# THE PRINCIPALS OF EDUCATIONAL REFORM:

# SUPPORTING MATHEMATICS AND SCIENCE TEACHING IN YOUR SCHOOL

# A HANDBOOK FOR ELEMENTARY AND MIDDLE SCHOOL PRINCIPALS

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INVERNESS RESEARCH ASSOCIATES

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## A HANDBOOK FOR ELEMENTARY AND MIDDLE SCHOOL PRINCIPALS

## I. INTRODUCTION

### THIS MONOGRAPH

This monograph is written explicitly for school principals. Principals, we believe, are critical to the success of any effort that seeks to improve the quality of instruction that is taking place in the classroom. Principals set the tone, provide the incentives, and create the shared expectations that shape what gets taught and how it gets taught.

This monograph has been written to guide you, the principal, through a process of improving the quality of math and science teaching in your school. (We also think that the ideas presented here are completely applicable to improving instruction in other disciplines as well.) In writing this monograph, it is important to note that we have made some assumptions about you, your goals and your willingness to assume an active leadership role:

- First, we assume that you are not satisfied with the mathematics or science instruction in your school. (If you were, you would not be reading this book!)
- We also assume that you are willing to act as a strong instructional leader and you want to take a proactive stand to improve the mathematics or science program in your school.
- Additionally, we presume that you are willing to make the improvement of math and science teaching a priority in your school for at least the next few years.
- And finally, we assume that you believe that all students in your school are entitled to a rich, steady diet of high-quality mathematics and science instruction – and that you are committed to see that they get it.

The process of improving the quality of instruction school-wide is a real challenge for any school community, and we believe that clarity, commitment and persistence are the keys to unlocking the door to change.

### A NATIONAL PERSPECTIVE

Over the last decade, the National Science Foundation and other funders have invested millions of dollars into programs designed to improve mathematics and science instruction in schools, and in turn, increase student performance. Recent initiatives (such as the New York State Systemic Initiative) differ from past reforms in that they are *systemic in their design*, meaning that they target whole school systems instead of single aspects of the instructional process. Past programs were narrowly targeted at single areas (such as professional development programs or new instructional materials). These projects resulted in isolated

successes, but failed to make lasting, widespread change throughout a state, district or school because they met with barriers in the other, un-addressed parts of the system. Thus, teachers would attend professional development sessions but would not have the materials to implement what they learned. Or standards would change, but state assessments would not match them. Consequently, there is now increased recognition that all parts of the system must be *aligned*. And there is increasing recognition that the "school" is an important unit of change.

There are many reasons for this focus on schools, not the least of which is the movement toward site-based management and a realization that a school can be a rich, growing community. An effective school is more than an assemblage of teachers and classrooms; it is the locus of powerful instructional activity and professional collaboration. It is a place where a principal, teachers and students live and work within an unmistakable culture. Oftentimes, school faculty can create and share an educational philosophy that strongly influences the classroom environment. It is no wonder then that meaningful change in schools requires more than professional development for individual teachers or new instructional materials. Systemic change programs acknowledge this complexity by addressing all aspects of the school community through multiple, simultaneous, rich improvement activities.

From the National Research Council's National Science Education Standards:

The National Science Education Standards state that students should be able to: "experience the richness and excitement of knowing about and understanding the natural world; use appropriate scientific processes and principles in making personal decisions; engage intelligently in public discourse and debate about matters of scientific and technological concern; and increase their productivity through the use of the knowledge, understanding and skills of the scientifically literate person in their careers."

The National Science Foundation, in particular, has targeted much of its education funding to improving mathematics and science through systemic reform initiatives. These programs are guided in part by national standards in mathematics and science, which provide a vision for student learning that includes a mastery of basic fundamentals of the subjects complemented by a student-centered orientation to instruction. These standards promote programs which provide students with deep understandings of content, greater appreciation for the disciplines, and genuine experience with the power of learning. The mathematics and science instruction that is called for in these national standards requires more than replacing current texts with newer ones, or even supplying new mathematics manipulatives or science kits. Standards-based reform involves far more than simply adding one or two teaching strategies to a collection of approaches. It is a complex and multi-faceted process that takes place at a state, district, school and teacher level.

National Standards in Science and Mathematics

National Council of Teachers of Mathematics [NCTM], Commission on Standards for School Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA.

National Council of Teachers of Mathematics [NCTM], Commission on Teaching Standards for School Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA.

National Research Council [NRC]. National Science Education Standards. (1996). Washington, DC: National Academy Press.

## LESSONS LEARNED FROM THE NEW YORK STATE SYSTEMIC INITIATIVE RESEARCH AND DEVELOPMENT (R&D) SCHOOLS

The ideas and insights within this monograph come primarily from schools in one of these projects, the New York State Systemic Initiative (NYSSI), which Inverness Research Associates documented for five years from 1994 - 1998.[1] The schools in this project started "from scratch" in their improvement efforts, with little prior experience or support; they had to "blaze their own trails." Along the way, the principals in these schools learned a great deal about initiating and facilitating a process of improving mathematics and science.

This monograph was developed so that you and others can benefit from their experiences. The advice and lessons learned captured here come through Inverness but are drawn from the collective wisdom of principals who "learned the hard way" about changing practice in their schools. Their firsthand experiences are invaluable for you and others on the way to providing high-quality science and mathematics instruction for your students.

The principals who have engaged in this process will testify that this is not an easy journey, but that it is well worth the effort and commitment. Commitment is key because substantial change will not happen in a week, a month, or even a year. If you are turning to this book because you are feeling the pressure of test scores and want to find a way to quickly improve your students' performance, you are looking in the wrong place. Genuine, lasting change requires what one might call a change in culture, or a refocusing of mission, guided by the belief that all students should have equitable access to high-quality mathematics and science experiences. This is an extended, deliberate, and strategic process.

Therefore, if your school is engaged in other subject area reforms or is focused on other priorities, this may not be a good time for you to embark on a full-scale science and/or mathematics reform. (We have found that "reform overload" is one of the most significant barriers to math and science reform efforts.) You must be willing to put aside, or at least effectively complement other priorities (if only for a two- or three-year period) in order for you

[1] Inverness Research Associates is a small research and evaluation company that has, over the last ten years, been studying and evaluating systemic science and mathematics education reform efforts around the country.

and your staff to focus on this effort and ensure that it takes permanent root. We don't wish to discourage you. Rather, we wish to challenge you and underscore the importance of your personal and school-wide commitment in spite of the constant and often unreasonable demands made on schools that have time and again stood as barriers to lasting improvement.

Are You Ready? The Goldilocks Metaphor

Not every school is ready for the commitment to a school-wide mathematics and science reform effort. The complex question of whether or not this is the right time is well captured in the simple childhood story of Goldilocks. A school that is faced with other troubling basic concerns such as safety, attendance or even takeover by the state is not a good candidate for a long-term instructional reform effort. Similarly, a school that has no history or ability to work together as a community to address instructional issues has no "reform infrastructure" that can support whole-school improvement efforts. Such schools may be "too cold" to undertake a math and science reform effort. There is simply a lack of capacity and/or too many other, more demanding basic needs which require the attention and resources of the principal and staff.

On the other hand, a school which participates in many school improvement programs ranging from partnerships to curriculum pilot testing in all subject areas may be "too hot." Serious change efforts require focus – and a genuine commitment of time and energy from the staff. When a school is overextended (i.e. focusing on too many programs), the result is that they all lose their importance and the staff is not able to make the necessary commitment to any of them. The school that is "just right" for reform is the school that has a stable, clean, communicative environment and has the interest and desire to make the change. They have some history of reform but are not overwhelmed with numerous reform efforts sweeping through the school every year. The staff doesn't have to know everything; they just need to have the capacity to learn as they proceed.

This document is not meant to be a prescriptive, step-by-step manual for improving science and mathematics education in your school. Rather, we have instead designed this monograph to present the voices of past experience to help you make decisions that will most effectively work for you. We have tried to capture the words of other school principals reflecting on what they wish they had known at the outset, what they have learned along the way, and where they still need to go as their programs develop. We aimed to capture their experiences in order to help you, the leaders of new school-based reform efforts, be more careful, critical and thoughtful about your work. You will not find everything you need to know here, but after reading this monograph, you will better understand the issues you need to consider, the questions you need to ask, and where you might begin to look to find the answers.

# II. THE TASK

You may feel that your school is well positioned for a school-wide mathematics or science improvement effort, but aren't clear about what we mean by "ensuring that your students have a rich steady of high-quality instruction" in these disciplines. This section offers some explanation which can help you better define what is meant by high-quality instruction. And here we ask that you look beyond the common dichotomous arguments for traditional, progressive or other approaches to teaching; this process doesn't require you to favor one exclusively over another. Instead, use the constructs provided here to clarify your own vision for high-quality mathematics and/or science instruction and to better understand its relationship to standards-based, systemic reform.

## RICH AND AT-RISK CLASSROOMS

In our research we have had the opportunity to visit many classrooms and observe many math and science lessons. In doing so, we have seen a wide spectrum of quality. Some classrooms we can almost immediately identify as "rich." That is, there is a richness in the way that the teacher shares his or her content knowledge, in the resources that are used, in the teaching strategies that are employed, and in the multiple approaches to learning that take place. Because of the richness in the classroom, we think it is very likely that the teacher will succeed in helping most students become engaged in and learn math and science.

By contrast, we see classrooms that we would identify as being very much "at-risk" in terms of their likelihood to succeed in presenting math and science instruction to their students. An "at-risk" student is one who has an impoverished background, a current lack of support, and ultimately few available options as he/she strives to succeed in the world. Similarly, an "at-risk classroom" is one where the teacher has an impoverished background in science, few current supports, and ultimately few instructional options. Most principals we have talked with can recognize immediately to what extent the classrooms they are observing in their own schools are "rich" or "at-risk" in terms of the math and science instruction they are offering.

## "RICH" AND "AT-RISK" CLASSROOMS

- RICH CLASSROOMS:
  - Presence of materials and resources
  - Teacher is knowledgeable, confident, and interested in the discipline
  - Teacher has lots of instructional options
  - Student has multiple routes to success
  - Redundancy of supports
  - Environment of hopefulness

- AT-RISK CLASSROOMS:
  - Absence of materials and resources
  - Teacher is lacking in knowledge, confidence, and interest in the discipline
  - Teacher has few instructional options
  - Student has single route to success
  - Lack of redundancy
  - Environment of hopelessness

Characteristics of "Rich and At-risk" Classrooms as Defined by a Group of Principals

Rich Classrooms

- Students are engaged (paying attention, physically active, intellectually engaged).
- There is a lot of evidence of student work – with teachers and students paying attention to the work.
- Teachers are differentiating the way they work with individual students.
- Teachers are purposeful in their instruction and are clearly guided by a vision of the content they want students to learn.
- Teachers are knowledgeable and confident about teaching the subject matter.
- There is a sense of shared trust – students trust the instructional lead of the teacher, and the teacher trusts the students to make an authentic effort to engage in the tasks that are set.
- Teachers show multiple approaches, flexibility, and good judgment in choosing when to use a given strategy.
- Student thinking is valued and made explicit.

At-risk Classrooms

- There is air of uncertainty in the instruction.
- Teachers seem focused on procedures and not guided by an underlying vision of what students are to learn.
- There is only one source of knowledge, and one way for students to learn something.
- The teacher is the sole focus of the classroom.
- The teacher is clearly not interested in or confident about the subject matter.
- There is a sense of fear, tension, or distrust in the classroom.
- The sole motivation for learning appears to be external (e.g. the test).
- The students are not engaged, e.g. their heads are down on their desks and/or their eyes are "glazed over."

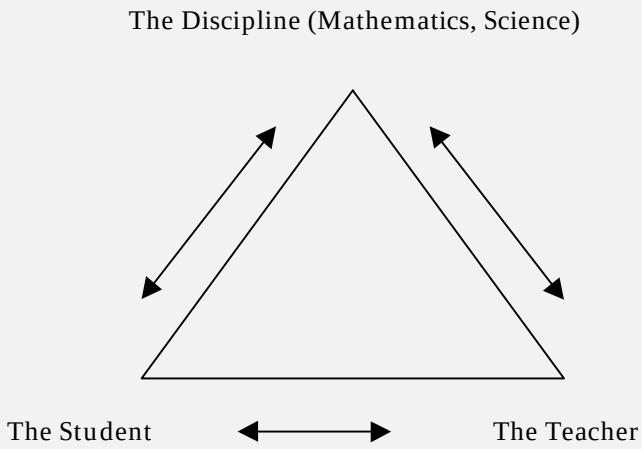
Generated by a group of principals in a workshop (May 1997, Las Vegas, Nevada)

To put it simply, the goal of the math and science improvement effort in your school is to increase the "richness" of the classrooms in your school vis-à-vis math and science teaching. The goal is also to decrease the number of classrooms that are "at-risk" in terms of their math and science teaching.

THE RELATIONSHIP TRIANGLE: A CONSTRUCT FOR CONSIDERING HIGH-QUALITY INSTRUCTION

One way to capture the characteristics of rich and at-risk classrooms in a single structure is to use what we call the "relationship triangle." Consider that the teacher, the student, and the discipline (in this case mathematics or science) are the three pivotal elements of the learning process. Then, place one of each of these elements at the corners of a triangle to represent a vision for high-quality instruction.

The Relationship Triangle for High-quality Instruction




Note that this triangle is about relationships. It comes from Martin Buber, representing the I-Thou-It paradigm. That is, the triangle suggests there is a very powerful dynamic that takes place when there is a three-part relationship between I, Thou, and some "It." In the case of teaching, it suggests there is a powerful learning dynamic that takes place when a teacher and student engage with each other around a shared interest in the learning of a discipline.

Note that the line connecting the teacher and the discipline is a double-headed arrow, suggesting that a strong teacher has a meaningful and long-term relationship with the discipline. (It is almost as if the discipline and the teacher were long-term friends.) You may well know, for example, a teacher in your school who is really interested in science, has a strong background in science, reads about it in the newspaper, watches NOVA, goes to museums, and genuinely enjoys learning more and more about science. Such a teacher certainly knows a lot of science content, but beyond that, he or she truly has a long-term multi-faceted relationship with the discipline.

Similarly, the line connecting the teacher and the student also is a double-headed arrow, suggesting that a strong teacher has a meaningful relationship with his/her individual students, built on authentic interest in them as individuals, and a genuine commitment to

helping them learn. Teachers need to know the interests of their students, how their students think about the discipline, and how they can be "reached" if they are to have "rich" classrooms.

A high-quality instructional experience, then, brings continuity to the triangle by creating a third double-headed arrow, this time between the student and the discipline. That is, it is the goal and authentic intention of the teacher to help develop the relationship between student and discipline. In such a classroom, the teacher is able help the students truly understand, appreciate, and cultivate a relationship with the discipline. It is clearly not enough in such a classroom for the teacher to help the student do well on tests; the teacher not only wants the student to learn the basic content knowledge, but, far more, wants the student to become excited by, interested in, and skilled at future learning in the discipline.

Characteristics of High-quality Mathematics and/or Science Instruction

- Each student experiences a variety of learning opportunities and teaching strategies designed to meet and engage his or her participation and motivation.
- Learning opportunities are authentic with regard to the real nature of mathematics and science.
- Each child pursues his or her own natural curiosity and the educational opportunities feed that curiosity and build upon it.
- Children discover for themselves by amassing evidence, making and checking hypotheses, searching for and finding patterns, theorizing and experimenting, making conjectures, providing relationships, and applying them to real and hypothetical situations.
- Children use equipment that is in harmony with the technological environment of the 21st century, and educational technologies that are aligned with the tools of mathematics and science – calculators and computers, rich data bases, and electronic networks and telecommunication systems.
- Each child works in teams or alone and enjoys the responsibility of his or her own learning.

From:
Science Education for the 1990s: Strategies for Change, Reflections on a 1991 Wingspread Conference.
Dr. Mark St. John, Inverness Research Associates.

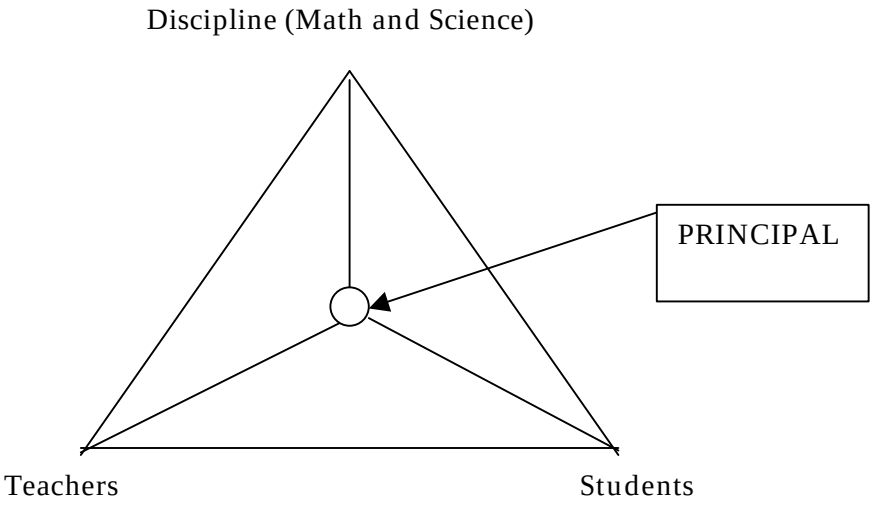
We can use the relationship triangle to contrast a "rich" classroom with an "at-risk" one – where there is no relationship triangle in place. In, say, an elementary classroom it may be that the teacher does not truly understand the conceptual underpinnings of the discipline. Even though he or she may love her children, the teacher does not have the ability to help them develop their own strong relationship with the discipline. In such an elementary classroom, science may not be taught at all. If it is taught, instruction is primarily reading *about* science, not doing it. Even if students do some so called "experiments," they are likely to be prescribed and static, not engaging, student-directed investigations. In such an elementary classroom, mathematics may be more likely to be taught, but in a classroom with a "weak triangle," it is done so in a manner which focuses on rote algorithms and arithmetic exercises only, and not at all on the fundamental concepts underlying mathematics or the dynamics of actively solving problems.

Or, say, in a high school classroom, a teacher may have only a superficial relationship with his/her students, and yet he/she loves his/her subject area. We once heard such a teacher say, "I am teaching the right mathematics, but the school keeps sending me the wrong students."

In such a case the teacher will fail to interest many students in the discipline because he/she can not help them connect with what it is that the teacher loves about the discipline.

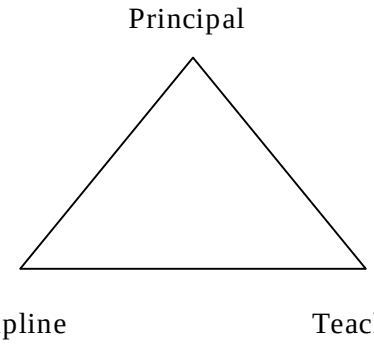
In a healthy classroom – that is, in a classroom that is rich in math and science – there is then a strong relationship between the teacher and the discipline, and the teacher and the students. But there is more than that. In a rich classroom the teacher has a rich repertoire of strategies and approaches for helping make the connection between students and discipline. That is, the teacher is not "at-risk" because they have only one approach, one way to teach the subject. Such a teacher may use inquiry-based activities to provide students with an experience of doing science, but they also may ask students to memorize terms when such an activity will productively promote their experience of success in the discipline. Thus, the relationship triangle includes multiple pedagogical approaches, and suggests that a high-quality classroom is not one that pursues only one method and one teaching philosophy.

Most principals interested in improving their programs have classrooms that vary greatly in their richness. They can identify almost immediately classrooms where the relationship triangle is strong; they can also identify classrooms where there is a "pathology" in one or more of the legs of the triangle. The goal of this report, then, is to help you move as many of your classrooms as possible from having a weak triangle to a strong one.



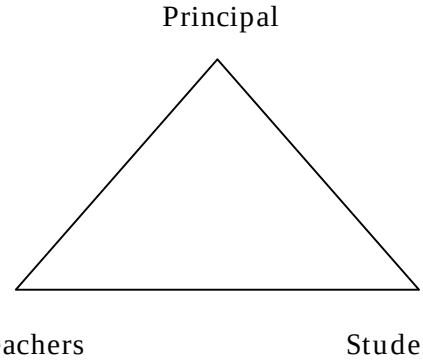

THE RELATIONSHIP PYRAMID

To extend our metaphor one might think of a "relationship pyramid" – where the principal is on the vertex of the pyramid. Then one can think of the relationships between principal and teachers, principal and students, and principal and discipline. Also, in this diagram, one can see that there are now three more triangles that are important. For example, consider the "western face" of the pyramid: there is a relationship between teachers, the principal and the discipline.

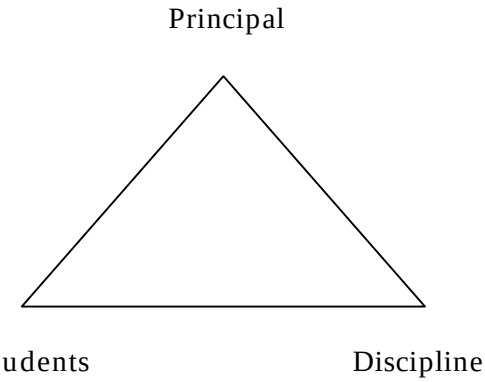



This triangle implies that it is important that the principal understand the individual teachers, that the principal understand the nature of the discipline, and that the principal intend that the teachers in the school develop a strong relationship with and understanding of the discipline.

Similarly, the "southern face" of the pyramid, suggests it is equally important that the principal have a strong relationship with the teachers as individuals and how they relate to their students as individuals. (In some sense this face of the pyramid relates to the health of the professional and working culture of the school.)




Finally, the "eastern face" of the pyramid illustrates the importance of having a principal who can understand how individual students learn and relate to the discipline. Thus, the principal needs, as teachers do, to understand the complexities of discipline-specific learning of children. That is, it is important for principals, if they are to be strong instructional leaders, to know something about how students master "number place" or how they become more skilled in conducting scientific inquiries.



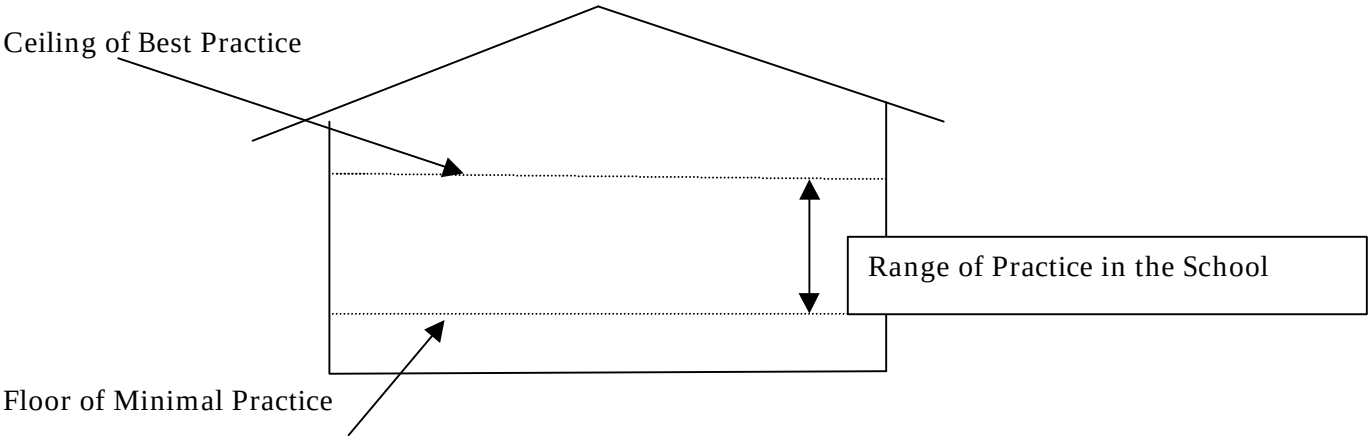

Hence, this diagram, although a little complex, clearly outlines the centrality of the principal in the process of creating math and science-rich classrooms within the school. It also suggests a way to understand what contributes to a school in which the classrooms are "rich" in math and science and not "at-risk" in these disciplines. We believe this diagram captures some important empirical truths, for in the best math and science schools we have visited, we have found principals who do indeed have strong relationships with the students, with the teachers, and with the disciplines they are teaching. Put in the opposite way, we think it is unlikely to find strong math and science programs in a school where the principal does not understand or appreciate teachers, students, and the disciplines.

## SETTING THE FLOOR AND THE CEILING

As you think more about the characteristics of high-quality instruction, you will begin to identify expectations for your teachers. It is important to remember that your teachers are at different starting points and that they will progress at different rates. For those teachers who find the process more challenging, it will be helpful for them to know your basic expectations – meeting those may be all they can handle at first. Likewise, for those who already advanced in their teaching or math and/or science and who want to "take off" more quickly, it will be helpful to know your ideal, or highest goals for instruction. We have found it useful to talk about these two ends of the spectrum as the "floor" and the "ceiling" for instruction.

The "floor" of instruction is the minimum acceptable level of instruction within your school. It is the least that any one student could experience and still have a "rich steady diet" of high-quality science or mathematics. It is the point beneath which you believe no teachers or students should fall. The floor, as you define it, should make sense on both a philosophical and a concrete level, and should avoid vague or rhetorical phrases. In fact, the most effective definitions of the "floor" are often comprised of simply stated expectations. For example, in one R&D school, the "floor" of the science program was: teach one science kit in the first year of the reform, two in the second year, and three in the third year and every year after that. Another school had similar expectations, but instead defined them in terms of students: "Every student in every class will experience two science kits taught well each year."

Sometimes, it can be difficult to define the "floor" with sufficient clarity and concreteness because there is a strong interest in honoring the autonomy of teachers. In these cases, the "floor" may not be something to dictate, but instead, to negotiate. As long as you and your teachers remain rooted in the shared vision that every child should have a rich steady diet of high-quality mathematics and science, the definition of "floor" you arrive at should work. If you find that your teachers absolutely don't want to make a commitment to that minimum, then reform is unlikely to work in your school. There must be a point at which the whole school has to say, "yes, we want to define a floor and we will work to set it in place."




FLOOR AND CEILING

Setting the floor is essential, but it is not sufficient for providing guidance for a high-quality mathematics or science improvement program. Teachers also need to understand the ideal toward which they are heading. Thus, you also need to continually "raise the ceiling." The "ceiling" is the best instruction you could hope for and will emerge in the teachers who develop a deep commitment to the content and pedagogy of the reform (the ideal teacher in the strong relationship triangle). Raising the ceiling requires that your program provide continuing support and professional development for these teachers so that they can become artful practitioners and can in turn serve as examples and leaders for their colleagues.

Thus, to summarize, there are two distinct and quite different tasks involved in improving the teaching and learning of math and science school-wide.

- The first task is to provide sufficient supports so that it is possible to establish a floor of math and science math teaching within the school. This setting of the floor involves a clear specification of – and agreement on – the minimal level of classroom practices which comprise a sufficiently rich set of learning experiences for the school's students.

- The second task is to provide a multitude of enrichment experiences and other resources so that the more advanced, interested and committed teachers can continue to raise the ceiling of best practice within the school.

How to Set the Floor and Ceiling

A strong floor for an elementary science program begins with high-quality curriculum materials. Once materials are selected, it is essential that all teachers have sufficient supplies (teacher's guides and manipulatives). Science is taught three times a week, but is also tied to other subject areas as is appropriate. Some schools also develop strong connections to their language arts program by purchasing class sets of trade books which focus on topics under study in science. With these elements as a minimum, your students are sure to get a "rich steady diet" of science learning.

Of course, you don't want your students' science learning to stop at the minimum. You are sure to have teachers who are naturally interested in science and including more science in their classrooms. They will facilitate projects that grow out of their students' interests by providing materials, access to information, and helping the students design investigations which will get them closer to the answers they seek. They also will invite science-knowledgeable guests to come to their classrooms and be resources for their students, on occasion inviting the students to their workplaces as part of their continuing investigations. They will encourage students to participate in other science-related activities and help students learn more about how they can expand their interests. These teachers will comprise your ceiling.

One example of a floor set by a school involves elementary mathematics. The school decided to adopt and use the TERC Investigations Curriculum. It was decided that all grade levels would use the curricula and teach at least three units per year. In addition, each class would also do mental mathematics and basic math skills practice. Finally, they agreed upon some minimal level of use of the computer in the teaching of elementary mathematics as well.

Providing Concrete Examples of High-quality Mathematics and Science Instruction

As you work to establish a floor and raise the ceiling in your school, it is extremely important that you provide your teachers with concrete examples of high-quality mathematics and science instruction. Even if you and any teacher leaders you have convey expectations clearly and provide sufficient opportunities for professional development, nothing will substitute for providing your teachers with opportunities to view other teachers' instruction (whether in person or on video tape) and discuss what they see. Following are some sources of commercially available video tapes that will provide examples of science and mathematics instruction you and your teachers can discuss:

*Sense Making in Science Video Series*
*Heinemann Publishers*
*360 Hanover Street*
*Portsmouth, NH 03801-3912*
*1-800-541-2086*

*Science First Hand Video Series and*
*Science IMAGES Video Library*
*The Annenberg/CPB Collection*
*Dept SB3, P.O. Box 2345*
*S. Burlington, VT 05407-2345*
*1-800-532-7637*

*Teacher to Teacher Video Series*
*Mr. Wizard Foundation*
*44800 Helm Street*
*Plymouth, MI 48170*
*1-800-258-2344*

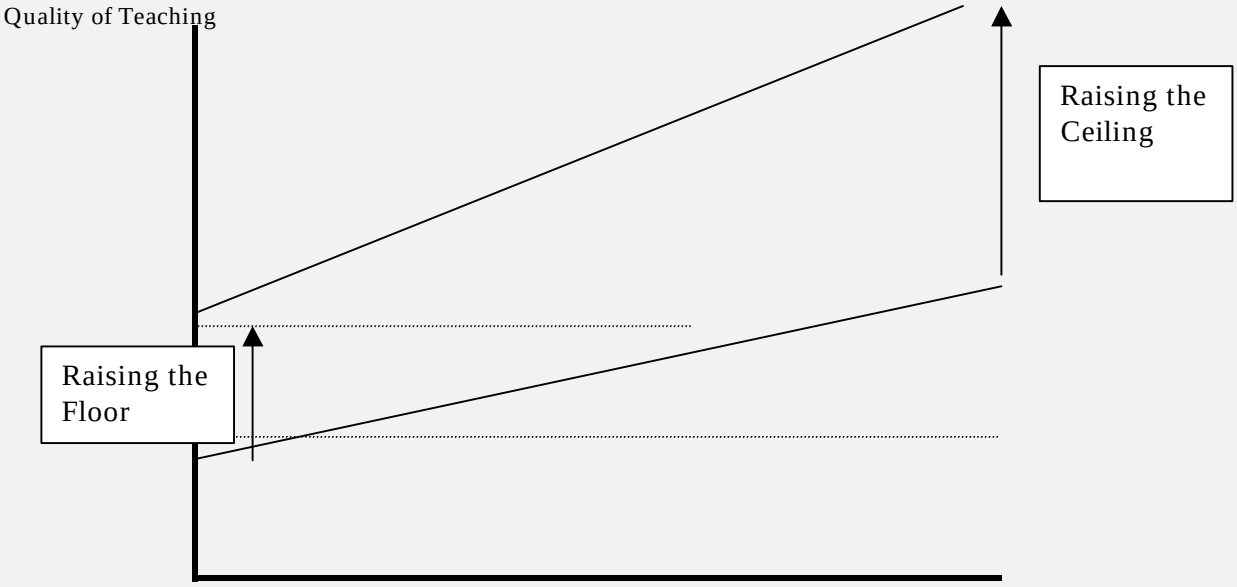
*Talking Mathematics Videos*
*Heinemann Publishers*
*361 Hanover Street*
*Portsmouth, NH 03801-3912*

Keep in mind that over time, if you continue to support the floor and raise the ceiling, classroom practice in your school will not get more and more alike; rather, it will become increasingly varied. Often, schools have a pocket of teachers who are already interested in

improving their science or mathematics teaching and "take off" when they become part of a school-wide change effort. At the same time, you are likely to have teachers who find it very difficult to make the changes necessary to get to the floor and are unlikely to move very much beyond. Given this variation, you can maintain coherency by finding ways to use the "ceiling-raising" pocket of teachers to help the others. By working with their colleagues, these teacher leaders can "bring up the floor" and at the same time develop and refine their own skills.

Differences in Teacher Development

Graph of teacher growth showing the different trajectories of development.




Note that as a school works to improve the overall quality of the teaching of math and/or science in its classrooms, teachers start in different places and they end in different places. That is, the improvement effort does not result in uniform quality. In fact, it may very well be that the most committed and interested teachers improve even more than those who are less interested or experienced. In every classroom the teaching quality improves, but this does not mean that there is equality in the outcome. Thus, one must be willing to accept even greater discrepancies in the quality of teaching as the reform movement proceeds.

## YOUR ROLE IN THIS TASK

Even the best plans for improving mathematics and science programs in schools will not work unless there are strong people who can make those plans a reality. Successful improvement efforts require leaders who are strong individually, and who can work collectively as part of a school-wide team. Though school-wide reform efforts must involve a range of individuals (including classroom teachers, district administrators, parents, and community members), this monograph focuses primarily on you, the principal, because in any whole-school change process, the principal is key. The principal is the "gatekeeper" of activity coming into the school, of the messages that are communicated to staff, and of the communications that go to the outside community.

After closely studying many schools, we found that principals' roles can vary widely depending on individual style, the organization of the school and the decision-making structures of the district. You might be working in a more "traditional" principal's role, or you might be part of a site-based or shared-decision making team. Still, successful principals share some common characteristics. They always have their 'finger on the pulse' of progress, and are just as aware of what is happening inside the classrooms as they are about what is happening in the school as a whole, and in the district. They easily identify and refer to specific instances of exemplary practice and recognize and praise the work of individuals who are helping the school move ahead. In sum, they actively participate in the effort at a variety of levels and have *firsthand knowledge* of what is happening.

Throughout our research, many principals expressed an interest in learning from other principals like themselves. The rest of this monograph highlights the "words of wisdom" they say would have helped them at the outset. It includes advice about your specific roles and responsibilities, the roles and responsibilities of others in the school community, the qualities and characteristics of individuals who fulfill those roles successfully, and the ways you can support them. This knowledge, we hope, will help you point your initial effort in the right direction and develop in yourself and others the capacity to implement and sustain meaningful change.

One Successful Principal

Since Pauline Selby has been principal, dramatic changes have occurred in her inner-city middle school. Attendance is up 14%; new, energetic recruits from science programs and from the medical profession have joined the teaching staff; community leaders have become more active in supporting school efforts; and the principal and other lead teachers have been called upon to run workshops in the district.

Pauline Selby takes risks for the school, serving as a model and inspiration for her teachers. She uses any forum to advocate for her school, and makes her school visible to the community. Right from the beginning, she has brought the whole community into the school, staging various symbolic "celebrations," such as a retreat with students, parents, and feeder schools to shape the vision for reform, and a "marriage" ceremony to celebrate the commitment of the school to the principles of reform.

Although she is unequivocally "the school principal" and is very present in every aspect of the school, the thrust of her work is carried out via connections and communication (within and outside the school). She promotes leadership opportunities in all aspects of school governance. This leadership serves as a communication channel as well as a fomenter of change. For instance, aside from establishing the compulsory site-based management team and other structures to ensure that many avenues of communication exist, Ms. Selby appointed three vice-principals from whom teachers could get support and information in three different areas. She also redefined people's roles and responsibilities so as to build a critical mass of leaders. For example, she asked select teachers to be "coordinators of student affairs" – not only to focus on building leadership among students, but also among teachers. These teachers functioned as "deans" of the mini-schools, attending leadership meetings, departmental meetings, and mini-school planning. These coordinators serve as links between all levels of the school and improve communication and clarity about the MST vision.

Ms. Selby has led sessions for her teachers on various aspects of change, including one on how to keep a portfolio of their own growth. She has also taken "her show" on the road. District-wide, as a member of the district advisory team, she gave a workshop for principals on MST inquiry, the statewide school assessment process, and on "how to light fires." Outside of the district, she has become involved in networking with other districts involved in NSF reforms, and has promoted the expertise of her teachers, encouraging others to draw on them.

**The Probability of a Successful Reform Effort**

In our work with many different reform initiatives we have come up with the following equation to describe the probability that any individual effort will succeed:

$$\text{Probability of Success} = \frac{L + D + RI + \$}{S + P + F + T + RO}$$

*Where*:

L = Leadership (People with expertise, commitment and political power who can advance the cause of math and science reform)

D = Design (Well-designed curricula, professional development, and overall change plans)

RI = Reform Infrastructure (The ability of a school or district to carry out reform activities such as planning, text adoptions, dissemination, etc.)

$ = Discretionary dollars available for math and science reform activities

*And*:

S = Scale (The scale of the district or school matters. The larger the scale, the more inertia the system has and the more likely the system is to fragment itself.)

P = Political turbulence (The more political dissension that surrounds issues of reform the less likely the system is to take significant action.)

F = Financial turbulence (If a school or district is suffering from financial cutbacks and financial crises, then reform is not likely.)

T = Turbulence in the system (Staff turnover, new administrators, new standards and assessments, and restructuring are all events that create instability in the system and make it more difficult to pursue long-term reform.)

RO = Reform Overload (If there are too many reform efforts, it is very hard for any one of them to succeed.)

The relevancy for principals is this: At best reform efforts are uncertain. But there are some important factors that principals can influence. Principals can bring their own leadership and help to foster additional leadership in their own school, and in the district. Principals can help create supports that allow teachers to learn about well-designed curriculum and well-designed professional development. Principals can also help to arrange for discretionary dollars to be used strategically in support of a long-term school improvement effort. While not guaranteeing success, all of these actions will greatly increase the probability of success.

# III. THE PROCESS

## OVERVIEW AND INTRODUCTION TO "THE PROCESS"

We have found that a successful process of school-wide change includes the following four components:

- Setting the Foundation;
- Building Critical Programmatic Supports;
- Building Critical Relationships; and
- Sustaining the Process

These components are not completely sequential, nor do they take place in isolation from one another. They develop concurrently and all need to be incorporated into a school's overall plan for change.

The best school plans are not complex; most begin with two basic premises. The first is the importance of a commitment to, and belief in a high-quality mathematics or science program. The second is the fact that significant change in classroom practice can not take place without a commensurate co-evolving change in the school as a whole. In trying to change just one subject area, successful schools address much more; mathematics and science is just the tip of the iceberg. Over time, they develop professionalism, improve their public relations and reputation, increase communication, and develop internal resources and capacity. The strategies laid out in their plans move beyond the narrow focus of a single discipline and support broader school-wide change.

The following sections of this monograph will share aspects of those plans, insights about these four components, and the ways they co-evolve. They will describe the critical dimensions of the improvement process, strategies for moving the process ahead, and the roles and responsibilities that key players in the school community play. Throughout the monograph we include illustrative examples from schools in our research which illuminate common issues, strategies and concerns shared by principals across the country.

## SETTING THE FOUNDATION

Once you have decided to seriously consider a school-wide reform, you will need take your first steps toward putting a foundation in place. Here, those steps are grouped into three sections: A) Conduct a School Self-assessment; B) Develop Common Vision; and C) Identify and Build Leadership. These steps don't operate in isolation, nor do they need to take place in a rigid order. Rather, you should adapt them to accommodate the context of your school so that your and your staff's knowledge and skills can co-evolve with mutual support as your school program grows.

### *A. Conduct a School Self-assessment: Make an Honest Appraisal of Yourself and Your School*

As we have noted, not every school is ready to initiate a science or mathematics reform effort. Even with the best intentions, you may simply not have sufficient time to learn about standards-based mathematics or science reform, or to get the implementation of such a program off the ground. Even if you are personally committed to initiating the reform, it still may not be an appropriate time for your school. This kind of change can not be done single-handedly; there must be others in the school who care about the program and will commit to seeing it through. You will need to assess not only your personal priorities, but also those of your staff to determine the extent to which your school is positioned for reform.

The appraisal of your school should include three main components:

1. Make sure the "basics" are in place.

   Any new program, whether mathematics, science, or another subject, will not take root and grow unless "the basic necessities" are already in place. By "basic necessities," we are referring to the requisite cleanliness, safety, organization and processes that support a basic health and comfort level of staff and students. Maslow's hierarchy tells you that reform can only happen when survival issues are handled. Some schools have tried to launch mathematics or science improvement initiatives without these basic elements securely in place, thinking that the reform program itself would help them improve. But when a school isn't functioning well, investments in science and mathematics reform are engulfed in the larger organizational concerns.

   Of course, no school is perfect; there is always room for improvement. Some principals who are wise enough to recognize where improvement is needed have found ways to address their broader school-wide needs *through* their mathematics or science reform. One school leadership team, for example, decided that "getting their house in order" through revamping their communication and management structure, would be the first step in revitalizing the school and preparing it for a more focused effort on improving mathematics. Once the rest of the staff saw the initial changes in their environment, momentum built for increased, in-depth change in mathematics.

A School that Put the Basics in Place

Adams Elementary is a school rich with innovative thinking, collaborative leadership, and commitment to reform. The staff is proud of the school (once considered one of the worst in the district) and its new emerging reputation as a lead school. During a series of their regular meetings, the faculty decided to pause to reflect on the progress they had made so far. In doing so, they noted that the change in their physical environment had an enormous impact on their work. They wrote, "A clean, safe environment was one of the first priorities set by the administration. To this end, one administrator focused endlessly on the daily grind of maintaining order, covering duty posts and maintaining discipline. This allows the rest of the staff to spend their energy on innovative teaching and facilitating learning."

2. Know the actual status of mathematics or science teaching.

   While many principals say they know the status of mathematics and science in the classrooms of their schools, they in fact have little firsthand, concrete knowledge or awareness of what is really happening. Just as a teacher needs to understand what a student already knows before trying to teach something new, so must you understand the current status of mathematics or science teaching in your school before attempting to initiate a change. As principal, you need to know how much mathematics and science is taught; what topics are being taught; how they are being taught; what materials teachers are using; and what learning goals teachers have for students. Even if your school or district determines curriculum and instruction in a very centralized manner, those mandates may have little or no connection to actual classroom practice.

   This may not be easy at first; you will need to visit your teachers' classrooms frequently enough so that you both feel comfortable discussing the content and pedagogy of classroom instruction. Once you learn about the strengths, you can take steps to preserve and take advantage of them. Once you have identified the weaknesses, you can develop strategies for addressing them. Put simply, you have to "know the playing field" before you start the game.

Self-assessment Tools

There are a number of tools which you may wish to use to assist you in learning more about the current status of mathematics and science instruction in your school. These include classroom observation protocols, checklists, guidelines and surveys. Sources of some of these tools are listed below:

*Hands-on Science Program Questionnaires*
Hewlett-Packard Company
Palo Alto, CA 94301

*Elementary School Science Programs Guidelines for Self-assessment*
National Science Teachers Association
NSTA 1742 Connecticut Avenue, NW
Washington, DC 20009
(202) 328-5800

*Elementary School Science for the 90s*
Association for Supervision and Curriculum Development
1703 North Beauregard Street
Alexandria, VA 22311-1714
1-800-933-ASCD Fax: 703-575-5400

*Getting Started in Science: A Blueprint for Elementary School Science Education*
The Network
300 Brickstone Square, Suite 900
Andover, MA 01810
(508) 470-1080

3. Identify the "culture," existing philosophies, and other reforms already in your school.

   Before you begin, it is important to consider whether a standards-based mathematics or science reform effort is appropriately aligned with the existing culture and overall direction of your school. By "culture" we mean the prevalent beliefs, attitudes and priorities of your school that together make it a unique place. Some schools may already have a philosophy in place that directly conflicts with inquiry-based mathematics or science. Other schools, however, may have a compatible philosophical foundation (e.g. child-centered education) which can facilitate the progress of an inquiry-oriented mathematics/science improvement effort. You need to learn where your school falls on the spectrum between these two poles, and conceptualize an improvement effort that is compatible with the existing philosophical perspective of your school.

   You also should look critically at the programs or reforms already in your school. Schools that try to make too many changes at the same time run the risk of having none take root. Furthermore, any programs that are already in your school must be philosophically aligned with the content and instructional goals of standards-based mathematics and science. If they are not, your efforts to improve mathematics or science may be defeated before they actually begin.

   If your school doesn't already have a predominant instructional approach or philosophical direction, you may find that one will grow out of your reform effort. In some schools we studied, as mathematics and science programs evolved, so did the

classroom practice in other subject areas and eventually the whole culture of the school. In fact, in some cases the change in culture was visible even before changes in content and pedagogy began to appear in classrooms. You may even find that as you and your staff plan and work together over time, you will build collaborative professional relationships and develop a coherency in your school that you did not have before.

Using the information gathered through this appraisal you will need to decide whether you will be able to manage the everyday complexities and competing priorities of your school as well as those associated with a mathematics or science reform effort. Principals who are most successful at striking such a balance are those who identify ways that mathematics or science improvement can serve their already existing priorities; all improvement programs can complement each other and point in the same direction. If, upon considering all of the information, you find that this is not the time for a full-scale mathematics or science reform initiative, you can still prepare your school to take on such a reform in the future by beginning the process at a lower "trajectory," or rate of change. Mathematics or science may not be your top priority immediately, but you can still make slower, incremental improvements until such time that the school is ready to commit to a broader change.

Self-assessment Questions

- Is this an appropriate time for the school?
- Who is going to see reform efforts through?
- Are there others in the school who care?
- How is that care going to be nourished and supported?
- What are the other priorities that might compete with science and/or mathematics reform?
- Are there any basic school-wide issues that must be addressed first?
- Are there other subject areas that the community and/or district are focusing on more?

### *B. Sharing and Reaching a Common Vision*

"Vision" is a much-used word that often suggests vague or ill-defined ideas. Here, however, by suggesting that you should have, and share, a "vision" for your mathematics or science reform, we mean quite the opposite – that you should have clear, concrete goals. You might consider these goals in four areas:

- a vision for classroom practice;
- goals for school-wide mathematics or science programs;
- a clear picture of student experiences and learning outcomes; and
- an envisioned scenario for the process of school-wide change.

We have found that the principals who can identify goals in each area are those who, at the outset, devoted time to understanding what standards-based science and mathematics is, what it looks like in a classroom, and what implications it has for children's learning. Their goals are both visionary and specific, striking a balance that helps the school staff understand where they're headed and why. Some of the advice these principals have to offer is below.

1. Have and protect a "vision" for science and mathematics teaching and learning, but share it widely. This vision should be both lofty and concrete and the basis of agreed-upon community standards and expectations for student learning.

   Principals who have successfully initiated a school-wide change program in mathematics or science know what high-quality instruction looks like, and always keep a clear image of it in the forefronts of their minds. The strongest principals don't compromise on that. While they may not necessarily perceive themselves as being "instructional leaders," they know exactly what kinds of instructional experiences they want their children to have. As you initiate a program in your school, such clarity of vision can make the difference between a reform that is comprised of coherent, complementary activities and one that is merely a collection of perhaps useful, but disjointed and unrelated activities.

Guidelines for Informing a Vision for Your School (adapted from the National Science Education Standards)

| CHANGING EMPHASES ON TEACHING | |
|---|---|
| LESS EMPHASIS ON | MORE EMPHASIS ON |
| Treating all students alike and responding to the group as a whole | Understanding and responding to individual student's interests, strengths, experiences, and needs |
| Rigidly following curriculum | Selecting and adapting curriculum |
| Focusing on student acquisition of information | Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes |
| Presenting scientific knowledge through lecture, text, and demonstration | Guiding students in active and extended scientific inquiry |
| Asking for recitation of acquired knowledge | Providing opportunities for scientific discussion and debate among students |
| Testing students for factual information at the end of the unit or chapter | Continuously assessing student understanding |
| Maintaining responsibility and authority | Sharing responsibility for learning with students |
| Supporting competition | Supporting a classroom community with cooperation, shared responsibility, and respect |
| Working alone | Working with other teachers to enhance the science program |

| CHANGING EMPHASES TO PROMOTE INQUIRY | |
|---|---|
| LESS EMPHASIS ON | MORE EMPHASIS ON |
| Activities that demonstrate and verify science content | Activities that investigate and analyze science questions |
| Investigations confined to one class period | Investigations over extended periods of time |
| Process skills out of context | Process skills in context |
| Emphasis on individual process skills such as observation or inference | Using multiple process skills: manipulation, cognitive, procedural |
| Getting an answer | Using evidence and strategies for developing or revising an explanation |
| Science as exploration and experiment | Science as argument and explanation |
| Providing answers to questions about science content | Communicating science explanations |
| Individuals and groups of students analyzing and synthesizing data without defending a conclusion | Groups of students often analyzing and synthesizing data after defending conclusions |
| Doing few investigations in order to leave time to cover large amounts of content | Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content |
| Concluding inquiries with the result of the experiment | Applying the results of experiments to scientific arguments and explanations |
| Management of materials and equipment | Management of ideas and information |
| Private communication of student ideas and conclusions to teacher | Public communication of student ideas and work to classmates |

The clear vision necessary for improving science and mathematics instruction doesn't come from reading a single book, attending a single meeting, or having one conversation. It develops over time and often emerges from experiences shared amongst your school staff. This notion of sharing a vision is key, and yet it is one of the greatest challenges of reform. It is not enough for you to have a vision; the commitment to inquiry-based science and mathematics instruction must be mutually held amongst all of your school staff. There is, of course, a paradox here in that you want your staff to "own" the vision, but you also have some specific ideas about what you want that vision to be.

The challenge, then, is balancing your own commitment to a vision with the need to develop ownership of that vision in others. Throughout your reform, you will be faced with the constant dilemma of how to share decision making while still providing strong and sometimes directive leadership and guidance. Negotiation of this balance can be a challenge, but it is a critical step. Even when holding fast to their visions, the most skillful principals create a culture in which the reform does not appear to be "top-down." They don't compromise on their visions, but they work collaboratively with the teachers to determine the best way to get there.

Your school may or may not operate with organizational structures that lend themselves to this kind of shared vision development. You may need to use ad hoc meetings, informal conversations or existing teams and committees to move the conversation along. Some principals begin by sharing their initial visions with a few teacher leaders. Others invite the entire staff into initial discussions. Or you may find, as one principal did, that you have to simply come out and say:

*In this school, children need to have a steady diet of rich science and mathematics learning. I don't think that currently exists… But I have a vision about that, and I want to generate a shared agreement about it and raise a discussion in the school to determine if that is what we all want… and how we might all work together toward that end…*

In the most successful schools, teachers feel very empowered and excited about the reform even though the principal has played a very active role in setting the direction and putting it in motion. Even when there is a democratic process in place, the most savvy principals still work very carefully to ensure that it doesn't get "off-track."

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One School's Process for Developing a Vision

The vision at Johnson School emerged from the entire staff of the school – they created it together and as a result, they all felt a collective sense of ownership. The teachers began the process of developing their vision by spending one school year visiting other schools, going to conferences, participating in workshops, and researching educational communities. These visits were focused on identifying strategies or programs that they thought might work in their building. Then, they had many meetings, facilitated by fellow teachers, to set both long- and short-term goals. During these meetings, they asked themselves questions such as: Where do we want to go from here? What do we need to get there? How will we know when we are there? Their very concrete goals – centered around classroom practices – ultimately evolved from these and other informal conversations and involved all members of the school staff.

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2. Be explicit about goals and expectations at all levels (classroom practice, school program, student learning outcomes, and the process for change). At the same time, remove barriers and provide supports and make sure everyone is aware you are doing so.

   Once you reach agreement on your vision, everyone in the school needs to have a clear understanding of how to accomplish it – what is expected of them, and what they can expect from others. Continuous, up-front discussions, agreements and ground rules are important. You should begin with introductions and orientations to the work that strike a balance between motivating the school community and challenging them. Then you will need to take the next essential step of conceptualizing the improvement process and generating specific expectations through consensus with your staff.

   You will find that this process may require continuous negotiation. You may even find that at times it is more a game of "let's make a deal" than it is a school improvement effort. You might consider offering your staff a "contract" of sorts: You will provide all supports your staff needs, and eliminate the barriers; in return, they must be willing to meet their responsibilities. You are essentially saying, "If you are willing to commit to this effort, I am willing to commit to supporting you in every way possible." The hesitant teacher will then have no excuses and the eager teachers will be pleased with your support. This kind of explicit bargaining is sometimes the key to generating the seriousness and the good will you need to effectively get your improvement effort off the ground.

Getting a "contract" in place may not be easy. Your teachers can find many reasons (some of them quite legitimate) for *not* changing the way they teach mathematics and science. Perhaps they are intimidated, frightened, or uninterested, or they may be wary of investing time in a reform that might follow the path of past reforms and eventually disappear. You may need to work with your staff to identify their reasons for not changing their practice and address those reasons one by one. Ask them what barriers they are facing, what is impeding them from teaching or providing rich experiences for students, and then get rid of those things – quickly, and visibly. Concurrently, provide them with the supports they need (instructional materials, professional development, and time). When you do so, make sure that everyone notices; you are sending a signal that the reform is important.

Removing the Barriers

Washington Elementary was a school new to science educational reform. They were part of a district-wide effort to improve science, but were to a great extent left on their own to create a plan that would lead to successful implementation of the curriculum. Washington had a number of teachers who were resistant to teaching science, so the lead teacher and principal developed a simple plan for success: spoil the teachers. They decided to identify the barriers that could get in the way of implementation of inquiry hands-on science, and remove them.

More specifically, the first step they took was providing teachers with sufficient materials. Although they got some materials from the district, they ensured that all teachers would have the materials they needed by writing a grant to a local foundation. This grant allowed them to clean out their science room, purchase new materials, and support the salary of a science aide. This aide did more than prepare materials, she also knew the lessons and provided valuable support to the teachers. They also decided to establish a science room and a schedule for its use. Now every teacher is scheduled into the room at least twice a week and is expected to teach science in their own classrooms on other days. The room is quite large, equipped with tables, and science-related books are out and available, as are live animals on carts that can be signed out to classrooms. Finally, the principal and lead teacher made sure that the school's teachers all attended training sessions that were offered by the district. They found attendance at these sessions to be a critical factor in teachers' enthusiasm and success with the materials.

The leadership at Washington knew that even when teachers are enthusiastic about teaching science, a science reform program can easily fail when there is no support for training, materials or space for materials. By eliminating all of the reasons a teacher might cite for not doing inquiry science, the principal and lead teacher at Washington created an environment in which even teachers who dislike science are willing to do it and succeed.

Below is a summary of some of the basic expectations that principals leading reform efforts hold for their classroom teachers:

- *Participation*

If there is one commitment that classroom teachers in your school need to make, it is to *participate* in the improvement effort. In this context, "participation" has a very rich meaning. It suggests that teachers will commit to changing their classroom practice by using any new instructional materials you (collectively) select; they will use the materials (at least at first) as written; and they will participate in the aligned professional development activities. This is core of the teachers' side of the "bargain" – you agree to provide supports and remove barriers and they agree to work with the program to the best of their abilities.

- *Participation Over Time*

As already mentioned, change will not happen in one month or even one year; it takes time. Therefore, teachers' participation has to be continuous and long-term. We already assume that you are going to make a commitment to focus your school on the mathematics or science reform for least two years. Your teachers will need the first year to simply familiarize themselves with the materials and strategies of standards-based mathematics and science. It isn't until the second year that they will begin to use the materials and strategies in their classrooms comfortably. Beyond that, it can take a few years to develop and enjoy the interactions with students, the interactions with the discipline and the learning that happens in the classroom. If you as principal can provide sufficient supports for that duration, then the classroom teachers should be able to continue to develop their expertise and maintain their commitment to the reform.

- *View Themselves as Learners*

The inquiry-based approaches to instruction found in standards-based programs place a strong emphasis on the developmental nature of learning for children. Children are encouraged to be self-directed learners who enjoy not only *answering*, but also *asking* questions. Just as your teachers try to develop these skills in their students, they too should view themselves as inquirers and as learners – willing to identify their own weaknesses and develop their skills. As long as they have sufficient materials and ample opportunities for professional development, they should continue to progress.

- *Engage in a Dialogue*

An important part of developing expertise in any teaching practice is discussing and getting feedback from others. Your classroom teachers can get feedback from you, teacher leaders you have identified, or their colleagues next door. At the same time, they should expect to contribute to a school dialogue about the mathematics or science program, its goals, and the progress the school has made. Their needs can not be met unless their successes are shared and acknowledged and their issues and concerns are discussed with you, and with each other.

### *C. Identifying and Building Leadership*

Leadership lies at the heart of a successful mathematics or science educational reform effort, and that leadership begins with you, the principal. But no principal can lead a reform effort alone. You must find ways to engage other individuals not only in the philosophy and beliefs of the reform but also in translating those beliefs to the hard work of implementation.

Most often, these other supportive individuals are "teacher leaders" who serve a range of functions and have a variety of responsibilities. Some schools are fortunate enough to have access to a fully released teacher (supported through district and/or grant funds) who provides part-time support (professional development, coaching, demonstration lessons) to classroom teachers. (These full-time teachers are sometimes called "teachers in residence," "teachers on special assignment," or "teacher consultants.") They can be a very powerful force for reform,

and in some programs work part-time in the school, and part-time in a district-wide role. More commonly, however, principals must rely on their own staff and create opportunities for their teachers to support one another. In some schools, for example, teacher leaders are given an extra planning period during which they are expected to work with other teachers in the building. In others, each grade level selects a teacher representative to be part of a planning committee that meets before or after school. Schools that are part of larger, district-wide programs may have one or two teachers who are the "point people" for the reform, while others may have a single teacher leader who works very closely with the principal.

Selection of leaders is a critical step in the process. As you consider your school's "readiness" and assess its current strengths and weaknesses, think carefully about what leadership approach might work for you. Think very carefully about who the potential leaders are, what strengths they have, and how you will be able to nourish and support them along the way. You will find some helpful advice below.

1. Strategically identify and develop leaders in the school who might be interested in, and are capable of playing leadership roles.

   Teacher leaders are a critical element of a successful mathematics and science improvement program; when identifying these teachers, many principals and programs falter. Some principals identify young teachers who are already excited about the discipline or familiar with inquiry-based pedagogy. Though these teachers can be enthusiastic and eager, they may not be the best choices because they don't necessarily have the recognition and respect that teacher leaders need. Other principals select teachers who are bored, or "tired," thinking that the leadership role will energize them. While some teachers do in fact get rejuvenated from participation in reform, this isn't a good strategy; just as the reform isn't going to mend problems in the school as a whole, placing ill-suited teachers in leadership positions won't mend their problems either.

   As you think about possible leaders, you may find that you are considering some of the teachers who already are recognized as leaders in the school. They may indeed be qualified, skilled leaders for this effort, but you need to consider the possibility that, *because* they have been leaders in the past, they may not be the most appropriate choices now. In many cases, teachers who already are recognized as leaders are accustomed to a particular kind of program and a particular kind of leadership. Standards-based school-wide change, however, requires a different conception of leadership than you and your teachers are likely to have experienced. Choose leaders who can adopt this new way of thinking and perhaps appoint an assistant leader who will support the "operational" aspects of the program (e.g. attending to all materials' distribution). Then you may invite others (e.g. an outside coach) who are more skillfully able to conduct inquiry-based instruction and do the classroom modeling.

   The most successful principals identify a group of potential leaders who have different, but complementary strengths. Not every teacher wants to be in a school-wide leadership position, but every teacher may be able to make valuable contributions. Some may be appropriate to be mentors. Other teachers may not be skilled at coaching, but have excellent management and organizational skills. Others may simply have inspirational

classrooms. Strategically bringing together such complementary individuals can be a powerful combination for helping a school progress.

An Exemplary Teacher

A resource and inspiration, Stuart Davis' classroom is filled to the brim with materials he has stockpiled over the years, all of which are neatly organized and accessible to the students and his colleagues. He models dedication and collegiality in everything he does, from spending his summers helping students enrich their math skills, to sharing his materials and expertise in informal and formal ways throughout the school. Like many successful teachers, his priority is the students. He expects his students to develop "habits of learning" in order to take control over their learning, and models the discipline and orderliness that enable such "habits" to form. His goal is to get his students to a point where they don't need him anymore, where they are self-sufficient learners.

Stuart Davis plays an active part in informal and formal professional development support within his school. In this area he is also a model. A former shop teacher who retrained himself to become a math specialist, he symbolizes the spirit of restructuring. He has led in-service workshops, collaborated with the district math coordinator, and generously shares his ideas on methods and curriculum development. He is frequently used as a coach, demonstrating problem-solving approaches to colleagues and supporting classroom practice of novice teachers.

2. Keep an eye out for teachers who may emerge in this role.

   Although you may need to identify some leaders at the beginning, you will find that as the reform picks up momentum, other teachers may emerge, even from the least likely places. In fact, you may wish to forego any selection of teacher leaders and instead introduce the reform to everyone and see who is eager and interested. You may be surprised and find a leader in a teacher to whom you have never turned before.

3. Identify the leadership structure that will work best in your building.

   Your approach to leadership should be tailored to your situation. Some schools, for example, choose to organize a committee to take responsibility for the mathematics or science program. The committee might include one representative from each grade level, one representative from the primary and upper grades, all of the science or mathematics teachers (in a middle school), interdisciplinary representation (in a middle school), or it might simply be made up of volunteers who are interested. Other schools may use their existing site-based decision-making group, or delegate primary responsibility to one member of that group who then convenes a group of interested non-committee members. Regardless of the structure, these leadership groups must have one thing in common: they must have authority and power to make decisions, or have immediate and direct access to you so that you can make the final decisions. Without this clear, demonstrated authority, the credibility of the group and of the reform will quickly diminish.

4. Use a team structure, and be inclusive at the outset.

   Many schools have found that starting with a team of individuals is important because it sends a clear message that you are serious about the reform and that you intend to engage the entire school in the process. The timing and process for initiating such a team will

depend on a number of factors, including the culture of your school, the formal leadership structures already in place, existing designations of responsibility for mathematics or science, the size of your school, and the interest level of teachers. Regardless of how or when the team is initiated, some principals have found that it is important to open participation on this team to the entire staff. This way, they establish the understanding that everyone has input from the outset. If you are in the fortunate position of having too many volunteers, you may consider organizing open forums or brainstorming sessions for all of the staff and then selecting a smaller leadership group from amongst them to translate their ideas into action.

Still, this inclusiveness must be balanced with the fact that having the wrong person on your team can be a detriment to your school's progress. As discussed already, shared expectations and agreements about the mathematics or science program are essential. You may find that, in spite of his/her apparent interest, a member of your leadership team doesn't support the educational philosophy of the reform, or that he/she isn't genuinely interested in working to change classroom practice. Then, these teachers clearly don't belong on your team and it is possible that they don't belong in your school, either.

Leadership Teams

When you begin to organize a leadership team, you should consider who can or should participate, how often the team should meet, and its relationship with other committees in the school. These should all be explicit so as to avoid conflict or confusion in the school's decision-making processes. You should identify the strategy for organizing your leadership team that will work best in your school. Below are some approaches others have used:

In one school, a steering committee was put into place which served as a school-based management team and coordinated the large undertaking of restructuring and revamping instruction. The steering committee was a very real, working, committed, shared decision-making group. This group met at least once a month and carried out the plans made by numerous sub-committees. While the steering committee was appointed by the principal, the many sub-committees were open to anyone in the school who wished to serve on them. It took a real effort to reach out and include people. It was desperately important that everyone had the opportunity to express his/her ideas and feel ownership for the plans and changes as they emerged.

In another school, the principal identified one person from each grade level to be the science or mathematics team member. One member of the team was identified as the "point person" and was responsible for staying "on top of" the reform effort. The responsibilities of the point person included: making sure the materials were replenished, helping people with logistics, and attending professional development and sharing with others on the team and in the school. The point person was given two additional planning periods a week to help accommodate these additional responsibilities. The team met once every two weeks and determined their own agenda which ranged from simply raising interest and support to sharing individual experiences with the new materials with one another. The key to the success of such a group was that they had the constant, clear support of the principal.

5. Balance skills and styles within the leadership team.

   When you assemble your leadership team, keep the varied skills and styles of your teachers in mind. The most effective teams are those that take advantage of the expertise that its individuals already have. So, you may try to find a person who is especially skilled at working with children, another who is good at talking to teachers, another who has strong content background, and another who is skilled at working with materials. If your team, then, is able to match the right person to the right job you will already have crossed over several hurdles.

6. Make sure that roles, responsibilities and expectations are clear to everyone.

   One of the greatest lessons learned about this process has been the importance of making sure that all of the players understand what is expected of them and what their roles and responsibilities are. This is particularly critical for the leadership team. Teacher leaders often are reluctant to step out of the comfort of their classrooms into an unknown situation. They need to understand what you expect of them, what authority they have, what they can expect from the classroom teachers in the school, and what they can expect from each other. Concurrently, it's critical that the rest of the staff in the school understand who the leadership team is, what their responsibilities are, and what they are trying to accomplish.

7. Remember that teacher leadership is grounded in classroom practice. Identify and praise examples of the "floor" and the "ceiling."

   Though it may seem obvious, it is worth reiterating that strong classroom practice is an essential element of strong teacher leadership. In some schools we visited, this wasn't always an assumption. In some places, for example, "leadership" was divorced from what actually happened in teacher leaders' classrooms; that is teachers could have the title of "leader," but still teach the way they had always taught. In other schools, we saw the opposite situation. The most skillful teachers were not formal leaders but still shared their expertise and classroom experiences with others. They were reflective about their practice and discussed their ideas with their colleagues. These teachers should be recognized and praised, and held up as examples for other teachers. Improvement of classroom practice and teacher leadership are two sides of the same coin.

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Teacher Leadership is Grounded in Classroom Practice

In a recent study of teacher leadership in California, we studied hundreds of teachers heavily involved in leadership activities. We found that teacher leadership was strongly grounded in the successes the teacher experienced in his/her own classroom:

> "If one thing clearly emerges from this study, it is that the origins of and the content for teacher leadership derives from the personal classroom teaching practice of the teacher leader."

From:
The Nature of Teacher Leadership: Lessons Learned From the California Subject Matter Projects. June 1997; Inverness Research Associates; p. 24.

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8. Facilitate the development of leadership skills.

   Even the most gifted teachers need support when moving into leadership positions. Teacher leadership provides teachers with new challenges they may never have faced before. For example, working with adults is very different than working with children in one's own classroom. Teacher leaders will need to develop new strategies for working with their "students," and can easily get frustrated if they fail to achieve with adults the levels of success they have with children. If you expect them to lead professional development sessions for their fellow teachers, they will need professional development for themselves.

   Another skill your teacher leaders will need to develop is the ability to create long- and short-term plans. For some, the notion of developing a plan for school-wide change is quite foreign. Your reform can happen without one, but a plan serves as a concrete common reference point that can be invaluable for communication and collaboration. Even if the plan is constantly changing, it is better than having no plan at all. Teacher leaders need to understand how to develop a plan that has input from all teachers and includes concrete, deliberate steps for putting in the floor and raising the ceiling. You may need to provide examples of plans or better yet, participate in the development of the plan along with your teachers.

As you develop your plan for bringing mathematics or science reform to your school, you can use a variety of organizational formats. In some schools, teams will work together to develop a plan for the year. In others, the teacher leader will develop a personal plan for him/herself to help identify specific goals and steps that he/she and the school must take.

Below is an example of one way to organize a school action plan for mathematics or science reform:

| **School Action Plan for Johnson Elementary** | | | |
|---|---|---|---|
| Melanie White, Principal<br>Don Hanson, Lead Teacher | | | |
| **Goals and Outcomes** | **Tasks** | **Responsibility** | **Dates** |
| **Awareness**<br>*Day of science for teachers to allow teachers to become aware of resource materials and equipment available.* | *Teachers will peruse resource materials and equipment. They will participate in hands-on activities from the units at their grade levels.* | *Lead Teacher*<br>*Principal* | *Last Week in September* |
| **Information Gathering** | | | |
| **Professional Development In-house** | | | |
| **Professional Development Outside** | | | |
| **Materials Piloting/Testing** | | | |
| **Teacher Support Activities** | | | |
| **Building School Culture** | | | |
| **Resource Building** | | | |
| **Principal's Leadership Goals:** | | | |
| **Principal's and Lead Teacher's Goals for Working Together:** | | | |
| **Principal's Signature:** _____<br>**Lead Teacher's Signature:** _____ | | | |

9. Define the role of the teacher leader.

As explained above, it is essential to make the expectations, responsibilities and roles of teacher leaders (and all players) in a reform very clear. Following are some of the responsibilities that your teacher leaders may need to take on:

- *Lead by Example in the Classroom and Allow Others to Watch*

  Perhaps the most direct way a teacher can lead is by example. The classroom practices of teacher leaders involved in a reform often co-evolve with the development of their leadership skills and are a good starting point for working with colleagues. You may be fortunate enough to have creative teachers who already are comfortable with inquiry-based approaches to teaching and can provide your teachers with concrete examples of high-quality mathematics or science instruction. Even teachers who shy away from other leadership roles or responsibilities may be able to make valuable contributions by allowing others to watch them teach.

- *Mentor Other Teachers*

  As teacher leaders develop their skills and expertise in inquiry-based mathematics and science, they can begin to serve the important role of actively mentoring others. Mentoring can take many forms which include modeling instruction but also include more active strategies for developing the abilities of other teachers. For example, a teacher leader might go into a colleague's classroom and teach his or her students once or twice in order to demonstrate how this type of instruction can happen with his/her actual class. Or, a teacher leader might observe a teacher teaching a class and offer feedback as a sort of "coach." The common, important characteristic is that the teachers are getting professional development from their own colleagues.

- *Work Strategically in the School*

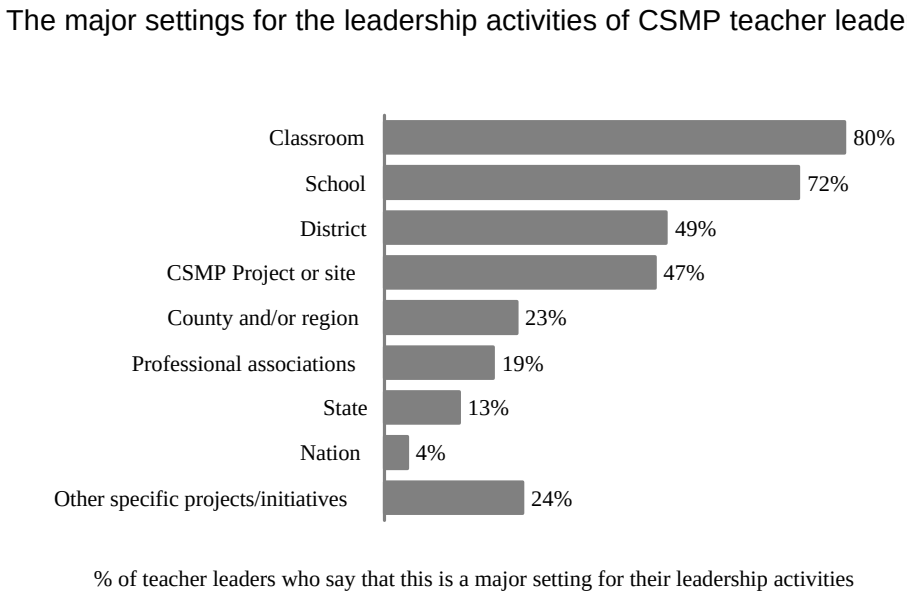
  Some teacher leaders prefer to limit their responsibilities to serving as coaches or mentors. A school-wide standards-based reform, however, requires more than these one-on-one efforts. Teacher leaders need to do more than provide guidance for their colleagues. They need to work with you and others in the school to develop a school-wide strategy that brings everyone in the school on board, garners support from others in the school community, and stimulates more widespread interest.

  To accomplish this, you might use a school-wide strategy, such as developing a school-wide plan with specific steps and strategies. Or you may prefer a more customized approach which entails each teacher leader figuring out how to develop interest and commitment to the reform amongst a small group. Other teacher leaders might work as a team and divide their responsibilities between them with some focusing on in-school professional development and support, while others focus on communication with parents and the community. The appropriateness of these decisions is directly tied to the nature, history and culture of your school. The important point is that school-wide change must be

just that – school-wide – and be conducted strategically with shared understanding and vision, not only on an individual basis.

The Arenas for Teacher Leadership

The following graph comes from a study of over 1000 teacher leaders in California. The results illustrate the importance of the classroom and the school as venues for teachers to share their "practitioner knowledge" with each other.




*Percentages represent teachers who selected 4 or 5 on a 5-point scale where 1 = "Not a part of my leadership activities" and 5 = "A major part of my leadership activities."*

From:
The Work of CSMP Teacher Leaders: A Summary of Key Findings from a Statewide Survey. June 1997; Inverness Research Associates, p.12.

- *Connect to and Communicate with Other Leaders*

  Teacher leaders in the school need to maintain open communication with each other as well as with other teacher leaders in their district, state and across the country. Your teacher leaders should actively work to collaborate with others in order to benefit from their experiences and bring new strategies to your school. There are many experienced teacher leaders already working to facilitate school-wide change in mathematics and science with much to share. They are the best sources of firsthand advice for the teachers in your school.

- *Go to Conferences and Join Professional Associations*

  Attendance at conferences and meetings, and participation in professional associations provide an avenue for professional growth for your teacher leaders and at the same time are a resource for your school. At a most basic level, your teacher leaders can learn about what is happening in other schools with other teachers. They then can facilitate discussions at your school, during which time teachers can consider the strategies you may want to use. At conferences, teacher leaders also may have one-on-one conversations with others which can build connections to other human resources. And finally, when your teacher leaders attend conferences, they raise the visibility of your school in the eyes of others. This can help bring new ideas into your school and help others know more about your mathematics or science reform effort.

## BUILDING CRITICAL PROGRAMMATIC SUPPORTS

There is no single way to approach a mathematics or science improvement effort, but many have found it useful to think of their effort as having multiple parallel "components" or "strands." This section offers advice about some of these components:

A. Curriculum and instructional materials;
B. Professional development;
C. Assessments; and
D. Resources.

It focuses on specific strategies, includes references to resources and has examples of plans or programs that other schools have used. It is important to remember that even though this section discusses these components separately, they do not operate in isolation. This is not intended to be a "check list" to be read selectively. It describes the interrelated aspects of a mathematics or science improvement effort that link to each other, to other components not addressed here, and to you and the other leaders of the program.

### *A. Curriculum and Instructional Materials*

The word "curriculum" is used in many different ways. In schools engaged in mathematics and science reform, it often refers to one or more of the following:

- *The Latin meaning of curriculum – the "course to be run," i.e. the curriculum specifies what teachers are to teach and what students are expected to learn:* Some schools may call it a "course of study," or "curriculum framework," others may refer to it as a "scope and sequence," and in other places it is equated with local "standards." Decisions about curriculum in this sense may be made by the school or the district, depending on the level of site-based decision making in a community.

- *The texts, hands-on materials and other instructional materials that teachers and students use:* In some places, the texts and materials used in the classroom are equivalent to the course of

study. In other places, schools or districts determine the course of study and then materials and texts are selected so that they support the achievement of those student learning goals.

- *The logistical and managerial structures and plans necessary to support classroom instruction:* Standards-based mathematics and science instruction call for an approach to teaching that often includes manipulatives, kits, and literature. Use of these materials requires a great deal more attention to management and organization than using only texts. Identifying space and strategies for distributing and refurbishing materials can be the "Achilles heel" of a school-wide reform program.

You will need to consider all of these as you begin to address "curriculum" in your reform. There are no absolutes, but following is some advice from other principals that can get you off to a strong start.

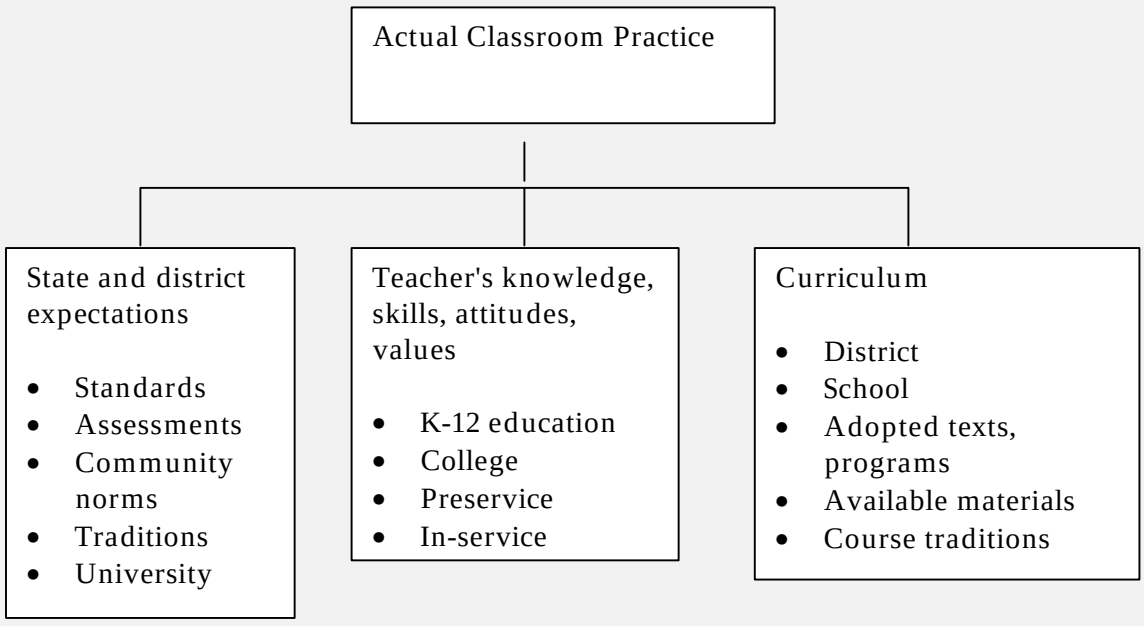
1. Come to agreement on what will be taught, and how it will be taught.

   The content and pedagogy of science and mathematics classroom instruction is subject to many influences outside of your school walls. In some schools, for example, they are shaped by a district curriculum framework, which in turn is patterned after state standards. Sometimes, these documents are quite specific, telling teachers exactly what to teach on what day. In other cases, they are broader, providing teachers with little guidance about what his or her students should be learning. You may be fortunate to have a district course of study that achieves the right balance between specific directives, and school and teacher freedom. It is more likely, however, that you are among the many who have broad guidelines, or no guidelines at all. In these schools, teachers simply follow the textbook, or, when the text is old or even absent, decide what to teach individually, resulting in widely varied (and not always equitable) learning experiences for their students.

Influences on Math and Science Instruction

Sometimes people speak of several different types or levels of curriculum. The *formal* curriculum is the curriculum that is outlined in state frameworks and standards. The *implemented* curriculum consists of the topics and ideas that are actually presented by the teacher in the classroom. The *received* curriculum includes those ideas and experiences that students perceive. And the *hidden* curriculum is composed of all the implicit and unspoken goals and values that are communicated along with the implemented curriculum. Thus, the idea that reform takes place simply because a "curriculum is implemented" is fraught with peril.

What actually happens in classrooms is, of course, a process that is shaped by many different factors – all interacting in very complex fashions.




A document that clarifies the concepts your students should be learning, how they should be learning them and when, will help bring coherency and consistency to your school's science or mathematics program. It can help ensure that there is a balance within and across grade levels and that by the time your students leave your school, they have a comprehensive foundation for their learning in the years still to come. You don't necessarily have to focus on this at the outset; some schools have found that it is valuable to first have a "year of learning" during which the principal and teachers become familiar with teaching strategies and new instructional materials. Then, the process of developing a course of study together serves as a tool for building school-wide consensus, and helps them take their first step in defining their "floor" for student learning.

2. Find out about exemplary instructional materials.

   Along with deciding what concepts and skills your students should know and be able to do, you will need to identify high-quality instructional materials which can support these goals. While an innovative curriculum, by itself, is not sufficient to create reform, a high-quality curriculum is a very important support in creating a school-wide standards-based mathematics or science program. It is essential if you are serious about having high-quality instruction on a wide scale.

   You or your teachers may be tempted to develop your own instructional materials, or to adapt materials that you already have. While some of these materials may be of use as supplements or as vehicles for "raising the ceiling," others have found that until a solid "floor" is in place, developing, inventing or adapting curriculum is a time-consuming mistake. They found that the process of doing so proved much longer and more labor intensive than originally anticipated and in retrospect have testified that they would not attempt to do it again. When you use curriculum that already has been proven to be sound, you are saving time and effort while benefiting from the expertise and experience of others.

   Perhaps the most important reason for using exemplary instructional materials is that it is the only way to ensure that you are creating an equitable environment for mathematics and science learning for your students. Many teachers at the elementary level are uncomfortable teaching science, and though they may be more comfortable with mathematics, they may not easily embrace the pedagogy that standards-based reforms advocate. Without the guidance of – and commitment to use – high-quality instructional materials, science or mathematics instruction may be inconsistent, sporadic, or absent. In order to ensure that *every* child will have an opportunity to learn, you will have to put in a "floor" with good instructional materials and make sure that at least at first, teachers use them as they were designed.

Exemplary Curriculum

In the last ten years, the National Science Foundation has directed funds toward the development of instructional materials in mathematics and science that can be used to support inquiry-based science and mathematics instruction at the elementary and middle levels.

Following are some of the curricula that you (or your district) might consider bringing to your school as part of your mathematics or science improvement effort:

*Full Option Science System (FOSS)*
*Delta Education*
*1-800- 442-5444 (phone)*
*1-800-282-9560 (fax)*
www.delta-ed.com

*Insights*
*Kendall/Hunt Publishing*
*1-800-KHBooks*
www.kendallhunt.com

*Science and Technology for Children (STC)*
*Carolina Biological*
*1-800-227-1150*
www.carosci.com/STC.htm

*Investigations in Number, Data and Space*
*Developed by TERC (617) 547-0430*
*Dale Seymour Publications*
*1-800-872-1100*
www.awl.com/dsp

3. Develop a process of curriculum selection using a set of criteria that allows you and your staff to be "critical consumers."

   Once you have identified the range of curricula that are available to you, develop a process for selecting the instructional materials that are best suited for your needs. When doing so, it is important to remember that the process can be as critical to success as the final "product" (in this case the choice of instructional materials). By being part of a careful selection process, teachers come to better understand the kind of instruction that you are collectively trying to bring to your school.

Curricula Selection Criteria

Following are some criteria that you might consider when choosing your curricula:

- Developmental Appropriateness: Are the materials appropriate for the age group?
- Philosophical Appropriateness: Do the materials interest students and have potential for exploration? Are they centered on investigations of mathematical concepts or scientific phenomena?
- Staff Development Needs: How much staff development is needed? How much will it cost? Who will do it?
- Equity: Do the materials include strategies that can help ensure a high-quality learning experience for all students?
- Flexibility: Can the materials be used as a core program or as supplemental to another program?
- Alignment with Standards: Does the program reflect national standards? State guidelines? District or school standards?
- Teacher Friendliness: Are the materials easy to learn and use?
- Cost: Can you afford sufficient materials for all of your teachers? Is it possible to begin with a smaller amount of materials and purchase more in the future? Are replacement / maintenance costs reasonable?
- Integration: Are the materials compatible with the language arts, social science and other programs already in the school?

Many schools begin by assembling a set of criteria for selection. This list may range from more substantive issues such as alignment with your district standards, to more practical ones such as ease of readability. Then, schools often go through a materials "piloting" process which serves both practical and political needs. You may find that piloting instructional materials is the most effective strategy for introducing the overall mathematics or science improvement program in your school. Piloting will ensure that your school obtains the best possible materials, and at the same time sends a message about the seriousness of the reform while enlisting more people to participate. We have seen many pilot teachers develop a deep investment in the use of the materials and in turn, in the success of the overall reform through their piloting experiences. You also may wish to tie the piloting process into your professional development plan since group discussions amongst pilot teachers can be an effective means of support for individual growth and understanding of standards-based instruction.

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Curriculum Matrix

In science, school or district leaders who wish to use standards-based materials as the core of their programs often will identify three modules to be taught at each grade level (one in earth science, one in life science, and one in physical science) and then supplement those materials with a favorite teacher-created unit or one that has local interest. Some will choose all of their units from the same publisher. For example, one district chose the following (FOSS) curricula:

| Grade | Life Science | Earth Science | Physical Science |
|---|---|---|---|
| 6th | Food and Nutrition | Solar Energy | Mixtures & Solutions, |
| 5th | Environments | Landforms | Levers & Pulleys |
| 4th | Human Body | Earth Materials | Magnetism & Electricity |
| 3rd | Structures of Life | Water | Physics of Sound |
| 2nd | Insects | Pebbles, Sand & Silt | Solids & Liquids |
| 1st | New Plants | Air & Weather | Balance & Motion |
| K | Animals 2X2 | | Paper |

Another community decided to combine materials from the different publishers. Their matrix looked like this:

| Grade | Life Science | Earth Science | Physical Science |
|---|---|---|---|
| 5th | Ecosystems (STC) | Land and Water (STC) | Circuits and Pathways (Insights) |
| 4th | Structures of Life (FOSS) | Earth Materials (FOSS) | Mysterious Powder (Insights) |
| 3rd | Growing Things (Insights) | Water (FOSS) | |
| 2nd | Habitats (Insights) | Pebbles, Sand & Silt (FOSS) | Liquids (Insights) |
| 1st | Insects (FOSS) | Air & Weather (FOSS) | |
| K | Senses (Insights) | | Balls and Ramps (Insights) |

You can see that they left some spaces blank. You may do the same as you try to identify materials that best meet your local standards and/or benchmarks. You may not always find a module that matches your priorities exactly. In that case, you may wish to wait to see what new kits may become available and substitute some other materials temporarily.

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You may be in a district that already has selected instructional materials for mathematics or science. If you are lucky, these materials will be amongst those that you and your staff have determined are high-quality. If not, you may be able to obtain a waiver of the

requirement to use those materials and request permission to conduct a "pilot" in your building. You might try to make the case that the materials you want to pilot are "exemplary," or "state of the art" and that your school's work can inform the district-wide selection process in the future. If this is not possible, you may wish to encourage your teachers to serve on the district-wide materials selection committee the next time the opportunity arises. This situation is an example of how critical strong relationships with your district office can be.

4. Provide materials for teachers and develop strategies for storing, sharing, and maintaining them.

   Instructional materials make a reform real. You can have repeated discussions about reform and even provide professional development, but if your words and activities aren't backed up by sufficient classroom materials, your teachers' enthusiasm can quickly turn to skepticism. Your staff can not be expected to take the reform seriously without an investment in instructional materials.

   This does not mean that all of the teachers in your school need all of their materials immediately. Some schools begin by providing the teachers with the minimum of what they need to begin experimenting with this approach to teaching and then increase the materials as experience and finances allow. Financial constraints often influence a school's ability to acquire materials, but some schools have developed strategies (e.g. rotate kits between teachers at a grade level, team teaching arrangements, and in some cases taking advantage of centralized district distribution centers) to address them.

   Regardless of which approach will be best for your school, visibility of materials is perhaps as important symbolically as it is practically. Provision of materials is another part of your "contract" with the teachers for helping them put in the floor. It is a "test" of seriousness, so it is essential that you make sure that materials are there.

Establishing a Materials System

Once you have made a commitment to acquiring instructional materials that support standards-based science and/or mathematics instruction, you will need to devise some strategies for ensuring that those materials stay in working, classroom-ready condition. Addressing concerns about materials may be more challenging for science, because it is more materials-intensive and requires replacement of consumable items. If you are fortunate to be in a district that is supporting use of these materials across many schools, you may find that your central office has organized a means of supporting the use of science materials in your school. If not, it will be up to you and your staff to develop strategies which will work best for you.

For example, depending on how many kits or units you have, you may need to organize a unit rotation system. Such a system would entail having three kits (one in earth science, one in life science, and one in physical science) for every three teachers. Then, each teacher always has a kit available (though this system has the disadvantage of teachers and their colleagues teaching different kits at the same time). If you have little space to spare in your school and you have extra kits, you may choose to have teachers store kits in their rooms. However, you may find that it is more efficient to identify a room where kits and refurbishing supplies are kept. Committing space in your school for the kits also can add credibility to your science program; you may even choose to identify a space for your materials that is large enough to provide meeting and preparation space for your staff.

In addition to working out a schedule for rotation, you also will need to develop a system by which consumable items are replaced. In order to do so, you will need to develop an inventory sheet, identify funds to purchase the replacement items and identify individuals who will have the responsibility for ensuring the materials are replaced. While the responsibility could fall to your leadership team, there are many creative ways to complete this somewhat tedious task. Some schools use parent volunteers; others rely on the older students to inventory and refill the kits; and others may find retired members of the community who are interested in contributing to the school program.

5. Talk about the ways the reform can best connect to other subject areas.

   It is tempting for teachers, particularly at the elementary level, to "integrate" their subjects, using topics or themes as the common "glue." When teachers do this, they are attempting to create a more coherent learning experience for their students. Instead, however, they often "water down" the mathematics or science by making them secondary to other learning goals.

   Integrating subject areas is extremely difficult to do well and requires a clear understanding of each of the disciplines. A more comfortable route to take might be to encourage your teachers to teach each discipline well on its own and *then* make connections between the disciplines. This way, students are more likely to learn the concept taught within that discipline and gain a greater appreciation for how disciplines interact and actually support one another.

6. Learn about, and integrate, up-to-date technology in your school.

   More and more, schools and districts are addressing mathematics, science, and technology as though they were one collective discipline, often referred to as MST. New York State has adopted this approach in its Learning Standards for Mathematics, Science, and Technology which describes content standards and performance indicators for these three fields in one document. So, many people are asking, where does technology fit into the curriculum? It

helps if you first separate technology used for instruction (computers, videodisks, VCRs, etc.) from technology education (teaching about the human-made world). In New York State, technology education refers to a program of instruction designed to assist all students in developing their technological interests and capabilities through the systematic application of knowledge, materials, tools, and skills that incorporate multidisciplinary concepts to solve real world problems. Although instructional technology and technology education often support each other, they are really quite different.

For many schools and districts, investing in instructional technology to support high-quality mathematics and science becomes one of the most confusing and costly enterprises facing administrators. Often, using funds made available specifically for technology, schools embark on ambitious endeavors; for example, they put two computers in every classroom or they wire every classroom to the Internet. Principals become overwhelmed with decisions about what hardware and software to purchase, and they do not make adequate plans for long-term and short-term professional development. Without paying attention to what teachers do and don't know about how to use technology effectively, and without figuring out how technology will support the school's vision of MST reform, after the initial glow wears off the equipment is likely to gather dust. Without professional development that incorporates the new technology, teachers will revert to their previous, comfortable ways of teaching. Or, perhaps worse, the new equipment will be used to support the same old teacher-driven "drill and practice" approach plaguing much of math and science instruction today.

You will need to provide professional development in the new learning technologies for your staff. This means developing leadership in the pedagogical use of technology among your staff, as well as comfort with the technology. Sometimes the technology trouble-shooter is not the one who can communicate most easily how to use the technology to support learning. Here again, leadership involves a team effort, combining skills of technical expertise, pedagogical know-how, knowledge of the best technology-based curriculum materials, mentoring capabilities, and professional development.

Starting to use technology can be intimidating, especially for those teachers who think they can't set the clock on the VCR. You can help them overcome their fears if you first overcome your own. Here are a few simple tips:

- Clarify your vision and that of your teachers about MST reform.

- Keep asking yourself: What do we really want to do? How can technology best support our math and science efforts?

- Learn as much as you can about what is available that is of high quality – curricula, hardware, software, and professional development – and how it can support what you and your teachers want to do.

- Take your time: Prepare your teachers to use technology in support of student learning, and don't be rushed into making hasty decisions that you will have to live with for years to come.

Technology education is one of the most powerful ways to introduce inquiry into the classroom. When students design, plan, draw, build and test structures like a bridge that will support two matchbox cars across a wide abyss, for example, or when they experiment with making a container that will protect a raw egg in a 3-meter drop, research becomes a real part of science education, and inquiry enters the realm of high adventure. Even very young children love it. But, your teachers may be wary. They may not know how to fit technology education into the curriculum. Usually technology education combines math, science, art, reading, and writing. Teachers may be anxious about technology education for some of the same reasons they are fearful of inquiry in general; they don't always know the right answer. Much of this anxiety can be allayed by supporting teachers as they try out activities in the curriculum and explore how they can introduce design into the study of familiar subjects. Providing appropriate professional development and leadership will help teachers become comfortable with the curriculum and see what fun they can have with their students. Teachers need to see models of good technology education in action.

### *B. Professional Development – Individual and School*

Like curriculum, professional development in a standards-based mathematics or science improvement effort has a number of different aspects. You might organize your discussions about professional development in your reform effort into three areas:

- *Activities that support the setting of the floor*

  These activities focus on introductions to the use of kits, manipulatives or other instructional materials. They also focus on some of the fundamental ideas behind standards-based instruction, classroom management, organizational strategies, and basic questioning and cooperative learning techniques.

- *Activities that maintain progress already made*

  These activities support deeper development of classroom instruction and may include a focus on teachers' content knowledge, alternative or portfolio assessment strategies, or refining classroom practice.

- *Activities that raise the ceiling*

  These activities are directed at teachers who are formal or informal leaders in the school and may include a focus on extended experiences with inquiry-based learning, topical study groups, leadership, and/or planning.

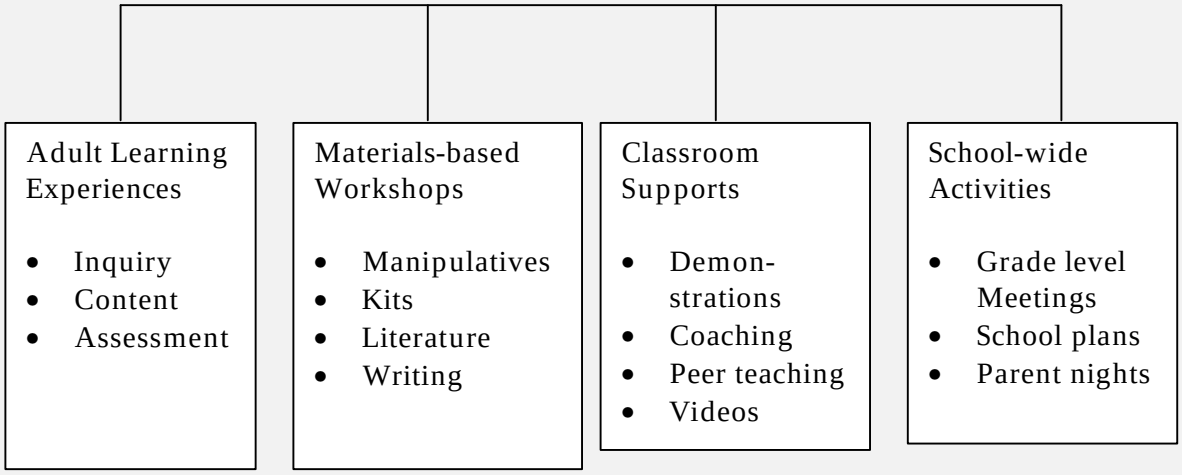
You will need all three eventually, but at first, you will need to decide where best to invest your energies and those of your staff. Following are some lessons learned from other principals, along with some of their "words to live by" that you may find useful when planning professional development.

1. Plan professional development to meet a range of "levels."

   Professional development should pave the way to high-quality, standards-based instruction. On that road, however, there will always be a range of teachers with a variety of needs. The professional development program you design must accommodate that diversity.

   Teachers just starting out, for example, need "basic training" of how to use the instructional materials. Some elementary teachers, for example, are afraid of science and reluctant to teach it at all. They need a basic introduction to the instructional materials accompanied by demonstration lessons and/or peer teaching as well as regular discussions with grade level colleagues. The first step for these and other beginning teachers is to use the instructional materials "mechanically" – as they are written. Teachers who are more experienced, on the other hand, need opportunities to refine their teaching practice, discuss it with others and extend their own learning experiences. And teachers who are even more accomplished need support in deepening their understanding and in working with other teachers at their level.

The Professional Development Spectrum




Identifying the range of levels is only part of the challenge. In addition, your professional development program will need to adjust as your teachers' skills and needs develop and change. Some districts engaged in reform made the mistake of designing multi-year professional development programs only to find that, due to either teacher turnover, slower rates of growth, or competing priorities for professional development, their teachers weren't ready for the next year's planned professional development. They had to re-establish professional development activities from the year before to bring teachers "up to

speed" and at the same time support the continued growth of teachers who had met or even exceeded their expectations. You may face similar challenges in your school, so you should anticipate them in your plan for professional development.

2. Use a variety of approaches to professional development.

   Professional development can take many forms. It may include: kit training, study groups, coaching, analyzing and studying children's work, demonstration lessons, and participation in developing frameworks and assessments. Each can be useful depending on your teachers' needs and circumstances and should be used accordingly.

   For example, looking at and discussing student work can be a powerful professional development experience with a range of goals. Teachers can discuss what they are doing in the classroom, what they think about it and why the student work is or isn't what they expect. Newer teachers and experienced teachers alike participating in such activities become critical analyzers of their students' thinking and as a result, learn themselves while gaining important insights for classroom implementation.

   You will need to work with your leadership team to identify the range of strategies that will best accommodate your teachers' needs and interests. Part of this process should include looking at professional development that your district has to offer, as well as opportunities that might be available through local universities or museums. We offer a word of caution, however, in taking advantage of outside opportunities. Some schools send teachers to professional development sessions that may be focused on mathematics or science but have little to do with their learning goals or the overall direction of the school's program. When selecting and identifying the various components of your professional development program make sure that they complement one another and are providing purposeful support for the reform.

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Getting it Going versus Getting it Good

Some of the schools and districts that we have visited have different points of view about where to start with professional development for standards-based reform. Some believe in starting their reform efforts by providing teachers with deep inquiry experiences. The idea behind this approach is to help teachers shift their overall perspective on teaching and learning so that everything they do is more focused on an inquiry approach. Their philosophy seems to be "get it good, then get it going," meaning that they intend to focus first on "raising the ceiling" by developing strong skills in a few teachers.

Others believe in focusing first on "setting the floor" by engaging more teachers at a more introductory level. The starting point here is to focus on the use of exemplary curricula, focusing on the mechanics of using the kits and manipulatives correctly. Then, after successful usage of the kits as designed, teachers can focus on "getting it good."

We think that it is important to realize that both are needed. For establishing a floor of practice for large numbers of teachers, it is probably best to focus on "getting it going" through materials-based workshops. For other teachers who express interest and willingness, more intensive and deeper learning experiences in inquiry and content are appropriate. Ultimately, one needs a balanced approach where there is attention paid to "getting it going" but also efforts made to help teachers "get it good," to setting a floor, but also to raising the ceiling. What is important is to realize that the two types of approaches are different, are appropriate to different teachers at different times, and require quite different types of efforts.

Classroom-based Professional Development

One professional development model is the classroom-based in-service. This in-service intends to provide teachers with an authentic learning experience grounded in classroom practice. The notion behind this model is that direct observation of a peer, coupled with thoughtful dialogue about the instruction, will provide teachers (both the observed and the observers) with invaluable insight into their own teaching.

The experience has three components. First, several grade level teams of teachers are released from their classrooms. Led by a skillful facilitator, each team meets to discuss the lesson they are about to observe. Second, teams observe an entire lesson taught by a teacher in her own classroom with her own students. Finally, the teams each reconvene to reflect on the lesson.

This model allows for a high level of involvement and self-directed learning on the part of teachers. Participants can thoroughly engage in their own teaching when witnessing actual teaching of a standards-based lesson. It is important to note that this model cannot work successfully without certain key elements – a genial and intelligent staff, a skilled facilitator, good questions and probes for generating quality discussion, and above average teaching of the lesson itself, among other things.

3. Don't neglect content support.

   As teachers become more familiar with the instructional materials, one potential barrier to their continued growth is their understanding of the underlying math and science content. In the past, a teacher using a traditional text needed only to read the book along with the students to find much of the content needed for a lesson. In order to implement the kind of instruction reflected in standards-based reform, the teacher needs to know more than the facts; he/she also needs to understand the underlying concepts of the discipline.

   Schools and districts often make the mistake of designing professional development which focuses on the processes of inquiry-based instruction (questioning, grouping, managing students, recording, facilitating discussions, etc.) but neglects to fully address the content. Those schools that do address content often do so through building relationships with local universities or industries that have employees with related content expertise. These scientists or mathematicians are likely to need training on how to work with elementary teachers, but once they are, they can be valuable resources for professional development.

Effective Professional Development

Over the last several years, practitioners and researchers have written much about the essential components of a professional development program which can support standards-based mathematics and science program. The following are principles "addressed in effective professional development experiences" identified in Designing Professional Development for Teachers of Science and Mathematics (cited below):

Effective professional development experiences:

- are driven by a well-defined image of effective classroom learning and teaching;
- provide opportunities for teachers to build their knowledge and skills;
- use or model with teachers the strategies teachers will use with their students;
- build a learning community;
- support teachers to serve in leadership roles;
- provide links to other parts of the education system; and
- are part of a professional development program that is continuously assessing itself and making improvements to ensure positive impact on teacher effectiveness, student learning, leadership and the school community.

For more information on characteristics of a high-quality professional development program, you may wish to look at:

*Designing Professional Development for Teachers of Science and Mathematics*
*Loucks-Horsley, S., P.W. Hewson, N. Love, and K.E. Stiles*
*Supported by the National Institute for Science Education*
*Corwin Press, Inc. 1998*
*2455 Teller Road*
*Thousand Oaks, CA 91320-2218*
*Telephone: (805) 499-9774*
*Toll Free Fax: (800) 4-1-SCHOOL*
*www.corwinpress.com*

*National Council of Teachers of Mathematics [NCTM], Commission on Teaching Standards for School Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA.*

*National Research Council [NRC]. National Science Education Standards. (1996). Washington, DC: National Academy Press.*

*Loucks-Horsley, S., M. Carlson, L. Brink, P. Horwitz, D.H. Marsh, K. Roy, and K. Worth. 1989. Developing and Supporting Teachers for Elementary School Science Education. Andover, MA: The National Center for Improving Science Education, the NETWORK, Inc.*

4. Remember that *professional* development means more than workshops – it means "professionalization" of teachers.

   Traditional approaches to professional development (such as workshops) are appropriate for some purposes but there are other strategies which not only develop improved practice, but also increase the professionalism of the teachers. These include peer coaching, participation in local or national organizational events, and designing, planning and leading professional development for others. Teachers who engage in these kinds of activities are more likely to be better informed and skilled leaders.

The professionalization of your teachers also depends on the environment you create and the expectations you hold. In some schools, for example, the principal dedicates a room to the mathematics or science reform, or more generally, to the professional lives of teachers. These rooms are not lounges or lunchrooms; they are equipped with reading materials, a telephone, computers and workspace and are set aside solely for teachers to work collaboratively. Having such a space adds some credibility to the program and to the professional work of teachers, and speaks to the seriousness of your commitment to support them.

Even if you have no space to spare for such a room, you can take other steps to increase a school-wide sense of professionalism around math and science teaching. Make sure that your school is a place where everyone's opinions are heard and respected; where responsibility is shared; and where teachers teach one another. Also, provide your teachers with a chance to leave the school and see what other schools and communities are doing. In this way, your staff become qualified, careful, critical "consumers" of educational reform and its resources – and they can then bring that expertise to your improvement effort.

5. Develop and support a teacher learning community.

Even when you create an environment which lends itself to professionalism, a "learning community" won't necessarily develop on its own. You also must provide opportunities for groups of teachers with similar interests, commitment, and expertise to meet, share, and develop expertise together. This requires a shift in mindset about professional development -- moving away from supporting individual teachers to supporting teacher networks or teacher learning communities.

One of the most important ingredients for supporting learning communities is one of the most simple: Make sure there is time for periodic planning and reflection. Reflective discussions help teachers develop common understandings about their goals for students and provides them opportunities to focus on their own learning about the instructional process. Time for discussion also allows teachers a chance to assess the extent and quality of their progress in their reform and consider ways to continue to grow while still maintaining "quality control."

Other aspects of reform can also benefit from an environment which allows these kinds of conversations to take place. Facilitation of shared vision and improved professional development are already mentioned; other benefits include the development of leaders, engagement of parents and other community members and increased attention and support from others in the district. Time for planning and reflection is one of the most challenging changes to bring to your school, but one of the most fundamentally important.

Developing a Learning Community

Creating a "learning community" within your school involves both development within the boundaries of the school and reaching outside. A key element in changing a school culture is identifying, supporting, and empowering many "leaders" (as we saw in the Pauline Selby example). Madison School became a "learning environment" where professional development, leadership, and collegiality was expected. As one teacher said, "Before, the norm was to be an observer. Now the norm is to be an active participant." Teachers here felt free to risk new ideas and inspired to become professionals.

Teachers' dedication to learn and improve is evident in their involvement in restructuring at many levels, from sitting on short-term and long-term action committees, to devoting release time to look outside the school for ideas, and even dedicating Saturdays to in-house workshops to share curriculum and assessment ideas. Conference participation is encouraged and supported by district funds, and structures within and outside the school serve to disseminate and adapt new information (structures such as demonstration lessons, coaching, in-house workshops, newsletters, and television media).

Interdisciplinary teaming has also served as a vehicle for spreading the excitement and expertise across subject areas; such collaboration also makes teaching more effective. The grade level teams – which plan together and manage approximately 150 students each – allow teachers to truly get to know their students, get ideas and feedback from colleagues, and advocate for school changes that would enable more collaboration and innovation (such as extended class periods).

6. If nothing else, make time.

   You may find it difficult to take on the many steps involved in school-wide improvement of mathematics or science. As you make choices about where to direct your energy, stay focused on your "floor" and the minimum materials and professional development your teachers need to put it in place. Then, if you do nothing more than provide time during the day for your teachers to work together, collaborate and plan, you have done a great deal to get the program off the ground. Even when teachers know what to do, they often have no time to do it. If you can provide materials, basic professional development, and time, you will be well on your way.

7. Don't forget yourself.

   As you are working to develop a professional development program for your staff, don't forget to build in learning opportunities for yourself. Many principals have little experience with standards-based reform and inquiry-based instruction and can benefit from some firsthand experiences. Networking with other principals who are engaged in reform in your community or nationally is one good strategy. Not only do you benefit from others' experience, but you can simultaneously raise the profile of your school in the district and in the country.

Professional Development Opportunities for Principals

You should look in a variety of places to identify professional development for yourself. A first place to look might be professional associations for principals such as the National Association of Elementary School Principals. Even if they don't have professional development activities specifically focused on mathematics and science, you may be able to network with other principals in your area and across the country who are engaged in improving their science or mathematics programs and with whom you can share experiences and advice.

You also might consider contacting a Principals Center in your area. Most often, these centers are established in collaboration with universities' graduate schools of education. They offer individual professional development sessions as well as series of programs for principals on a variety of topics. You may find that if a number of your colleagues are interested in mathematics or science reform, you or your district could contact the Principals Center regarding establishing a program focused specifically in these areas.

There are also programs funded by NSF and others that are specifically designed for principals. The Exploratorium's Institute for Inquiry Administrator's Seminar is a four-day event that provides district and school administrators with an understanding of inquiry, as well what administrators can do to support inquiry teaching in their own domains.

### *C. Assessments*

State or district assessments can be your greatest barriers or your greatest supports, particularly if you are in a state or community in which the tests are highly visible. When tests are closely aligned with the curriculum and instructional strategies you are trying to bring to the school, they can raise the priority and attention given to your reform. On the other hand, when they highlight content or teaching strategies less compatible with your efforts, they focus energy and resources away from your goals.

Depending on the culture of your community and the positive and negative pressures that come with the testing process, wide-scale assessments may help, or hinder your work. You will need to strategically consider the testing issues within your school and community, identify your most immediate needs, and go from there. Following are some words of advice which may help guide you along the way.

1. Assess the tests that are given at the district or state level and consider the extent of their alignment with your vision.

   As you develop the various components of your reform effort, you will need to give attention to how those components align and interact with each other. Your policies must align with your priorities; your curriculum must align with your professional development; and your learning goals must align with your instruction. Components that are aligned become supports for each other and the program as a whole. Components that are not aligned become barriers which must be addressed if real, meaningful change is going to happen.

The issue of assessment is most often discussed in terms of alignment. The best assessments are those that are aligned with your curriculum and instructional strategies. Unfortunately, many large-scale assessments are not well aligned with standards-based programs.

A good starting point for understanding and improving your school's experiences with tests is to conduct an overview of the tests currently in place. Work with a group of teachers to look at the tests that are required of your students. Consider the kinds of questions the tests ask of students, how the substance and design of these questions compare with national and your local standards, and how they align with your school's curriculum. Many times teachers and others react to the image of testing, not to real test items. By focusing on real test items, you may discover that the tests are not as negative as previously thought. You may well find that the assessments your students are required to take stand in the way of your reform; or, you may be more fortunate and find that they are well aligned with the inquiry-based instruction you are working to bring to your school. Either way, it is important for you and your staff to understand the extent of this alignment so that you can find ways to make the implementation of your program as compatible as possible with the administration of the tests.

Also, it is important to remind yourself and your staff that your job is to educate children, not to produce test results. Clearly one should not be so naïve as to think that test results do not count, but it is important not to lose sight of the goal of providing a rich multi-faceted education for students.

2. Identify appropriate classroom assessments.

As you know, large-scale tests and assessments conducted on a classroom level serve different purposes and needs. District-wide or statewide tests are often designed to measure program or school effectiveness and track student achievement. They are not useful in informing the teacher about student understanding. Your teachers will need assessments that align with the content and pedagogy of the curriculum and are specifically designed to assess student knowledge and inform instruction. Most of the exemplary materials noted earlier include such assessments which can become a vehicle for helping teachers focus on and learn about student thinking and performance.

Because the nature of your instruction will change with your reform, the nature of your assessments must change as well. Standards-based reforms include a range of assessments including pencil and paper tests, performance tasks, portfolios, and exhibitions of students' work. Remember that, as you plan your professional development, your teachers will need support in learning more about developing and using some of these "alternative" approaches to assessment. Appropriate assessments are often the last part of a program to fall in place, but they are essential for sound, high-quality instruction.

Classroom Assessments

Below is a chart from National Research Council's National Science Education Standards. It conveys a shift in attitudes about and design of classroom assessments.

| CHANGING EMPHASES ON ASSESSMENT | |
|---|---|
| LESS EMPHASIS ON: | MORE EMPHASIS ON: |
| Assessing what is easily measured | Assessing what is most highly valued |
| Assessing discrete knowledge | Assessing rich, well-structured knowledge |
| Assessing scientific knowledge | Assessing scientific understanding and reasoning |
| Assessing to learn what students do not know | Assessing to learn what students do understand |
| Assessing only achievement | Assessing achievement and opportunity to learn |
| End of term assessments by teachers | Students engaged in ongoing assessment of their own work and that of others |
| Development of external assessments by measurement experts alone | Teachers involved in the development of external assessments |

For more information on classroom assessments, you may wish to look at:

*Active Assessment for Active Science*
*George E. Hein and Sabra Price*
*Heinemann, Portsmouth, NH (1994)*

*Assessing Hands-on Science: A Teacher's Guide to Performance Assessment*
*J. Brown and R. Shavelson*
*Corwin Press, Thousand Oaks, CA (1996)*

*Improving Science and Mathematics Education: A Toolkit for Professional Developers: Alternative Assessment*
*Northwest Regional Educational Laboratory, Portland, OR (1995)*

You also may wish to contact:

*Center for Research on Evaluation, Standards, and Student Testing (CRESST)*
*10920 Wilshire Blvd., Suite 900*
*Los Angeles, CA 90024-6511*
*(301) 206-1532*

3. Communicate about the tests.

When you and your staff have a good understanding of the tests currently in place and the assessments you hope to use, work together to communicate with parents and the community about them. Some schools have designed open houses focused on assessment during which time parents actually do some assessment tasks themselves. This not only helps the parents better understand the assessment, but it also helps them better understand the science (or mathematics) content and processes that their children need to know and be able to do. Parents who are skeptical about the value of "hands-on" instruction often leave this experience with a better understanding of the depth of instruction that can result from standards-based reforms.

4. Avoid pre-test preparation and drilling.

   In communities with tests that have "high stakes" consequences, teachers often will spend many class periods drilling and preparing their students. This disrupts the flow of learning and doesn't benefit the students in the long term (and in many cases in the short term either). If you find that your students are required to take a test that reflects a non-standards-based approach to instruction, you may instead try to find ways of infusing what they need to know into your new curriculum so that your teachers do not have to resort entirely to pre-test preparation. If you take the steps described earlier in this section, you will be in a stronger position for identifying ways this might be done.

A Balanced Approach

In some schools that are embarking on mathematics reform but which are still required to be assessed in standardized modes, teachers have become skillful at balancing the needs of "the test" with those of their standards-based curriculum. For example, they spend the first ten minutes of each math class developing "mental math" skills of their students, asking students to: mentally calculate a series of computations; list the factors of 36; name the even numbers below 11; or name the number of sides on a pentagon.

These quick activities function as a review of terminology and of concepts, and build and strengthen computational and recall skills, often needed for any standardized test. Further, teachers often phrase these questions in a style similar to those on a test, e.g. in multiple choice form, and thus students become familiar with a variety of questioning formats.

But after approximately ten minutes, teachers begin the lesson which is part of their standards-based curriculum. They find that this kind of daily practice serves their students' skill-building needs but doesn't take away from students' sustained and meaningful mathematical thinking.

5. Remember that in some cases, the imagined pressure is worse than the real pressure.

   It is not uncommon for tests to raise political trouble for schools and their programs. In some cases, the stakes are as high as the existence of the school itself. But in many cases, teachers' and principals' perceptions about testing and the consequences are worse than the reality. When the pressure to do well on tests comes from more local sources such as family and community members, improved communication and explanation prior to and after the test can help reduce anxiety levels.

   It also is important to realize that it is possible that your students may perform less well on a large-scale test in the first year or two of your reform if the test is not aligned with the kind of instruction you are trying to implement. Everyone needs to accept that change is incremental and although you will see evidence of change in some places, some "indicators" will not reflect improvements right away. Be willing to be vocal about this to parents and the rest of the district. You may need to do so in order to act as a protective "buffer" between your teachers and other stakeholders in the education community.

### *D. Resources*

Money is always at the top of the list of concerns and questions about reform. At the outset, few schools have all of the resources they will need for the duration of their improvement effort. The key is to earmark some money to begin, and then work with your leadership team to identify strategies for allocating funds to continue.

1. Use the resources you have in creative ways.

   This advice may seem obvious, but it is worth articulating since it often lies at the crux of successful reform. The most successful schools have started by assessing what resources they already have supporting mathematics or science education and what other funds (if any) are supporting other efforts in the school. You may find that there is money available (from Eisenhower funds, organizations such as the PTA, or sales tax programs) but that currently, those funds are targeted in a haphazard way. You also may wish to look at funds that support individuals in your school (such as classroom aides, Title I-supported individuals, or resource teachers) who can serve new roles. Be creative about working with them to define their responsibilities. By bringing various sources of funds together in support of your reform goals, you can develop a funding strategy that uses already existing money, but in a more coherent way.

2. Be creative about identifying potential sources of funds.

   In addition to getting their own financial houses in order, successful schools also find ways to bring resources in from the outside. Although some teachers bring in small grant moneys, most often, funds are granted due to the efforts of a strategic, savvy principal. The most successful principals turn to local industry and business, hook themselves into central funds, or take full advantage of offerings that are part of a larger district-wide reform. They understand the importance of connecting to the district and the community and using those relationships to garner support.

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Kit Sponsors

One administrator went to local industry and asked different companies to become "sponsors" of particular science kits. For example, she asked the power company to purchase and help maintain the electricity unit, and asked the local water board to sponsor the sink and float unit. By acknowledging the support of these companies in a very public way, the school was able to create a win-win situation that also supported science in the district to a great degree.

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## BUILDING CRITICAL RELATIONSHIPS

As explained already, school-wide mathematics or science reform is by necessity a collaborative venture. Teacher leaders, classroom teachers, parents, students, and community members all have a part to play. Each group has many roles and responsibilities. As principal, you need to understand what to expect of others and how to best support them, and they need to understand what they can expect from you. Below are some of descriptions of the roles that

you might expect others to play and some words of advice on how you can support and build these critical relationships.

### *A. Building Relationships with Students*

As the ultimate beneficiaries of the school-wide reform efforts, students can have roles and responsibilities which help the reform process. In traditional instruction, the teacher is the sole generator of work. In inquiry-based instruction, students take responsibility for their own learning and for assisting in the work of their peers. You may wish to work with your teachers to identify ways to discuss these roles with students so that they become more aware of and invested in the changes your school is making.

Students should:

1. Communicate with their parents.

   Many parents learned mathematics and science in a traditional, text-based manner and may not understand the strategies and materials used in standards-based instruction. In addition to your teachers communicating with parents, your students also should communicate with their families about what they are doing in science or mathematics and why. This can help begin to educate and hopefully engage the parents early on in the process.

2. Be open to new modes of teaching and learning.

   When it comes to educational change, students sometimes are the most stubborn members of the school community. Like teachers, students also need to be open to trying new approaches to instruction. Students will find the new curriculum to be extremely challenging and may find it difficult to change the ways they ask questions, work in class without a textbook leading the way, and work with others to solve problems. Your teachers may need to communicate with your students about being open to change. Once they become more comfortable, you will find that your students may become your most important advocates and may push any still-reluctant teachers along.

3. Compete less and try to help each other.

   Students are accustomed to "one right answer" and knowing that not every student is going to get it. They often are competitive with one another and are used to learning in a solitary manner. Standards-based mathematics or science requires that students recognize that there sometimes is more than one right answer, that they may not be able to find an answer at all, and that they may need to rely on another member of the class to get the answer. This is not to suggest that all competition or individual learning is bad, but that there are other aspects of a high-quality learning process that need to be recognized and valued.

In order to help students understand and assume the roles described above, you should:

1. Empower the students.

   Helping students succeed is part of empowerment. In the past, however, success was equated only with improved test scores. In this reform, an "empowered" student is also one who asks his/her own questions and knows how to go about finding out the answers. You and your teachers can help students understand that increased test scores are not the only scale by which you judge achievement; you also want them to know that you value student participation in instruction which allows them to be critical, thoughtful, collaborative learners.

   Another strategy for empowering students is to engage them directly in the reform process. You might consider interviewing them, either as whole classes, focus groups or even individually to find out their views about the changes they have experienced in their mathematics or science classes. If you can find ways to respond to their criticisms or incorporate their suggestions into your reform effort, there will be many, multi-purpose benefits. The students will be more interested and engaged and, they will see that they too have input into the school as members of the school community.

2. Find out what the students are interested in and use them in your reform.

   Student excitement and engagement is one of the greatest motivations for reform, for both the students and teachers. Many teachers in successful schools explain that they began teaching inquiry-based science or mathematics in spite of their fears because once exposed, their students won't let them *not* teach it. In some schools, even the teachers who were most reluctant had a change of heart when they saw the excitement of their students and evidence that they were learning. You can feed this excitement and build this momentum by asking students what activities or topics they enjoy most and helping teachers highlight those in their classrooms and throughout the school.

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Ms. Carter

Ms. Carter has been teaching inquiry science lessons, literally, "by the book." A veteran traditional teacher, Ms. Carter never enjoyed science herself, nor did she enjoy teaching it. As she stated, "I hate science.... I only do it because the kids love it so much..." Ms. Carter found that once she began teaching science using the materials and guides provided for her as part of the science reform program, there would be no turning back. Her students found science an engaging, enjoyable treat that, once it became theirs, could not be taken away.

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3. Keep the students' projects and other student work visible.

   Keeping students' work visible allows everyone to see how students are learning – other students, teachers, parents, staff – anyone who comes into the school. You may wish to assign school bulletin boards to classrooms, or rotate student work from various classes in the school office, hallways and cafeteria. Portraying the reform through the students' work increases awareness of mathematics and science and increases the importance and credibility of the reform in the eyes of the whole school community.

The Center for Inquiry

The Center for Inquiry (CFI) at Hughes Academic Magnet School in Syracuse was established to provide an extra challenge to students who exhibit a commitment to learning. In a change from the old Gifted and Talented Program, which chose its students on the basis of high test scores, CFI students may be recommended to the program by teachers, parents, or themselves. The CFI resources and teacher are available to all students. Students set personal learning goals in cooperation with their teacher. Through an educational network, Common Grounds, the students are working in collaboration with scientists from museums, universities, and zoos, as well as garnering partnerships in business and industry to conduct short- and long-term research projects in real-world contexts. One of the research projects includes CFI students working with Cornell University scientists on patterns of geographic location and coloration of pigeons. The local cable company has opened its facilities to CFI editors to produce the WCFI News Show that promotes and shares activities with the entire school. Students in other classes may pose questions that CFI students investigate. They report their findings through the news show.

### *B. Building Relationships with Parents and Other Family Members*

Interacting with parents and families can be one of the biggest challenges schools face. Communities that suffer from little parent involvement have less of a challenge in dealing with parents who oppose the new program, but they also lack the support they need for the school and for their children at home. Communities that have more parent involvement, while benefiting from better communication and involvement, may have a harder time getting parents to understand and accept new approaches to science and mathematics instruction. Following are descriptions of roles you should expect family members to play and ways you can support them.

Family members should:

1. Keep an open mind to the effort to improve mathematics or science instruction.

   You may find that it is valuable to have very explicit conversations with parents and family members about the new program and what they should expect to see. They may not understand exactly what will be happening in the students' classroom, but at a minimum, they need to understand that it is likely to be different from their own experiences in school. It is up to you to educate family members about the reform; it is up to them to try to maintain an open mind.

2. Engage in the process of learning and work with their child.

   You and your teachers should develop and implement ways for parents to understand the mathematics or science program, and work with their child at home. In turn, they have a responsibility to participate. Of course, every school holds hopes that parents will engage more often and more completely with their children's learning. As you progress on this reform, you may wish to make this expectation more explicit. Some schools have organized parent nights during which students walked their parents through some classroom experiences. This can be a great introduction to the kind of learning support a child needs to have at home.

You should:

1. Communicate with parents and/or other family members about your mathematics or science program. Open their minds to the reform.

   Family members need to know about the programs that take place in your school. You can't assume that just because you and your staff have decided to bring mathematics or science reform to your school, that parents and family members will be supportive. You may find that you need to "make a case" for the reform and provide them with the background information necessary to understand why you have chosen to do this. Simple communication may not be enough; they may need to hear carefully-designed, strategic arguments for the value of the changes you are trying to make.

   Communication could also take the form of letters home, invitations for visits in the classroom, or school-wide open-houses. You might invite parents to visit a school-wide science fair or to attend class on the days that your students make presentations on long-term projects. Explain to family members the kinds of changes they can anticipate, the content their children are going to be learning, what the students' homework will look like, the kinds of projects their children will be doing, and how they can help.

2. Get to know context and culture of your students' homes and respect their boundaries.

   Occasionally, cultural differences between a teacher or staff of a school and a student's home can cause clashes that stand in the way of reform. As you work to engage families in the school, it is important to demonstrate that you and your staff recognize how their various circumstances may affect their participation. Be sensitive to any issues they may have and accommodate them when possible so that they can participate as much as their circumstances allow.

3. Try to engage the parents and family members in the learning with the children.

   Parents become more supportive of a program if they can help their child as they learn themselves. You may consider working with teachers to develop "homework" assignments that must be done in the home with the assistance of an adult, or are in some way related to something in the home. Or, you may invite parents into the classrooms as assistants, to participate in the lessons as they happen. Some schools we studied had great difficulty engaging parents at first, but continuous, small efforts helped build the necessary momentum.

Strategies to Engage Parents

Principals have used a wide range of strategies for engaging parents and other family members in the process of improving their science or mathematics programs. For example:

- Schools hold family-student nights where students come with a parent or other family member to the school for an evening. With the assistance of the students, the family members do one or more of the science investigations that the students have done in class. Once family members start to get their "hands dirty," their enthusiasm for the program is bound to grow. This excitement is complemented by the fact that many family members are impressed with the amount of understanding the students have about the investigation and the science phenomenon they are exploring.

- Another strategy for engaging family members is to invite them to the classroom to discuss their work in the context of science. This would differ from a more conventional "career day" type discussion in that the teachers and students would try to identify all of the connections between science or math and the profession(s) they are discussing with the family member. If at all possible, they should try to relate that profession to some of the specific concepts / topics that have been the focus of the curriculum.

- Another strategy for engaging parents doesn't require an addition to the regular math / science program. Rather, it grows out of the actual science or mathematics lesson. Some teachers identify homework assignments that must be completed at home either because they require the student to make observations in the home or because they require the assistance / involvement of an older person at home. This strategy, combined with others, can help engage parents and other family members with genuine learning in a continuous way.

Making the Case for Your Program

Schools need to use a range of resources to help them "make the case" for their science or math programs to parents. Given the recent growth of interest in high standards and student outcomes, a first place to turn would be the National Research Council's National Science Education Standards and the National Council of Teachers of Mathematics Standards. These documents offer benchmarks for student learning and portray science and mathematics as an active, student-driven endeavor. As national documents, they can hold some authority in the eyes of parents and provide support for changes in the science and mathematics programs. Additionally, you might turn to TIMSS, the Third International Mathematics and Science Study. This world-wide study demonstrated that the curriculum and instruction of science and mathematics in this country differs greatly from those countries that were top performers. The TIMSS findings can help to justify a focus on teaching fewer topics in depth, and a movement away from rote memorization of facts and algorithms.

In addition to these formal documents, you can gather data from your own school. Examples of students' work including presentations and investigations can be very powerful evidence of the value of your science or mathematics program. Similarly, photographs of students engaging in challenging mathematics and science can have a strong impact on parents.

In general, use a variety of materials to "make the case" for your program. Different kinds of evidence will appeal to different audiences at different times.

### *C. Building Relationships with the District*

Whether your school's efforts are part of a larger district-wide reform or you are working on your own, you need to pay careful attention to the conditions and context of your district. Some principals believe it is best to stay away from district issues and politics, and choose to distance themselves and their schools from the district as much as possible. The most successful principals, however, have found that by getting to know people throughout the district and staying in the paths of communication they have been able to better "protect" their schools and at the same time bring more resources into their buildings. They carefully frame their conversations about their reforms to illustrate how not only one school, but all schools in the district can ultimately benefit from their efforts. Following is some of their advice:

1. Find multiple ways to connect with the district.

   There are many ways to build connections between your school and your district. In some cases (when your work is part of a larger district-wide program), the reform may already be on the district's agenda. In these conditions, school efforts and the district efforts co-evolve and support one another's growth. For example, the teacher leaders that develop in one school can become resources for the district's broader efforts by conducting professional development for other teachers across the district. Similarly, a single school might field-test instructional materials for the whole district with the resulting benefits of professional development for the teachers in that school and valuable feedback for the district about the quality and worth of the materials.

   If your district is not engaged in a large mathematics or science improvement program, your school could become the "seed" for such an effort. You might discuss with district leaders the possibility that your school could be a "pilot school" for the district. As such, you might receive district resources for materials or professional development in exchange for serving as an example for the rest of the schools. You might be a demonstration site for a whole reform program, or for parts of your program (such as curriculum or professional development) or even for individual strategies. In this way your school informs the district and provides expertise and resources. In return, the district provides additional supports. Your school can get great substantive and political mileage from this sort of collaboration.

   Perhaps most important is that you develop a relationship with the Assistant Superintendent and other Central Office administrators. Meet with your Assistant Superintendent for Curriculum and Instruction and your Mathematics or Science Coordinator (if you have them) to make sure they are supportive of and involved in your school's effort. If they are aware that you are focusing on mathematics or science reform and that your school is willing to offer assistance to them when needed, they may be more likely to alert you to available resources or supports before others. And district supports are not limited to financial resources. If the district is well appraised of your efforts and knows you are willing to collaborate, they may be more willing to provide you with waivers for tests, provide access to district services, or work closely with you on staffing changes. Keep them informed of your progress and keep your school foremost in their minds.

2. Become a "buffer" between district/state pressures and the teachers working to change their practice.

   State policies and district practices can be an important source of support for the school, but they can also can be the biggest barrier. If you find that current state or district policies or practices might interfere with the direction you and your staff want to go, you may wish to act as a "buffer" between the district and your school. In some cases, you might be protecting the teachers; in others, you might be protecting the program *from* the teachers who might use district pressures as an excuse for their lack of participation. You need to assess the reality of these pressures and their consequences, and act accordingly. Consider yourself a semi-permeable membrane that allows the supports in, but keeps the barriers out.

3. Network.

   Networking is professional development for you, and can be beneficial to your school. Principals involved in school-wide reform benefit greatly from talking with other principals in their district, state and across the country. Try to meet, either formally or informally, with other principals to exchange and share ideas, strategies, resources and support. At the same time that you build collegial relationships with other principals, you have the benefit of their previous expertise and experience.

### *D. Building Relationships with Community Organizations, Institutions of Higher Education, Businesses, Unions and Other Interest Groups*

Many groups have an interest in what happens at your school. They can be great advocates for your reform, or they can put up challenging barriers. It is important to engage them in your school's work early on and offer them opportunities for direct participation so that they can become your political supports in the district and the community. Following are some suggestions for engaging them in your school's effort.

1. Connect to small businesses, community organizations and institutions of higher education.

   Many businesses that focus on mathematics or science are likely to have an interest in becoming more involved in your program. They may be willing to open their site for field trips, send staff to your school as guests, or provide more general supports such as meeting space, food for professional development sessions, and money. Other businesses might offer services such as telephone or cable service or computer support. If you are aggressive and creative, you may be able to obtain more for your school than you ever expected.

   Community organizations can also be valuable supports. They may be able to provide assistance for your in-school activities by acting as volunteer classroom aides, providing people or places to manage and distribute materials, and sponsoring fundraising activities. If you have a local university, departments of education may wish to place student teachers in your school and in exchange may make their services or resources available to your

teachers. Similarly, science and mathematics departments may be able to provide faculty who are interested in collaborating or communicating with students or assisting in providing content-related professional development.

A Math and Science Booster Club

In one small rural district a local drugstore owner has agreed to become the chair of a "community engagement" group. The group meets every month for a dinner and a discussion. Facilitated by a high school science teacher, the group discusses how they might best support the entire district in improving its math, science and technology programs. The group realizes that the future of their community depends on having good schools, and on having scientifically literate children. Not many jobs, they say, will be available for people without good technical, communication, and computer skills. And not many industries will come to a small community like theirs if the schools are weak, and the workforce untrained. The drug store owner says that the community engagement group is like a "booster club" – but for academics, not the band or football team. He also says that the group is a useful way for local stores like his to contribute to the schools in meaningful ways. Last year he gave $3,800 to the schools, in the form of free food for parties and social events. He likes using his time and money to support math and science teaching in the school. So far the group has considered ways to raise money for more teachers to attend professional development events; the money will pay for substitutes or will provide day-care for teachers who have young children.

To get started working with people outside your school, simply invite them in. When outsiders are asked to come to a school and participate, they become more invested in the progress of the reform; sometimes they can even rejuvenate a process that has slowed down. Visitors also can help bridge your school with programs happening in other schools, in your district as a whole, or in other communities. In general, community relationships are challenging to build, but the rewards of increased visibility and support are well worth the effort. Local scientists, mathematicians and others who take an interest in the reform effort can become the key to keeping it going.

Partnerships

In one elementary science reform effort, community support comes from scientists. Hailing from university, local industry and business, they are initially enlisted to attend teachers' kit trainings. Working in cooperation with the teacher leader who leads the workshops, scientists raise and answer questions and help the teachers look more deeply at the content of the kit. Later while the teachers are teaching the kit in their classrooms, the scientists are available to make regular visits to provide additional classroom support. The teacher-scientist relationship is carefully negotiated so that it is mutually beneficial; the scientists help the teachers and students to improve their knowledge of content and inquiry-based teaching, while the teachers help the scientists to rethink their own university teaching practices, as well as evaluate the influence they might have on elementary education.

Perhaps more importantly, the scientists provide advocacy and credibility to the program. They are respected in the community and their public support (e.g. in school board meetings, among their colleagues) raises awareness of what exemplary science teaching and learning can look like.

2. Communicate and publicize.

   In addition to communicating with parents and district administrators, it is important to communicate with the community at large. Publicize your school's efforts so that you build greater momentum that becomes more and more difficult to slow down. A good starting point is to give your reform effort a name that everyone can recognize. Then, spread that name everywhere and be aggressive about letting others know what you are doing. Press releases, for example, take a small amount of effort, but can provide great returns if your local newspaper or radio station broadcasts the information. Or, you may want to contact news organizations directly when your school has a special event that the media may wish to cover. Don't be shy about sharing what you are doing. It is important to the community and it is critical to sustaining your work.

3. Gather evidence to support what you are doing.

   When you publicize a reform, you should always be prepared for the skeptics. You may find that you need to assemble a collection of resources to "make the case" for your reform effort. Remember to turn to national authorities such as the National Academy of Sciences Science Education Standards or the National Council of Teachers of Mathematics for research on inquiry-based methodology. Collect anecdotes and photographs from teachers. And keep careful records of your students' work so that you can demonstrate growth. You will need to assemble a "portfolio" of evidence that your reform effort *can* and *is* making a difference in your students' education.

## SUSTAINING THE PROCESS

Some schools get their science or mathematics reform effort off to a strong start and then lose momentum. As principal, you can take some important steps to ensure that this doesn't happen in your school. Below are some general guidelines and "rules of thumb" for supporting and sustaining your program.

### *A. Provide a Supportive Environment for the Teacher*

Some feel that creating an environment in which teachers feel completely comfortable trying new things is an unrealistic ideal. But many principals have come close. In fact, this is one of the most important roles you can play in a reform effort. You need to recognize that many teachers may feel awkward and nervous experimenting with new approaches. Let teachers know that you *expect* them to experiment, that you are hoping to see them try new strategies, materials, and activities in their classrooms and that they should not worry about what might happen if a lesson doesn't go as planned.

Finding and Eliminating Barriers

One principal we spoke with recounted a story of identifying and removing a barrier he had not anticipated. He noticed a young teacher who was reluctant to use the science kits that were delivered to her room. When he asked why, and what he could do to help, she finally admitted to him: "I want to teach the kits but I am afraid of looking awkward as I do it… and I don't want you to see me that way…" The principal then quickly agreed to stop looking in on her so often, and agreed that he would wait to be called before observing her teaching the kits.

Some teachers can be overwhelmed with the prospect of a completely "new" way of teaching and may get defensive about their current practice. They need to understand that no reform effort could diminish the value of their own expertise and what years of classroom experiences has taught them. You can help by balancing new approaches to instruction with more basic or traditional approaches that your teachers already use. Let them know that standards-based mathematics and science reform doesn't advocate abandoning "basic" approaches, just placing a decreased emphasis on them.

There are many other reasons that classroom teachers may not jump wholeheartedly into a reform program. They might feel that there is insufficient time, that their students are not sufficiently under control, or that the students aren't learning enough. In the case of science, teachers might feel that it is less important than other subject areas; they may be afraid of it; or they may not like science or math as it was taught to them. It is important to bring these issues to the surface so that they can be addressed either through policy or schedule changes, professional development, or other supports. Even small changes that acknowledge their opinions can provide the teachers with an assurance and sense of confidence that this reform is worth the investment they must make.

### *B. Try to Convert the Resistant, but Focus on Those who are Most Ready*

You may have teachers in your school who are not at all interested in exploring ways to change their practice. If you have such resisters, it is important to do everything you can to persuade them to participate. Listen to their concerns, give them the professional development and materials necessary, and provide them with encouragement. There will always be people who are simply shut down to change. But the change can happen without them. Don't focus too much of your energy on these individuals, for you don't want to neglect those who are ready and willing. The reluctant ones will eventually need to come on board but at the beginning it is more important to make sure support is available for those who want it.

Speedboats, Rowboats, and Rocks

One principal told us quite candidly, "In our school I think of the teachers in three groups – the speed boats, the rowboats, and the rocks. The speedboats will go full speed ahead trying all kinds of new things no matter what I do. The rowboats are the regular teachers, who with a little help, can make incremental but important progress. The rocks simply aren't moving and won't move. My job, I think, is to work mostly with the rowboats – and also to make sure that none of the moving boats crashes and sinks on one of the rocks!!!"

Still, if you think resistant teachers are going to actively undermine your progress, you may wish to consider exploring ways to remove them from your school. You may find that the teacher is just as happy to leave the school as you may be to see him/her go. Since changes in culture are likely to co-evolve with those in practice, teachers who "fit in" before may become less and less comfortable as the reform continues. In the long run, if these teachers move, it may mean that everyone is happier.

At the same time that successful principals are working to relocate staff, they are keeping their eyes open for new individuals who can assist in shepherding the effort. Good prospects may include student teachers who will be looking for teaching assignments in the coming year, teachers who are actively leading or participating in professional development elsewhere in the district, or simply people who have some kind of personal connection with you or others in your school. Ultimately, the goal is to have as many "like-minded" people in the school as possible.

### *C. Foster Openness, Experimentation and Collaboration*

Some principals say that they believe in collaboration and experimentation, but offer little concrete support to make it happen. There is much that a principal can do to demonstrate a genuine commitment to facilitating more teacher-teacher interaction. For example: organize the schedule so that all of your teachers at a grade level have common planning periods; encourage teachers to keep their doors open and look in on one another's rooms; take one of your teachers' classes so that he/she can go watch another teacher teach; or, reorganize the placement of the teachers' rooms, putting like-minded teachers near one another so that they can work together. Welcome and support teacher-initiated ideas especially when they come from eager teachers, and have visible, school-wide celebrations or acknowledgments when your school reaches a marker of progress. All of these strategies can contribute to developing a genuine school community focused on mathematics or science improvement.

Fostering Collaboration

Principals can use many strategies to foster collaboration amongst the teaching staff. Among the most common is the scheduling of common planning periods for teachers at each grade level. When teachers at a grade level have a consistent, long-term opportunity to work together, they develop a collaborative rapport with one another. As this collaboration develops, with guidance, they are likely to devote increasing amounts of that time to improving the science or mathematics program either at their grade level or in the school as a whole.

Other schools have "found" time using alternative strategies. For example, one school worked with parents in the community to gain approval to lengthen the school day for four days a week (Monday, Tuesday, Thursday, and Friday). Then, on Wednesdays, students were released early and the teachers used that time for planning, grade level meetings and other collaborations specifically focused on instruction.

Although providing time to meet together is important, other strategies also can contribute to fostering collaboration. In one school, for example, the principal asked her school leadership team to survey all of the teachers to determine their needs and "wish lists." One of their requests, for example, was time for peer observation which the principal then orchestrated into the schedule. This kind of responsive interaction fosters a culture of collaboration which can begin to permeate all activities in the school.

### *D. Make a Place for Reform*

Many of the most successful schools have taken the concrete and critical step of making a "place" for their reform. These places serve various functions. In some schools, the room is a place where teachers can meet with one another outside of their classrooms without having to put up with traffic in the teacher's lounge or lunchroom. In others, the room is a physical storage place for materials and supplies. And in others, it is a classroom, where special science or mathematics events take place. Just as important, if not more so, is the symbolic value the "place" has. It becomes the "node" for reform activity and is a concrete sign of commitment to the reform and to professional growth of your teachers.

A Designated Space

In one school, a room called the "Grant Room" or Teacher Technology Center serves as a teachers' office, lending a sense of professionalism to the staff. The room is for staff only, and has several computers, a conference table and telephones for teacher use. It serves as the site for many formal and informal educational dialogues. As the school began redesigning itself, many changes and projects evolved from the sharing that went on in this room.

In another school the principal found a room and designated it as the school's "inquiry center." All teachers have a key to the room, and stored within is a large supply of materials useful in teaching both math and science. There is also a library in the room, and several different science kits are stored there so that they can be piloted by teachers who wish to do so. Teachers who work on the school's "inquiry team" meet there, and occasionally teachers give small workshops there.

### *E. Communicate*

When communication structures are working well, they can be difficult to identify; when communication is not functioning well, it quickly emerges as one of the greatest barriers to reform. Your school may have formal means of communication such as distribution of information through mail boxes, grade-level representatives and faculty meetings but these may be insufficient to ensure that all of the teachers in your school feel they have a voice. You may need to consider new formal structures for communication such as grade-level meetings, teacher team meetings and decision-making committees. Equally, if not more important are the opportunities for on-going informal communication. In schools where teachers and administrators have common planning periods and a place to work with one another communication happens naturally. In successful schools, principals make every effort to make sure teachers understand the purpose of procedures, deadlines and changes made in the building, and teacher input is constantly requested.

# IV. THE JOURNEY: WHAT ARE THE NEXT STEPS FOR YOUR SCHOOL?

This monograph has attempted to capture the wisdom of experienced, skillful principals interested in high-quality mathematics and science instruction. We have tried to portray the richness and complexity of this process and provide you with an understanding of the necessary "pieces" of reform which are common among successful schools. This monograph will help you get started. Then, as you pick up momentum, you and your teachers can engage directly with others to become active contributors to this ever-growing knowledge base.

Following are final "words of wisdom" from the principals we have visited:

## REMEMBER THAT THIS IS A JOURNEY OR A PROCESS

Full-scale change takes a long time. It is most important for you to keep in mind that standards-based mathematics or science instruction is not something that you can put in place as quickly as a new textbook. This isn't something that you do once and then it's over; you revisit it continuously, looking at what has gone well, what hasn't and how you can continue to improve.

Some schools have found that "rituals of passage" or symbols of success play an important role in acknowledging accomplishments and maintaining their momentum. They also continuously look for new, varied sources of motivation for their students, the school as a whole and themselves. Remember that the various aspects of the reform – professional development, time, planning, experiences in the classroom, successes, failures, energy levels, leadership – all change at different rates. So it is important to develop a mechanism for looking at and reflecting on your progress inside and outside the school. Your time scale for change has to be carefully balanced. If it goes on too long, your effort will lose its vitality; if it is too short you will feel rushed and frustrated by unrealistic goals. Remember, it's going to be a "long haul."

Noting Major Milestones

A large school district in New York recently passed a major milestone in their multi-year effort to establish a kit-based science program. They developed a district-supported materials center which is capable of serving all the district's elementary and middle school teachers. By keeping careful records of kit requests, they were able to establish that on average, each elementary school teacher was now teaching one kit per year. This milestone was important in their effort, and they now felt renewed enthusiasm as they worked toward implementing two and even three kits per year on average.

## CREATE A CUSTOMIZED, FLEXIBLE PLAN FOR REFORM

It is important to write down your plan for reform, even if it is constantly changing. This plan doesn't necessarily need to be extremely detailed or even complete. In fact, you don't want to spend too much time planning, as you run the risk of planning too many things that never happen. Rather, you should take an incremental approach which helps you ask: "Given where our school is now, what is an appropriate next step, a small one that we can do and do well?" Along with your plan, you should also identify indicators or possible evidence that you

are making progress. If your team has a clear understanding of how to know how well they are doing, they will be better prepared to articulate the plan and expectations to other teachers, parents and students.

### BUILD ON YOUR STRENGTHS, BUT PREPARE NOT ONLY TO BUILD UP, BUT ALSO TO BREAK DOWN

It seems obvious that you should build on your strengths in determining steps for reform. It is less intuitive to look for existing circumstances in your school that are standing in your way. You may have communication systems, hierarchical structures, reward systems, or common classroom strategies that must be revised or removed if your mathematics and/or science reform effort is going to succeed. As you embark on your reform, make sure you look for these sometimes hidden barriers.

### DEVELOP A TEAM OF "CRITICAL CONSUMERS"

The resources in this monograph are a starting point for identifying high-quality examples of some of the basic components of school-wide standards-based reform. But this is only the starting point. You and your staff need to develop the skills and "taste" to make appropriate choices well into the future. You may wish to work with your team to develop a set of criteria for evaluating curriculum, professional development opportunities, assessments, and other areas of interest and need. You should develop into a team of critical, thoughtful, and strategic decision-makers.

### BALANCE THE USE OF "INTERNAL" AND "EXTERNAL" RESOURCES

It is important to balance using internal and external expertise. In order to build capacity in the school, you will need to draw on the expertise of outside resources. Thus, it is important that you learn about others who are doing this work. But, as you use outside expertise, it is very important that you also find ways to use the knowledge and expertise that are developing in the teacher leaders in your own school. Thus, it is always a productive balance of inside and outside expertise that provides the best long-term growth.

### CREATE THE SENSE OF BEING PART OF A BIGGER MOVEMENT

Get out and talk to other principals, educators and scientists who are part of this kind of reform in their communities. As the reform builds, beyond establishing alliances locally, help the school and teachers feel like they are part of something greater, not just in terms of the changes that are happening in the classroom, but also in connecting with a broader reform.

## COMMIT TO THE REFORM

This has been reiterated a number of times in this monograph but is important enough to mention once again as a final statement. Make the reform a priority for at least two years, and if possible, focus on one subject area at a time. Assert that the school is going to do something very real very well, and that it is going to be over the long term. Roll up your sleeves, get into the classrooms, and make it start to happen.

How NOT to Support Mathematics or Science Educational Reform in Your School

Finally, as a bit of light heartedness, we will share with you some good examples of non-productive approaches to stimulating better math and science teaching in your school:

- Dictate that your teachers will teach more math and science in a memo in their mailboxes.
- Tell your teachers that they are going to be on a leadership team. Don't bother asking or getting volunteers: just tell them.
- Select your teachers who seem the most "burnt out" and bored to lead the reform in an effort to rejuvenate them.
- Ask three people to spend four days over the summer designing the curriculum for the whole school.
- Withhold funds from your teachers at the outset.
- Don't provide any training on how to work with others.
- Do science this year, math next year and something else the following year.
- Make sure teachers spend no time out of their classrooms whatsoever.
- Say that you are going to focus on new standards-based mathematics and science but reward teachers based on their students' scores on the standardized computation and vocabulary tests.
- Make sure that you constantly refer to test scores and impress upon your teachers how important it is to get basic scores up.
- Order kits that are half filled and tell your staff that they have to go out and supply themselves with the rest of the needed materials.
- Don't read research.
- Do read research.
- Make as many reforms as possible happen at the same time in your school.
- Explain to the teachers, the district and the parents that they have been teaching incorrectly all along.

Principals from 80 elementary schools, in predominantly rural Western Pennsylvania, completed and returned a 22-item questionnaire designed to assess the nature and extent of technology use for the teaching of elementary mathematics and science within their buildings. Technologies included calculators, microcomputers, overhead projection panels, videotape, and interactive video. Microcomputers were being used in at least some elementary grade levels for mathematics or science instruction in 84% of the schools. Teachers used microcomputers more frequently in mathematics (82.5%) than in science