether US adaptations can maintain the essence of the procedure that integrates so many characteristics of good professional development.

Partnerships in Reform in Mathematics Education (PRIME)

The PRIME project was designed to be a partnership in professional development for student teachers (ST) preparing to be high school mathematics teachers, practicing teachers who served as mentors (MT), and university teachers and researchers who were teaching courses for the student teachers (UT). Each participating school had at least three student teachers, at least three mentor teachers, and one university teacher. Each student teacher worked with at least one mentor teacher and was encouraged to work with all of the mentor teachers at the school as well as other student teachers. The university teacher visited the school at least once a week and worked with both student teachers and mentor teachers, visiting classes, discussing lessons and communicating through e-mail between visits. The group, consisting of student teachers, mentors, and the university
teacher, was referred to as a cluster and the cluster was asked to meet weekly to discuss mathematics. The contents of the cluster meetings varied according to events in the mathematics classes and the leadership of the university teacher. The project has been part of the program for preparing secondary mathematics teachers at the University of Georgia for 8 years. We began with six schools in 1998 and grew to 13 schools in 2006 when we had 51 student teachers, 54 mentors, and 14 university teachers. The program took advantage of the field experiences for the student teachers to create opportunities for mentor teachers to discuss their practice with protégés, colleagues, and university teachers, and for university teachers to be immersed in the work of a mathematics faculty within a high school. In addition to the cluster meetings, the university teachers met in a weekly university seminar to discuss what they were seeing, learning, and doing in the schools. Despite encouragement to work as a group, traditional mentor/student teacher pairings formed, and were productive in creating conversations about mathematics teaching that were difficult to initiate in cluster meetings.

This professional development was designed to focus on mathematics and student learning of mathematics. The degree to which mathematics and student learning were discussed varied greatly among clusters. There were many opportunities to discuss mathematics and student learning, but they were often sabotaged by urgent managerial issues, time constraints, lack of leadership at the meeting, or a reticence to share personal knowledge. The professional development was built on teacher knowledge and was embedded not only in the work of teaching but also the culture of the school. Collaboration was encouraged through the cluster meetings and the assignment of a group of students to work with a group of mentors. A stated goal of the project was to
create professional learning communities at each school, but only a few schools moved toward this goal. It was very difficult to create a community at a school. Even though some schools had participated for several years, the student teachers always changed, some mentors changed, and some university teachers changed. As members of the clusters changed, the group goals, work, and ways of relating changed making the formation of a learning community very difficult. Cluster meetings were often fruitful, but they were perceived as requirements of the university rather than collegial communities. Participation in PRIME has required many hours of commitment and has been sustained for 8 years, but the time and strategies have not been sufficient to establish learning communities at each school. It is important to note that in schools where there were daily and weekly time periods devoted to discussion of student learning and mathematics, the community building was more advanced.

Center for Proficiency in Teaching Mathematics (CPTM) Summer Institutes

CPTM is part of the NSF initiative to develop centers to improve the learning and teaching of science, technology, engineering, and mathematics (STEM). CPTM is a collaborative effort at the University of Georgia and University of Michigan seeking to improve the preparation of those who prepare teachers of mathematics. As educators, we have not given enough attention to thinking about the needs of those who are designing and implementing professional development for teachers. Typically, they have been prepared in their STEM field with little support in interpreting and implementing the characteristics of good professional development. Those preparing mathematics teachers include mathematicians, mathematics educators, school district personnel, and teachers themselves. They may have excellent preparation in mathematics, but have not had the
opportunity to think about mathematical knowledge for teaching. They have very few
opportunities to immerse themselves in the culture of a school, or study student learning
or teacher knowledge. The goal of our center is to investigate ways to provide good
professional development for professional developers.

The following is a brief description of two summer institutes and how they tried
to incorporate characteristics of good professional development. In the summer of 2003,
23 middle school teachers accepted an invitation to take a course, Geometry for Middle
School Teachers, taught by Dr. James Wilson, a mathematics education professor.
Eleven mathematicians were invited to observe and discuss the teaching and learning that
occurred in the Geometry course. The institute lasted for 5 full days with the teacher
course extending beyond the institute. Each morning the middle school teachers and
mathematicians participated in the Geometry course. They worked at tables with laptop
computers using dynamic geometry software. Most tables had 2 mathematicians and 4
teachers. At lunchtime, teachers and mathematicians ate together. In the afternoon, the
teachers continued their course and the mathematicians met together to discuss the
morning activities. The mathematicians’ discussions were focused on student learning
and the teaching as well as the mathematics that had been taught. Each afternoon session
included an introduction to the mathematical topics and problems that would be taught
the next day. Time was also provided for mathematicians to write e-mail messages to the
middle school teachers related to the day’s events. After the middle school teachers left
for the day, the mathematicians had an opportunity to talk with Dr. Wilson about his
teaching and his goals. The participating mathematicians were asked to think about the
implications of what they had seen for teaching in their own classes. The professional
development was clearly focused on mathematics and on students’ (middle school teachers) learning. By sitting at the tables with the teachers and learning to use the software with the teachers, the mathematicians had an opportunity to learn about the middle school teachers’ knowledge. However, it was very tempting to try to tutor the teachers at the table rather than trying to understand the teachers’ thinking. This was discussed during the afternoon sessions and there was a shift to focusing on student learning toward the middle of the week after a set of presentations, by the middle school teachers, that impressed the mathematicians. They became more focused on the mathematical knowledge that the teachers exhibited and how they could apply teacher knowledge to their own teaching. The group at each table began to collaborate more on the work and the expectation that the mathematicians would lead the way diminished. The mathematicians were very impressed with the instruction and were able to identify particular features such as when the instructor was leading the students and when the students were expected to investigate ideas on their own. They were impressed by the effectiveness of student exploration and the transitions between topics. In general, they left the institute with a better conception of what teachers knew and how they learned.

The second institute was held at the University of Michigan in 2004 and also used the laboratory format. At the second institute, participants viewed an instructor teaching undergraduate students preparing to be elementary teachers. This institute was much more elaborate and involved 61 participants who taught mathematics to teachers. The group included mathematicians, mathematics educators, and school district coordinators of mathematics. Each morning, participants sat on risers surrounding a U-shaped table with 12 university students. Dr. Deborah Ball instructed the group on fractions for about
2 hours with a brief break. Before each lesson, the participants talked with Dr. Ball and discussed the intent of the lesson and points to think about. After each lesson was completed and the students had left, the participants could study student notebooks, discuss what they had seen, and write comments or questions to the institute organizers. Part of the afternoon was dedicated to small group sessions where participants took mini-course on topics such as curriculum, assessment, and textbooks. Toward the end of the one-week institute, all the participants met as a full group to discuss the student learning and debate approaches to teaching the mathematics. In the evening small groups met to discuss the day’s work and to provide suggestions for the instruction. The institute design allowed for extensive interaction among participants and with the instructor of the course. Several participants helped to design the final assessment. The participants were focused on student learning and mathematics. They were active participants in thinking about what happened each day and planning for the next day. Because of the intense nature of the institute, the demanding schedule, and the shared interest, there was a common bond among the participants. They came with different goals and left with a variety of intentions, but they seemed to value the shared expertise that permeated the group. Simple mathematical ideas were pulled apart and their complexity exposed along with the learning difficulties of the students. The participants recognized the value of the diverse knowledge that was shared among the group. For example, mathematicians had formal, elegant definitions of rational numbers but they were not able to get the group to agree on a definition of fraction for 4th graders. Popular definitions and representations promoted by textbooks and used in teaching were found lacking on both mathematical and pedagogical grounds. Everyone had something to contribute.
Both institutes exemplify an approach to embedding the professional development in the work of teaching. They both focused on mathematics and student learning. They incorporated the knowledge of the participants, and in varying ways encouraged collaboration. Both institutes were one-week with no formal follow-up or support beyond the friendships that were built. Each institute was an intense week for all involved, but it is not clear whether than can substitute for the sustained duration that has been identified as a characteristic of good professional development. We are currently collecting data to assess the impact of the institute on the practice of the participants.

The models illustrate ways that the characteristics of good professional development could be implemented. The presence of some characteristics enhanced the professional development models, and the lack of some characteristics created problems (e.g. lack of community, lack of time), but the success of the professional development remains unevaluated. It is safe to say that the characteristics are not sufficient to ensure successful professional development, but they can guide the design and help in analyzing the problems. As with good teaching, good professional development is a product of many variables and the interaction among the variables. There is probably an art component in designing effective professional development, but studies suggest features that contribute to successful professional development. We not only need good professional development to improve teaching, we need good research to help us design, evaluate, and conduct effective professional development. This research is only in the beginning stages, and could mature if we make an effort to include research into the design of the professional development.
References


