

# Professional Development

“More is expected of our teaching force now than ever before. Successful efforts to restructure schools for the demands of a knowledge-based economy depend critically on the nation’s teachers.”

INTASC, 1995



# Chapter 5

*“The teacher is the gatekeeper to mathematics for our students. What the teacher knows and believes about mathematics, about teaching mathematics, and about the teaching and learning environment determine what students learn and how they will play out their roles as citizens.”*

MSEB, 1991

Minnesota teachers of mathematics, like teachers everywhere, recognize that the future isn't what it used to be. Though this is not the first time in history that major changes in mathematics education have been called for in response to social, economic, historical, and cultural circumstances, it may be the most complex. Several changes in the workplace, in schools, and in technology are impacting teaching and learning.

### **In the workplace:**

- society has changed from an industrial emphasis to one that emphasizes decision making, the use and transfer of information, and a service economy
- employers and communities expect schools to prepare students with deeper content, more complex thinking processes, and technology-related skills
- new, more complex jobs are constantly evolving; hence today's students will often have jobs that do not yet exist

### **In schools:**

- newly developed mathematics and newly important topics include content that many teachers have never experienced
- educators are finding a broader range of backgrounds among students and families
- research on learning, brain function, instructional practices, and learning styles indicate a need to depart from current practice
- previous modes of assessment no longer measure needed knowledge and skills

### **In technology:**

- inexpensive, hand-held calculators are readily available for performing a variety of computations, from routine to complex
- computers are a crucial part of the workplace and everyday life; they are used to process, store, and transfer massive amounts of information throughout the world with great speed, quickly and accurately performing all elementary and many advanced mathematical procedures

In our world, where everything changes more and more rapidly, all aspects of teachers' professional lives, as well as the learning needs of students, are changing. Among the changes affecting the educational world are the movement toward content and performance standards, systems thinking, and a constructivist approach to teaching. The *standards movement* attempts to define the outputs expected from an educational system, specifying what students should know and be able to do, while leaving the means and inputs to accomplish this up to local professionals. *Systems thinking* moves away from piecemeal change and dabbling around the edges, and looks instead at the educational system as a whole, recognizing that the various components interact and affect one another. (See the section on Systemic Reform in Chapter 7: Making It Happen.) Finally, a *constructivist model* leads to an environment where students actively participate in the building of their mathematical understanding. The challenge for teachers in this model is to facilitate educational experiences that will lead students to learn sound mathematical concepts. (Cognitive

*“The current reform movement requires a fundamental shift in teaching practices, and change is difficult.”*  
ENC, 1997

*“What is needed is professional development that is dramatically different — not just in content, but also in form of delivery and level of commitment... Professional development should be ongoing, intensive, and integral to a teacher’s regular work day.”*  
ENC, 1997

learning theory and constructivist learning approaches are discussed more thoroughly in Chapter 2.)

All of these changes demand that, at all levels, teachers of mathematics:

- understand new mathematical content and applications
- teach critical thinking skills within the discipline of mathematics
- incorporate up-to-date and research-based instructional strategies into their classroom practice
- learn effective ways of addressing diversity issues in the classroom
- develop a range of assessment strategies
- use technology to promote mathematics understanding and job readiness
- become teachers of reading, writing, and communication

Old models of professional development are no longer adequate to effect these changes in teachers’ knowledge and practice. Research on how teachers and institutions change indicates that inservices need to be replaced by more varied forms of continuing professional growth opportunities. These opportunities often must include a qualitatively different and significantly richer understanding of mathematics, giving teachers more insight into the process of learning, and a more sophisticated understanding of mathematics content. Experiences such as these prepare teachers of mathematics to guide their students to construct the big ideas of mathematics (Schifter, 1993).

Change in professional development will require focus and creative thinking by education professionals and the continuing education community. The challenge is to provide ongoing learning experiences for all teachers, from preparation for initial licensure throughout the entire teaching career. Principles for initial preparation are well addressed in *Transforming Teacher Education: A Minnesota Framework for Mathematics and Science* (Simpson and Wallace, undated). Since this *Minnesota K-12 Mathematics Framework* document is directed toward practicing teachers, this chapter will consider principles and issues related to their professional development. It will examine the issues surrounding professional development through the experiences and lives of three hypothetical Minnesota teachers. Let’s meet them.

## LIZ

Liz has taught at the elementary level for twelve years, though her initial preparation occurred more than twenty years ago. She is considered a good teacher in her medium-sized district, which is located in a first-ring suburb. She is energetic, enthusiastic, and ready to work hard to implement programs and instructional materials. Her academic preparation in the area of mathematics is typical of many elementary teachers her age. In high school she took a general mathematics course as her ninth grade requirement. Mathematics teaching was one component of a year-long methods course for elementary teachers; no mathematics content courses were required for students preparing to teach elementary school.

After teaching for two years, Liz spent a number of years at home caring for her young children. Since returning to the classroom, she has taught fourth grade. She is regularly assigned the “top” mathematics group because her colleagues know that she will put in the effort needed to prepare supplementary materials to challenge these students.

Liz believes that teaching mathematics is mastering the procedures and skills of the subject and she assumes that all children can do this, though some can do it more quickly than others. She has

always emphasized speed and accuracy in computational skills. Much of the acceleration she practices with her advanced class involves going faster and farther than the other classes, with supplementary problem-solving experiences to add enrichment.

Liz regularly uses approaches to learning in other subjects which model what we know about how students learn. She provides hands-on, active learning in science, facilitated by the district's adoption of a new kit-based science curriculum and the extensive staff development provided with it. In social studies she encourages students to work on interesting projects in small groups, building new understanding from what they already know. In language arts, she makes sure all students are called on regularly and that all students grasp the core concepts which the district curriculum has specified as the focus for fourth grade. However, it has never occurred to her that these techniques might also be applied to mathematics, which she views as very straightforward and easy to teach. Her previous experience and perception of mathematics limit her practice.

Liz would benefit from an "aha" experience similar to a participant in the Mount Holyoke SummerMath Program for Teachers, who writes: "I hadn't made the connection before today, but many of the science classes I teach begin with an open-ended problem to solve. By experimenting with materials, the group reaches a solution which is later shared with the class. I question why I do this in science and not in mathematics. Is it that I'm aware that science is always changing—[that] new discoveries are continually being made? Have I been teaching mathematics as a stagnant discipline? I suppose I was taught math as a method toward solution to be memorized—facts and algorithms unchanging and coming to us from some unknown deity never to be tampered with!" (Schifter, 1993, p. 168).

Liz teaches in a moderately supportive environment. All the third and fourth grade teachers meet regularly to plan. There is good camaraderie among them, although several colleagues frequently verbalize their discomfort with or dislike of mathematics. Participation in a variety of workshops is encouraged, if not demanded, though there is little participation in professional mathematics organizations or reading of educational journals on mathematical topics. There is little innovation in Liz's school, not because of any organizational deterrent, but because of satisfaction with the status quo. There is an unstated assumption that teachers will get new ideas throughout their professional lives and try some out from time to time. Liz is an eager participant in professional development opportunities. She easily takes hold of new ideas and quickly becomes an enthusiastic promoter of them with her colleagues.

Liz's professional development needs include:

- a deeper *conceptual understanding* of mathematics content
- a broader *range of mathematics content* (especially in areas of shape, space and measurement, and in data and chance)
- connections to the *big ideas* of mathematics both within and outside of mathematics

She will benefit from a Professional Development Plan focused especially on Principles 2 and 3 in the following recommendations.

**MARIA**

Maria is a middle school teacher in greater Minnesota. She teaches mathematics to all the sixth grade students in her school. She completed her initial preparation in another state which offered a special program for middle school mathematics licensure. The program emphasized the needs and developmental attributes of middle school students as well as the mathematics appropriate for them. Her college mathematics work took place in a department with an enlightened philosophy influenced by the *Curriculum and Evaluation Standards for School Mathematics* (1989) and the *Professional Standards for Teaching Mathematics* (1991) of the National Council of Teachers of Mathematics (NCTM). Her college professors were active in the mathematics education profession, integrating a standards-based approach into both their mathematics and education courses. As a result, even though Maria has taught for only three years, she understands how students learn. In addition, she has a deep understanding of mathematics at the middle school level. Her manner is very gentle and non-threatening, and despite her inexperience, Maria is the person in her middle school to whom other mathematics teachers quietly come with their questions.

Maria is lucky to be in a district with a very enlightened administration. The superintendent believes that the best teachers are also willing to take risks as they work to improve student learning. She supports them and their efforts whenever she can before parents, school board members, and others in the community. The teacher evaluation process supports continuous improvement and thoughtful change, using a five-year and one-year planning instrument as part of an annual review. Maria's principal also understands that well-planned change in instructional practice takes time to implement, and he will fund substitute teachers for those who request occasional collaborative planning days during the school year.

Maria's professional development needs include:

- *ongoing updates* about teaching and learning
- opportunities to *deepen her understanding* of mathematics
- experiences to *develop her capacity* to be a teacher leader

She will benefit from a Professional Development Plan focused especially on Principles 4 and 5 in the following recommendations.

**KENT**

Kent is a veteran secondary mathematics teacher. He has spent most of his twenty-two year teaching career in the high school mathematics department in a medium-sized city. As one of the senior members of a six-person department, he teaches mostly upper-level courses. He has always believed that not all students can, or should, study more mathematics than the minimum one year required for all ninth graders. However, the new *Minnesota Graduation Standards*, which expect that all students will study several strands of mathematics at a high level, challenge this conviction.

Kent believes that calculators impede thinking and acquisition of skill, though he concedes they are useful tools for physics or chemistry. He prides himself on preparing students for the next level of mathematics and for college entrance exams. Though only about 30% of the seniors in Kent's school attend college, 75% of Kent's students intend to go to college. He helps prepare students for college by encouraging careful note-taking during his lectures, giving challenging exams, and using rigorous grading practices. He usually takes his turn attending the state mathematics conference every third or fourth year.

Kent, like Liz, is unfamiliar with ideas from educational research about the effectiveness of having students construct their own meaning through exploration and collaboration. Kent has not changed his approach to teaching over the years, despite the increasing diversity of students. He believes any lack of success is tied mostly to students' lack of ability or unwillingness to work.

Kent's district, like many districts, often reduces the staff development budget in order to cut costs. The administration and community believe that teachers belong in the classroom, and that if they need to update their skills, they should do so in the summer or during school vacations. Kent, like many of his colleagues, works hard during the school year and likes to relax during vacations and in the summer. He is not comfortable taking risks nor is risk-taking valued by his department, the administration, or the community. The prevailing attitude toward curriculum innovations is: "If it ain't broke, don't fix it." Teachers generally plan individually, although Kent and his colleagues do share expectations about traditional content coverage as defined by the textbook. If the expected content is not *covered*, then the teacher of the next mathematics or science course will be unhappy. This discourages innovation and experimentation, which usually take extra time. Recently, Kent has noticed some changes happening in science curricula and wonders if this will impact the sequence and content emphasized by the mathematics department.

Kent has always prided himself on preparing students well for advanced mathematics assessments such as the Advanced Placement (AP) tests, the Scholastic Aptitude Test (SAT), and the American College Test (ACT). He has recently learned that these tests are undergoing change, incorporating the use of powerful graphing calculators, adding an AP statistics component, and moving gradually toward a reform approach to mathematics and calculus. Kent's school has never taught any statistics courses. His fellow teachers do not know much about statistics and consider it inferior mathematics since it is applied, rather than pure, abstract mathematics.

Kent's professional development needs include:

- exposure to some of the *newly important topics* in mathematics, such as data analysis techniques, probability, and discrete mathematics
- opportunities to learn about and use new *technology* for studying advanced mathematics, especially graphing calculators and those with symbol manipulation capacity
- participation in lessons that model more *active instructional practices* for enhancing learning
- experiences that will help him see the power of *mathematics for all students*

Kent will benefit from a Professional Development Plan focused especially on Principles 1, 2, 3 and 6 in the following recommendations.

## Principles for Professional Development

A recent document, *Principles of Effective Professional Development for Mathematics and Science Education: A Synthesis of Standards* (Loucks-Horsley, 1996), provides principles that could be applied to Liz, Maria, and Kent in their professional development planning. The standards reviewed reflect a common vision and specify that all good professional development experiences must include the following seven principles.

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### **Principle 1: Professional development experiences must be driven by a clear, well-defined image of effective classroom learning and teaching.**

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This image includes:

- commitment to the concept that *all* children can and should learn mathematics
- sensitivity to the diverse learning needs of individuals, especially to females and those of various ethnic/racial, language, and socio-economic backgrounds
- emphasis on inquiry-based learning, problem solving, and application of knowledge
- an approach to the understanding of mathematical knowledge and skills that helps students construct new understanding through experiences that challenge and extend what they already know
- development of in-depth understanding of the core concepts in mathematics
- building and extending new concepts from old
- collaborative work
- clear outcomes and assessment of progress toward them

There are many results from study, research, and experience that have been shown to improve student learning. These are the practices used in many other countries in which teachers experience success in helping all students learn important mathematics. Teachers in Minnesota, like their colleagues throughout the United States, have heavy teaching loads and little time to implement changes, even when they have been shown to be effective. Nevertheless, it is unfair to students for teachers to continue using old practices that are not effective. All parts of this first professional development principle represent a divergence from current and past practice and recommend the following transitions:

#### **FROM less emphasis on:**

- mathematics for a few elite students
- appealing to only abstract learners
- an emphasis on direct teaching
- abstract, decontextualized exercises
- teachers demonstrating procedures
- many topics taught specifically
- individual seat work
- assessing procedural knowledge

#### **TO more emphasis on:**

- mathematics for all
- appealing to all learners
- an emphasis on inquiry-based learning
- problems related to real-life
- students constructing understanding
- core concepts developed in depth
- collaborative group work
- assessing progress toward a standard

**Liz** is not familiar with ideas from cognitive science that support the importance of helping students construct their own understanding of mathematics through exploration and collaboration, nor has she had experience with how much student success can be increased through providing multiple entry points to a problem by connecting problems to everyday life. Liz doesn't know how to incorporate what she's heard about multiple intelligences into her classroom although the idea

*“Educational change depends on what teachers do and think — it’s as simple and as complex as that.”*

Fullan & Steigelbauer, 1991

intrigues her. She also does not understand the underlying concepts of mathematics well enough to emphasize them in the classroom in an overt manner. Liz could use professional development experiences which incorporate and model what is known from research and experience about effective teaching and learning.

Professional development planners, providers, and other leaders must help Liz and other teachers understand these effective practices and support the teachers in gradually implementing them through mentoring, study groups, and cognitive or peer coaching. Since this principle represents so much change, ongoing programs are needed to guide and support teachers as they gradually shift their practice. Some of the new, standards-based curriculum programs embed all of these features and support teachers as they try to change. This principle of professional development can be addressed as planners and providers prepare and mentor teachers in implementing one of these programs.

In **Maria's** district, issues of diversity are growing more important as the needs of the current student population are changing and students from a wide range of backgrounds, preparation, and experiences enter the school. Her college training gave her an introduction to cultural and gender issues in the learning of mathematics and to the special learning needs of various students. She would like to understand the background of her students better and is concerned with some of the achievement gaps among various groups of students. Her professional development needs might be met with a program such as *Generating Expectations for Student Achievement: An Equitable Approach to Educational Excellence (GESA)*, which includes classroom practice, observation, and feedback to support teachers in responding to the diverse learning needs of students. (See page 21 of this chapter for more information.)

**Kent**, like Liz, is unfamiliar with ideas from educational research about the effectiveness of having students construct their own meaning through investigation and dialogue. He does understand the basic concepts of algebra, geometry, trigonometry, and functions, though he does not emphasize them. He assumes that the students with more mathematical ability will learn the procedures that he emphasizes and connect them to the underlying concepts, as he has done in his own learning. Many are able to do this, and he feels this is one of the criteria for real success in mathematics. His teaching style appeals to the abstract, logical learners among his students, who are quite successful in his classes. Few, if any, of the examples or problems he uses have real-life applications. Since Kent's professional development needs in this area are quite similar to those of Liz, planners should consider the same issues and directions for Kent.

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**Principle 2: Professional development experiences must provide teachers with opportunities to develop knowledge and skills and broaden their teaching approaches.**

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This process includes:

- engaging teachers in learning experiences that enhance major mathematical concepts and pedagogy
- strengthening teachers' knowledge of how children learn
- enabling teachers to make informed decisions about curriculum content and implementation

Many important aspects of mathematics are new. For example, discrete mathematics and approaches to data analysis contain content that did not exist a few years ago, yet that same content is widely used in today's workplace and culture. Other topics, such as shape and space and graphics animation, while not new, are newly important. Thus virtually all teachers can benefit by

*"Teachers' comfort with and confidence in their content knowledge influences how and what they teach. Good teaching demands that teachers reason about pedagogy in professionally defensible ways within the particular contexts of their own work."*

NCTM, 1991

*“In order to teach mathematics effectively, teachers of young children need an understanding of the subject that goes beyond what they are formally charged with teaching. They need to be comfortably knowledgeable about mathematics, so that they can respond flexibly and creatively not only to the difficulties students encounter, but also to their insights.”*  
Cipra & Flanders, 1992

enhancing their learning of mathematical content. Projects such as *Cognitively Guided Instruction (CGI)*, based on research done at the University of Wisconsin Madison, are building a firm foundation supporting the idea that teachers’ conceptual understanding of mathematics forms the basis for making continual and ongoing instructional decisions. (See p. 21.) Much more is known now about how children learn and how the brain processes information and makes connections than was known even a few years ago. All of this suggests that this principle provides a rich and fertile area for professional growth for all teachers.

**Liz’s** greatest needs are related to this principle. To improve her conceptual grasp of mathematics and to prepare her students for their futures, she should learn more mathematics and experience how her own conceptual understanding translates to appropriate learning for intermediate students. This understanding will better enable her to make instructional decisions for each of her students based on the student’s own progress. Liz already knows much about students and teaching. With additional content and an awareness of the misconceptions students may hold about mathematical concepts, she will be better prepared to conduct the fourth-grade mathematics “orchestra.” This suggests that for Liz, professional development planners and providers must incorporate substantial levels of mathematics content, coupled with other issues related to the teaching of mathematics.

**Kent** needs to extend his knowledge to include a better understanding of how students learn the mathematics he teaches. This could help many more students in his classes emerge with a stronger functional understanding which will prepare them for living and working in a variety of settings. However, he does not currently see any need for this. Thus, the challenge for those who plan or deliver staff development for teachers like Kent is finding a way to motivate them to initially participate. He might be encouraged to participate in opportunities to learn some new mathematics topics contained in the *Minnesota Graduation Standards* such as discrete mathematics, probability, and data analysis. In terms of pedagogy, if Kent is able to see what new ways of teaching look like, he may become more open to trying them. Kent might benefit from a visit to another teacher’s classroom to observe students using an integrated secondary curriculum, one that includes several mathematics strands such as algebra, geometry, probability, statistics, and discrete mathematics in each year’s coursework.

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**Principle 3: Professional development experiences use instructional methods to promote learning for adults which mirror the methods to be used with students.**

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Good learning opportunities for teachers:

- build on teachers’ current mathematical knowledge, skills, and attitudes
- allow them to construct their own knowledge through immersion in mathematical processes
- provide teachers with opportunities to work in collaborative teams, to engage in professional discourse, and to observe the modeling of effective strategies
- give teachers adequate and ongoing opportunities to develop, practice, and reflect on new knowledge and strategies
- plan and design structured, continuous follow-up opportunities
- unify the set of learning opportunities through a comprehensive plan

These learning opportunities are crucial because teachers typically teach the way they have been taught. In order to move away from a curriculum emphasizing memorization and the rote use of algorithms, continuing professional development experiences must provide opportunities for teachers

*“...time for planning and professional development is urgently needed — not as a frill or an add-on, but as a major aspect of the agreement between teachers and districts...Teachers need time to develop effective lessons...They need time to read professional journals, interact with their colleagues, and watch outstanding teachers demonstrate new strategies.”*

National Education Commission on Time and Learning, 1994

to personally experience new ways of learning and to reflect on these strategies. Follow-up must provide structure and support for practice in a low-risk environment (e.g., by having pairs of teachers plan lessons, try them out, and discuss the results afterward). For all students to reach high standards, professional development must be well planned and focused on classroom practice and student achievement. It is especially imperative that providers of professional development be willing to “walk the walk” and not just “talk the talk,” consistently modeling the thinking environment that these same teachers are expected to provide for students in the mathematics classroom. New requirements for license renewal, district policies, and teacher contracts can all support teachers’ efforts to continually improve their practice, using long- and short-range professional development plans, incentives, strategies for peer support groups, and data-driven evaluation procedures. An excellent model is provided in the national certification process of the National Board for Professional Teaching Standards. (See p. 23.)

As **Liz** expands her conceptual base in mathematics and her knowledge of how children learn mathematics, she could easily become overwhelmed as she begins to see the possibilities before her. She will need time to reflect to determine a manageable starting point for her learning. She will also need assistance in designing a long-range plan so that she may focus and prioritize strategies to achieve her goals. This might include meeting with someone responsible for staff development in her district, working with a peer support group, or engaging in cognitive coaching with a trusted colleague.

Liz would benefit from a more focused emphasis on continuous professional development, such as a regular study group to share teaching ideas or journal articles from publications like *Teaching Children Mathematics*, the elementary school journal published by the National Council of Teachers of Mathematics. To provide appropriate professional development for teachers like Liz, planners should seek out or create programs which have a strong but accessible content focus offered in a supportive environment.

Sometimes **Maria** runs into a perplexing situation while trying to use a strategy and would benefit from opportunities to discuss her teaching with supportive and knowledgeable colleagues. Not all teachers in her building use standards-based practices. Professional development experiences which model good practice would offer Maria an opportunity to talk to like-minded teachers, maintaining her dedication to this style of teaching while renewing her enthusiasm for this type of learning.

**Kent** needs to have a breakthrough experience in a workshop. For example, a summer institute dedicated to exploring data investigations with a graphing calculator might offer an opportunity for Kent to close gaps in his own understanding of mathematics, while offering deeper insights into the learning process. If these insights are objects of reflection and discussion, Kent might have an “aha!” experience. This will serve to personally convince him that there are better ways to learn, and hence to teach, mathematics than the methods he has used with varying degrees of success for over twenty years. If he can try out new ideas and see a broader group of students experience success, he may accept that these new methods make sense. Planners and providers should be knowledgeable about opportunities that would enable Kent to have a learning experience that causes enough disequilibrium to influence him to examine his beliefs on teaching and learning mathematics. It is important that Kent attend such a program with at least one other colleague to ensure ongoing support and sharing.

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**Principle 4: Professional development experiences build or strengthen the learning community of mathematics teachers.**

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In an effective learning community:

- collegiality and collaborative professional exchanges are valued and promoted
- teachers are encouraged to take risks and are provided opportunities for experimentation
- professional development is viewed as a life-long process that is part of the school norm and culture

*“Only when teachers are allowed to see themselves as members of a group, collectively and directly improving their professional practice by improving pedagogy and curricula and by improving students’ opportunities to learn, will we be on the road to developing a true profession of teaching.”*  
Stigler & Hiebert, 1997

In order to promote the development of a learning community of teachers and other staff, the culture of many schools needs to change. Structures must be in place to support thoughtful experimentation and long-term implementation beyond the often prevalent *try it once and quit* mentality. Collegial exchanges of all kinds and stable, long-range planning with room for risk-taking need to become the norm. Currently, teachers need to make extraordinary efforts to collaborate with peers. Policies and practices such as allowing only one teacher from a building to attend a given conference must be revised. If professional development is to become a high priority in the mission of a school district, dedicated time for related activities must be built into the school calendar, separate from student contact days and not in conflict with other school programs and activities.

All teachers of mathematics should be familiar with the state professional organization, the Minnesota Council of Teachers of Mathematics (MCTM), and its professional development programs. Teachers may also want to work with their contract negotiations team to move to a more peer-based evaluation process, where each teacher has a long-range plan that is developed with and supported by colleagues. Schools and districts need to value and find time for teachers to observe each other, explore an important component of instruction, and reflect on their practice. Only with this type of support can schools create vibrant communities of life-long learners.

**Liz**, by herself, will probably not initiate practices which strengthen the local learning community but she is very willing to cooperate. The district policy makers and staff development coordinator need to provide the leadership and structure to promote this collaboration. Activities might include the expectation that teachers will participate in study groups and mathematics conferences regularly and will use the *Minnesota K-12 Mathematics Framework* to examine the elementary curriculum in order to move toward a more focused and coherent program.

A strong learning community already exists in **Maria’s** district, and both administrators and staff pursue opportunities for continuous professional growth. Sharing, discussion, and planning among peers is encouraged on staff development days and on committees involved in curriculum and site-based management. The district’s continuing education committee offers regular workshops, follow-up support, and time for implementation of the district planning tool which includes a peer review program. There is also strong support for reaching out to collaborate with the community, which has become helpful to both staff and community members as the student population increases in diversity.

**Kent** might benefit from subscribing to a statewide listserv of mathematics and science teachers who are making attempts to integrate graphing calculators into their curriculum. He could “listen in” on the professional conversations of other teachers with an opportunity to later become an active contributor to the network. He would also profit from opportunities to explore mathematics in local workplaces. This could include a program sponsored by the local Chamber of Commerce or conversations with instructors at the nearby technical college. Staff developers and providers would do well to organize programs offering opportunities such as mentorships or business partnerships

for Kent and other teachers to learn about the real needs of today's workplace, which will stimulate them to prepare students for the workplace of tomorrow.

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**Principle 5: The professional development experiences prepare and support some teachers to serve in leadership roles.**

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Leadership support includes:

- planning and implementing professional development opportunities for themselves and others
- acting as change agents in school districts, with the goal of improving student learning
- promoting a shared vision of mathematics education
- supporting other teachers

Many leaders, with all types of expertise, are needed to implement mathematics reform. Especially credible and effective are practicing teachers who work with their peers. Some will provide resources or work with colleagues on a one-to-one basis, some will serve as team leaders, others as committee members or parent group organizers. Other roles include officers of professional organizations, facilitators for workshops, providers of staff development, and peer coaches. Those teachers so inclined by desire and temperament to serve their profession in these roles should be encouraged and nurtured to grow as teacher leaders.

Though **Liz** is not likely to serve as a leader beyond her building, she would benefit from administrative encouragement and support to strengthen her leadership skills and occasionally broaden her view outside her building or district. Liz would be a good choice to serve on a district mathematics curriculum committee as a representative of her grade or building.

**Maria** has the qualities needed for a state leadership network. She is already an exemplary practitioner and shows evidence that she has the credibility needed to be a teacher leader, not only in her building and district but also in regional and state groups. Her principal has nominated her for the Best Practice Mathematics Network sponsored by the Minnesota Department of Children, Families & Learning, and Maria is interested in accepting an invitation to join.

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**Principle 6: The professional development experiences consciously provide links to other parts of the educational system.**

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Links are provided by:

- integrating professional development activities into other initiatives
- aligning activities with curriculum frameworks, academic standards, and assessment
- establishing active support within the school, district, and community, including structured opportunities for networking with colleagues

In order for a shared educational vision to become reality, all professionals in the system must understand the *big picture* as well as how the parts fit. This requires multiple linkages, particularly for state policies and programs. The necessary links with Minnesota initiatives are quite explicit. This includes, for all teachers, a thorough knowledge of Minnesota's Basic and High Standards and all aspects of the *K-12 Graduation Standards* initiative, including performance packages to provide evidence of student learning. Only when everyone in the system understands the complexities and the change required to focus on outcomes rather than inputs in the educational system can everyone begin to work together toward implementation. For the foreseeable future, all initiatives at the

*"We believe that professional teachers assume roles that extend beyond the classroom and include responsibilities for connecting to parents and other professionals, developing the school as a learning organization, and using community resources to foster the education and welfare of students."*

INTASC, 1992

*“Another factor is today’s emphasis on national, state, and local curriculum standards. These standards require teachers to have a deep knowledge of the subjects they teach and to use various teaching practices depending on the learning needs of their students. Teachers need sustained and rigorous professional development to help prepare students to perform successfully on the new forms of assessments that are a product of the standards movement.”*

Sparks & Richardson,  
1997

school, district, and state level need to be driven by the *Graduation Standards*, with alignment and support evident at the building and district level. This *Minnesota K-12 Mathematics Framework* supports such implementation, with content strands organized around the same big ideas as the state standards.

Planners and providers can provide multiple and ongoing opportunities for all district staff to make necessary links among current efforts and the entire *Graduation Standards* initiative. This necessitates a variety of vehicles for information sharing, updates, and a study of the implications for individual classrooms.

**Liz** has resolved for this year to try to fit together several recent local and state initiatives. She has been encouraged by the leadership in her school and by her personal need to have the pieces fit together. This will motivate Liz to engage in opportunities to better understand the state mathematics standards and curriculum framework and to link assessments to the standards. She will participate in a series of informational and working meetings to help all teachers in her building understand and implement state standards, and she is excited to be able to use the *Minnesota K-12 Mathematics Framework* in her curriculum planning.

**Maria** is ready to look at the big picture. She is interested not only in being familiar with state mathematics standards, framework, and assessment results but in findings from national and international assessments such as the National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS). (See pp. 22-23.) She would like to learn what these reports can tell educators about effective learning and teaching of mathematics. She is working to organize a study group around these initiatives so that interested teachers will have an opportunity to study and discuss these topics and try to apply them to their teaching.

Besides the changes in standardized and national tests, the state now expects schools to provide all students the opportunity to learn more about topics in chance, data analysis, and discrete mathematics, as well as algebra and geometry. **Kent** realizes that if he is going to meet the expectations of students, administrators, parents, and the community, he needs to update himself along with other members of his department. He is a prime candidate for a series of regional workshops which tie together the following themes: helping *all* students succeed, new mathematical content, new instructional approaches, and new ways of assessing student learning. Kent will find the *Minnesota K-12 Mathematics Framework* helpful as he attempts to incorporate these ideas into his classroom.

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**Principle 7. The professional development experiences include continuous assessment.**

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Professional development programs must constantly be reviewed in order to:

- determine participant satisfaction and engagement and to make short-term adjustments
- evaluate the long-term impact on teaching effectiveness, student learning, leadership, and the school community

Rather than continuing routine district-wide programs, it is time to institute a planning approach that calls for analyzing teachers’ needs, synthesizing them, and matching or creating opportunities to help meet those needs. **Above all, programs of professional development must be tied to student learning.** In the past, a measure of success has often been participant satisfaction—a “happiness quotient.” While it is still necessary for any adult learner to have an enjoyable and rewarding experience in order to choose to participate, teachers’ professional growth must be consciously and continually connected to student performance as a measure of success. Action research by practicing teachers provides one way to carefully document results of authentic change in

*"[T]here are several indicators for effective staff development.*

- 1) Student learning continuously improves for all students.*
- 2) Principals, supervisors, and other observers report improvements in instructional practices in all classrooms.*
- 3) Teachers say staff development makes a difference for them and for their students."*

*Sparks & Richardson, 1997*

classroom practice. The real measure of accountability is found in teachers' ability to provide thoughtful explanations of their continuous instructional decisions, decisions that are based on understanding effective practice (Elmore, 1997).

Professional development for **Liz** needs to be practical and address her question of "how will this look in my classroom?" The idea of directly linking professional development to effectiveness of teaching and student learning is new to Liz, and she will need to ease into such things as tying her own professional growth plan directly to the increased mathematical achievement of her students.

**Maria** is ready to begin doing action research in her classroom, having realized the need for documentation of her instructional decisions and careful implementation of research-based practice. She is looking for an orientation to action research and a mentor or master teacher with whom to work as she seeks deeper insight into how to improve the number and thinking level of her questions in the classroom and to identify a planning model to build more effective questions into her lessons. Staff development leaders could assist her in finding a structure for using action research and should encourage her to continue assessing her needs regarding her professional growth.

**Kent's** teaching is affected most forcefully by student response and achievement. Once he sees his students becoming more enthusiastic and engaged in learning and sees the increased achievement of a larger group of students, he will be motivated to extend his learning to provide similar experiences for his students. For Kent to be satisfied, professional development activities need to have substantial components of teacher-to-teacher exchange. He is ready to share his own experiences of effective change; his testimonials are especially compelling to other teachers.

*“The Professional Standards for Teaching Mathematics rest on the following two assumptions:*

- *Teachers are key figures in changing the ways in which mathematics is taught and learned in schools.*
- *Such changes require that teachers have long-term support and adequate resources.”*  
NCTM, 1991

### Related Criteria for Evaluation

Teachers, district coordinators of curriculum/staff development/graduation standards, as well as professional development providers, all need to use these seven principles as guidelines for planning and selecting learning experiences in mathematics for teachers. Some related general criteria have been suggested by McKean and Nelsen (1993) to evaluate professional development opportunities. An effective professional development experience, whether short-term or long-term in nature:

- responds to identified state or local needs and priorities
- is well planned and suited to the needs and beliefs of participants
- provides a high quality experience, incorporating best practice in staff development and mathematics education
- provides structured follow-up
- builds evaluation into the program, including the impact on student learning

Professional development providers and planners need to continually assess the needs of staff and to be both creative and resourceful in designing programs to respond to those needs. They must be familiar with the types of programs which are effective for those at different stages in the continuum of change and coordinate and make available a range of learning opportunities for staff.

### Future Scenarios

What if the preceding seven recommendations for professional development were followed? What potential does effective professional development have to alter the classroom practice of these teachers? Here are some future scenarios. Let’s look in on these teachers over time.

#### One year later:

**Liz** has decided to focus on the content area of *Shape, Space & Measurement* the first year and on *Number Sense* next year. She has made a major commitment to enroll in a 3-year summer program and has started the first year. Though she is working very hard, she is amazed at the feeling of power she gets from taking charge of her own learning and of how well she is doing. In the classroom, Liz already feels more secure with concepts of mathematics.

**Maria** is now part of the state mathematics leadership network, the Best Practice Network, and has made connections with teachers from all parts of the state, an experience she finds quite exhilarating. In her district, she is involved in training for Cognitive Coaching and realizes she is someone who is able to give feedback to peers without cutting off collaboration. (See p. 21.)

**Kent** is becoming a strong advocate for change after participating in the first year of a five-year program for teacher enhancement funded by the National Science Foundation (NSF). Because he bases his conviction on the difference he observes with his students, his colleagues are noticing what he’s doing. He enjoys exchanging ideas with the other participant teachers in the NSF program and is taking every opportunity to meet with them. He has resolved to attend state MCTM meetings every year and plans to attend a workshop on using the many options available on advanced graphing calculators the next time one is offered.

**Five years later:**

As part of her initial three-year professional development program, **Liz** has been exposed to *Cognitively Guided Instruction* (see p. 21), and it has dramatically changed the way she organizes her class. Because she is more aware of what to expect in students' thinking at progressive stages of development, she is able to tailor learning to students' readiness. She has taken a graduate mathematics course for elementary teachers and has a much better grasp of the unifying concepts of the discipline. Liz has added *Patterns* to the topics she teaches and is thinking of getting an endorsement as an elementary math specialist, which is a new addition to licensure options. Liz has tracked the performance of her students on the state comprehensive tests and is pleased that they have shown steady improvement over the last three years. She is particularly encouraged by their performance in the two mathematics strands on which she has focused most of her professional development work: *Number Sense* and *Shape, Space & Measurement*.

**Maria** is chair of the mathematics curriculum/staff development committee for her district. She is gradually pushing herself past her natural reticence to assert more active leadership by running for a position on the board of MCTM, the state mathematics teachers' organization. Maria is also in the process of applying for certification by the National Board for Professional Teaching Standards. (See p. 23.) She has been using a standards-based curriculum for several years, and her classroom is often visited by other teachers. Many of the parents of her students have commented to her how pleased they are that their children's attitude about mathematics and motivation to study it really took a positive turn during their year in her classroom. Maria has recently taken one quarter off to work at the regional Math/Science Center for teachers to further develop her role as a teacher leader.

In talking with another teacher at the MCTM state conference, **Kent** learned that this teacher had recently achieved certification by the National Board for Professional Teaching Standards. Kent realized from their discussion that the process of justifying instructional decisions is very complex, and he is beginning to wonder if participating in this process himself would help him reflect on how and why his teaching has changed to create more successful learning experiences for his students. He is now a regular user of graphing calculators and is in the second year of using an integrated high school mathematics curriculum. Last summer Kent worked at a local business in a teacher/industry partnership program which opened his eyes to how mathematical thinking and problem solving is embedded in today's workplace. He is also active on the local parent/community mathematics group, which was formed when a group of parents became concerned about some of the new mathematics programs and voiced their opposition. Because Kent and others in the district responded quickly by presenting evidence of student achievement with a variety of assessments, these parents are now the staunchest supporters of the integrated high school mathematics curriculum, leading monthly meetings for other parents.

## Guidelines for Personal Professional Development Planning

Developing a coherent personal professional development plan is a different way of thinking and doing professional development. The assumption that learning to teach mathematics is something that teachers do rather than something that is done to them changes expectations and outcomes. Creating a professional development plan involves a tension between personal needs, student needs, and the needs of one's professional community within the department, school, and/or district.

The following steps may guide teachers who are interested in beginning a professional development planning process. These steps have been adapted from *Assuring Professional Excellence* (Nordgren, 1996), the professional development planning process of the Minneapolis Public Schools, and are aligned with Minnesota staff development legislation.

*" [Professional development] is a dynamic process extending from initial preparation over the course of an entire career. Professional teachers are responsible for planning and pursuing their on-going learning, for reflection with colleagues on their practice, and for contributing to the profession's knowledge base."*

INTASC, 1992

### 1) Write your plan:

- a) Assess: Study your school improvement plan and consider what you could do to support that plan within your classroom. Study the *Minnesota Graduation Standards* and this *Framework* and think about the learning needs of your students.
- b) Set Goals: What goals and strategies would best support your students in improving their learning outcomes? In what ways can you improve on your content knowledge, instructional methods, or assessment strategies to help you reach your goals?
- c) Develop Strategies and Resources: What options might you use to help you carry out your plan? This could include developing a portfolio, taking classes, applying research in the classroom (action research), making videotapes of your lessons, inviting peers to observe your teaching and support you as a coach, keeping a journal, working with a mentor, or exploring other teaching methods. This whole planning process can be done with other teachers or alone and then shared with your team.

### 2) Organize your Professional Development Team:

A team should have a minimum of three people but should not have more than five or six. Include yourself and anyone else you feel would help you grow as a teacher. This may be an administrator, a peer, a parent, a community member, a student, a friend, or family member.

### 3) Plan your sharing and feedback:

- a) Establish indicators for determining whether you are "getting there." Is your professional development plan meeting your students' needs? your needs? Is it meeting the needs of your department/school/district? How do you know? What data will help you measure your growth?
- b) Determine how you are going to share your professional growth plan with your team. This could include observations, meetings, journal and portfolio presentations, viewing videotapes with your team, and informal discussions. Include a timeline and dates where possible. Plan to meet with your team at least three times during the year. Ask your team members for feedback. Seek acknowledgment for growth and insight and assistance for continuing difficulties.

### 4) Revisit your Professional Development Plan:

Review your professional development plan between meetings to help you focus your efforts and reflect on your work.

### 5) Personal professional growth is a continuous process:

Revise your goals, your strategies, your plan and your team as necessary.

*" Professional development ideally leads to exemplary teachers who, in partnership with others in the school and community, have a good command of their subject matter, and have the pedagogical skills necessary to create productive learning environments for diverse populations of students."*

Hart et al., 1994.

## Strategies for Professional Learning

Loucks-Horsley, Hewson, Love, and Stiles (1997) describe fifteen possible strategies for addressing the goals of professional development. None of these should be used in isolation. Every professional development plan should use a variety of strategies to best address the goals of the plan, the knowledge base of the participants, and the context for the professional work.

### Immersion

#### Immersion in inquiry into science and mathematics

Engaging in the kinds of learning that teachers are expected to practice with their students—that is, inquiry-based science investigations or meaningful mathematics problem solving

#### Immersion in the world of scientists and mathematicians

Participating in an intensive experience in the day-to-day work of a scientist or mathematician, often in a laboratory, industry, or museum, with full engagement in research activities

### Curriculum Work

#### Curriculum implementation

Learning, using, and refining use of a particular set of instructional materials in the classroom

#### Curriculum replacement units

Implementing a unit of instruction that addresses one topic or concept and incorporates effective teaching and learning strategies to accomplish learning goals

#### Curriculum development and adaptation

Creating new instructional materials and strategies or tailoring existing ones to meet the learning needs of students

### Examining Practice

#### Action research

Examining teachers' own teaching and their students' learning by engaging in a research project in their classroom

#### Examining student work and student thinking and scoring assessments

Carefully examining students' work and products to understand their thinking and learning strategies and identifying learning needs and appropriate teaching strategies and materials

#### Case discussions

Examining written narratives or videotapes of classroom teaching and learning and discussing what is happening, the problems, issues, and outcomes that ensue

**Collegial Work****Coaching and mentoring**

Working one-on-one with an equally or more experienced teacher to improve teaching and learning through a variety of activities, including classroom observation and feedback, problem solving and troubleshooting, and co-planning

**Study groups**

Engaging in regular, structured, and collaborative interactions regarding topics identified by the members of the group, with opportunities to examine new information, reflect on their practice, or assess and analyze outcome data

**Partnerships with scientists and mathematicians in business, industry, and universities**

Working collaboratively with practicing scientists and mathematicians with the focus on improving teacher content knowledge, instructional materials, access to facilities, and acquiring new information

**Professional networks**

Linking in person or through electronic means with other teachers or groups to explore and discuss topics of interest, set and pursue common goals, share information and strategies, and identify and address common problems

**Tools/Vehicles****Workshops, institutes, courses, and seminars**

Using structured opportunities outside of the classroom to focus intensely on topics of interest, including science or mathematics content, and learn from others with more expertise

**Developing professional developers**

Building the skills and knowledge needed to create learning experiences for other educators, including design of appropriate professional development strategies; presenting, demonstrating, and supporting teacher learning and change; and understanding in-depth the content and pedagogy required for effective teaching and learning of students and other educators

**Technology for professional learning**

Using various kinds of technology to learn content and pedagogy, including computers, calculators, telecommunications, videoconferencing, and CD-ROM and videodisc technology

**Summary**

Professionals understand that constant improvement is the norm in any occupation. Of all professions, teaching may be the most important for our society. Unfortunately, teaching has not, until recently, considered the importance of a coherent, life-long professional development plan as central to its mission of raising student achievement. As we move into the next millennium with its complex demands, we need to prepare our students to compete in this global economy as citizens of the world. This requires teachers who are on the leading edge of their profession with up-to-date knowledge and skills, empowered to make critical decisions regarding curriculum, instruction, and assessment. Such teachers see their profession as a journey of reflective practice.

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**For More Information:****Cognitive Coaching (or Peer Coaching):****Description:**

Coaching is a set of strategies, a way of thinking, and a way of working that invites teachers and others to shape and reshape their thinking and problem solving capacities. The end result of coaching at the classroom level is the improvement of student learning. It is based on the assumption that the teacher benefits from self-reflection and is a professional who is capable of changing his/her practice with the support of a coach whose major focus is to cause the teacher to think. Coaching skills include establishing rapport, questioning, paraphrasing, observing, collecting data, and stimulating metacognition.

A Cognitive (or Peer) Coaching workshop actively involves participants in understanding and applying the philosophy, goals, and skills of coaching with each other.

**Cognitively Guided Instruction (CGI):****Description:**

Funded by the National Science Foundation (NSF), CGI was started as a research program to investigate the impact of research-based knowledge about children's thinking on teachers and their students. The learning environments of CGI workshops are structured so that teachers learn how the research about children's mathematical thinking can help them learn about their own students. With CGI support, teachers decide how to use that knowledge to make instructional decisions.

**Generating Expectations for Student Achievement: An Equitable Approach to Educational Excellence (GESA):****Description:**

The GESA program is based on the premise that in order to ensure quality and excellence on an equitable basis, school districts need to directly confront the issue of gender, race, ethnic, and other bias in teachers' interactions with students. GESA emphasizes the research on teacher perceptions and expectations in the classroom, suggests alternative behaviors, and provides techniques for application and practice. The program recommends that teachers have opportunities to observe each other in a non-threatening manner and encourages self-discovery and analysis.

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**National Assessment of Educational Progress (NAEP):****Description:**

For more than a quarter of a century, the National Assessment of Educational Progress (NAEP) has reported to policy makers, educators, and the general public on the educational achievement of students in the United States. As the nation's only ongoing survey of students' educational progress, NAEP has become an important resource for obtaining information on what students know and can do.

The 1996 NAEP assessment framework has been influenced by the *Curriculum and Evaluation Standards for School Mathematics* (NCTM) as well as recent curricular emphases and objectives. The framework measures five mathematics strands: (1) number sense, properties, and operations; (2) measurement; (3) geometry and spatial sense; (4) data analysis, statistics, and probability; and (5) algebra and functions. In addition, the assessment examines mathematical abilities (conceptual understanding, procedural knowledge, and problem solving) and mathematical power (reasoning, connections, and communication).

**National Information:**

Reese, C.M., Miller, K.E., Mazzeo, J., & Dossey, J.A. (1997). *NAEP 1996 mathematics report card for the nation and the states*. Washington, D.C.: National Center for Education Statistics.

**Local Information:**

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The reports are also available on the World Wide Web: <http://www.ed.gov/NCES/naep>

**National Board for Professional Teaching Standards (NBPTS):****National Contact:**

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**Description:**

The National Board is a nonpartisan, independent, nonprofit organization of teachers and other education stakeholders working to advance the teaching profession and to improve student learning. The mission of the NBPTS is to establish high and rigorous standards for what accomplished teachers should know and be able to do, to develop and operate a national voluntary system to assess and certify teachers who meet those standards, and to advance related education reforms for the purpose of improving student learning in American schools.

A National Board certificate is a credential attesting that you have been judged by your peers as one who is accomplished, makes sound professional judgments about student learning, and acts effectively on those judgments. Offered on a voluntary basis, a National Board certificate complements, but does not replace, a state license.

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**Description:**

TIMSS is a comprehensive 41-nation study of mathematics and science teaching and learning. It has several parts: (1) assessments of student achievement at grades 4, 8, and 12; (2) data on differences in teaching practices and learning environments; (3) analyses of textbooks and curriculum guides; and (4) videotaped observations of mathematics classroom instruction in Germany, Japan, and the United States.

TIMSS is of particular interest to teachers of mathematics and science in Minnesota because the state participated in the testing as a "mini-nation" and will receive reports parallel to national reports throughout 1997 and 1998.

**Ordering Information:**

National Center for Education Statistics  
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555 New Jersey Avenue NW  
Washington, DC 20208-5574  
202.219.1395

The reports are also available on the World Wide Web: <http://www.ed.gov/NCES/timss>

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