B . . I´T L . .

A Report to the Nation from The National Commission on Mathematics and Science Teaching for the 21st Century

C

Archived Information

Dear Secretary Riley:

On July 20, 1999—the 30th anniversary of the first landing on the moon—you announced the appointment of the 25-member National Commission on Mathematics and Science Teaching for the 21st Century. In your charge to the Commission and its eight ex officio members, you asked us to investigate and report on the quality of mathematics and science teaching in the nation, directing us to consider ways of improving recruitment, preparation, retention, and professional growth for mathematics and science teachers in K–12 classrooms nationwide. You reminded us that, three decades after a historic achievement, "we need to set the stage for advancement in mathematics and science for the next thirty years."

It has been my privilege to chair the Commission, and I am pleased to report to you, on behalf of its members, that we have completed our work. With this letter, we transmit to you our report, *B I' T La*, which summarizes our findings. It presents to both the Department of Education and the American people a set of ambitious goals for improving mathematics and science teaching and specific action strategies for achieving each of them.

We trust that we have been faithful to your charge. As we have listened to the presentations of scholars, deliberated over the studies of outstanding researchers, and attended to the experience of dedicated administrators and teachers, we have learned much. Our assumptions have been called into question. Our individual views have been tempered by the perspectives of colleagues whose judgment we have come to respect, even in disagreement. As we have sought to understand today's problems in mathematics and science education, we have also worked to uphold a constant vision of high-quality teaching as the irreducible minimum for creating tomorrow's solutions.

We believe that the issues and concerns raised in our report can be understood, addressed by, and potentially unite policymakers, teachers, the business community, parents, students, and private citizens alike. The goals and action strategies we suggest may be seen by some as too great a reach, by some as not bold enough. We are convinced, however, that if they are ignored, our children and our nation will soon pay the high price that always accompanies apathy.

Each member of the Commission, through this letter, expresses appreciation for your leadership in having brought this diverse group together to examine an issue that has pivotal significance for our country as we embark on a new century and millennium. It is our collective and earnest hope that you will continue that leadership by encouraging widespread discussion of our views and suggestions, and by urging appropriate action based on our findings and recommendations.

Finally, we offer our profound thanks for having provided us with this opportunity to serve our country—and our children—as members of this Commission.

Respectfully,

John Glenn, Commission Chairman

First, at the daybreak of this new century and millennium, the Commission is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically.

From mathematics and the sciences will come the products, services, standard of living, and economic and military security that will sustain us at home and around the world. From them will come the technological creativity American companies need to compete effectively in the global marketplace. "Globalization" has occurred. Economic theories of a few years ago are now a reality. Goods, services, ideas, communication, businesses, industries, finance, investment, and jobs— — *b* —are increasingly the competitive currency of the international marketplace.

Among the first things Americans watch every morning on TV is the global marketplace at work. The quotes not only from Wall Street itself, but also from the Nikkei, Hang Seng, and Hong Kong exchanges, followed in turn by those of Frankfurt, Zurich, and London—along with reports on the status of the yen, peso, and Euro—all reflect investment flows of hundreds of billions in assets around the world. Times have changed. In an integrated, global economy, whose key components are increasingly knit together in an interdependent system of relationships, will our children be able to compete?

Beyond the world of global finance, mathematics and science will also supply the core forms of knowledge that the next generation of innovators, producers, and workers in every country will need if they are to solve the unforeseen problems and dream the dreams that will define America's future.

Second, it is abundantly clear from the evidence already at hand that we are not doing the job that we should do—or can do—in teaching our children to understand and use ideas from these fields. Our children are falling behind; they are simply not "world-class learners" when it comes to mathematics and science.

The Third International Mathematics and Science Study (TIMSS) tested the students of 41 nations. Children in the United States were among the leaders in the fourth-grade assessment, but by high school graduation they were *a* *a* . Here at home, the National Assessment of Educational Progress basically substantiates our students' poor performance.

In short, our children are losing the

competence they will need to live their lives and work at their jobs productively. Perhaps worst of all, we are not challenging their imaginations deeply enough.

Third, after an extensive, in-depth review of what is happening in our classrooms, the Commission has concluded that the most powerful instrument for change, and therefore the place to begin, lies at the very core of education—

ac .

The teaching pool in mathematics and science is inadequate to meet our current needs; many classes in these subjects are taught by unqualified and underqualified teachers. Our inability to attract and keep good teachers grows. As a result, newer, technologically oriented industries are having trouble finding enough qualified employees from among those teachers' students. Worse, creativity atrophies and innovation suffers.

We are of one mind in our belief that the way to interest children in mathematics and science is through teachers who are not only enthusiastic about their subjects, but who are also steeped in their disciplines and who have the professional training—a ac —to teach those subjects well. Nor is this teacher training simply a matter of preparation; it depends just as much—or even more—on sustained, high-quality professional development.

Fourth, we believe that committing ourselves to reach three specific goals can go far in bringing about the basic changes we need. These goals go directly to issues of quality, quantity, and an enabling work environment for teachers of mathematics and science. For each goal, we offer specific action strategies for achieving that particular goal, ideas on who should implement them, and how. Specifically, we offer suggestions on how to:

- E ab a , a a a c a c c ac a K 12;
- I c a ca b a a c a c c ac a , a , a a ; a
- I , a a ac , a ac K 12 a a c a c c ac .

The goals we set before the American people in this report will not be easily attained, nor will the action strategies we offer be readily implemented. Most other nations have a national education system that can change direction more rapidly than our K–12 system, which is operated by nearly 16,000 independent school boards. Even when the majority of board members are firmly dedicated to good education, it is still a difficult job to change direction when needed.

The task to which we call the American people is therefore not an easy one. Nor will our goals be met at bargain-basement rates. But we believe we have a well-focused view of the needs facing our country and its youth, and that we have identified the right starting points for preparing them to meet their future. We are just as strongly convinced that the downstream cost of not turning this problem around will be exponentially higher than the cost of beginning to solve it now.

But rising to great challenges is a part of our national character—not only in such

consistent and powerful predictors of student achievement in mathematics and science are full teaching certification and a college major in the field being taught.

Better mathematics and science teaching is therefore grounded, first of all, in improving the quality of teacher preparation and in making continuing professional education available for all teachers. A closer look at the teaching that goes on in mathematics and science

classrooms today puts the performance of U.S. students on national and international assessments in sharper focus. The basic teaching style in too many mathematics and science classes today remains essentially what it was two generations ago. By contrast, teaching innovation and higher student performance are well documented in other countries, where students' improvements are anchored to an insistence on strong professional development for teachers.

What *c* be happening in U.S. mathematics and science classrooms is markedly different. The report names an extensive set of characteristics of "high-quality teaching." When they are focused through the lens of exemplary teacher preparation and an integrated of professional development, an enormous potential for empowering teachers and improving instruction is apparent.

The pressing national need for - described in this report, therefore, demands a vigorous, national response that unifies the efforts of all stakeholders in mathematics and science education. To that end, three wide-ranging, intertwined goals focus the report's call for action at local, state, and federal levels. As an aid to implementation, each goal is accompanied by a coordinated set of well-funded action strategies that identify key stakeholders who should take the lead in implementing each strategy. The estimated annual cost to achieve these action strategies is over $5 billion. These funds and other resources will come from a diversified set of sources, including all levels of government, higher education, business and industry, professional education associations and teachers' unions, community groups, and the citizenry. The goals and action strategies set forth in the report are as follows:

E ab a

a a a a c a

c c ac a K 12.

Seven interdependent action strategies are offered to implement this system: (1) each state must immediately undertake a full *a* to determine what teachers require, both in their schools and their professional lives, if they are to routinely deliver high-quality teaching; (2) *S I* must be established to address the professional development

the nation's governors gathered in Charlottesville, Virginia, to set ambitious goals for our schools. Among the challenges the governors issued was this one:

B Y a 2000, U S a b a a c a c c ac . [1]

A goal like that might be tough, Americans thought, but it was reachable.

But our effort since has not matched our rhetoric. Results from the Third International Mathematics and Science Study (TIMSS) show U.S. students devastatingly far from this goal by the time they finish high school.

In an age now driven by the relentless necessity of scientific and technological advance, the preparation our students receive in mathematics and science is, in a word, unacceptable. Despite our good intentions, their learning is too often superficial. Students' grasp of science as a process of discovery, and of mathematics as the language of scientific reasoning, is often formulaic, fragile, or absent altogether. And perhaps most alarming of all, as recent assessments seem to show, the longer our children study these crucial disciplines, the less favorably they compare with their peers in other countries.

economy and workplace, (2) our democracy's continuing need for a highly educated citizenry, (3) the vital links of mathematics and science to the nation's national security interests, and (4) the deeper value of mathematical and scientific knowledge.

A Changing Economy: Science and mathematics exert the most visible influence on the economy through their most rapidly changing offspring—new technologies.

- New technologies are the relentless drivers behind the nation's standard of living. Since 1996, national productivity (i.e., output per worker hour) has increased, on average, by 2.6% per year, a rate that doubles the standard of living roughly every 25 years.[7] Such productivity gains are unsustainable without a workforce sufficiently educated in the sciences and mathematics.
- The technology-driven economy of the 21st century will add about 20 million jobs to the American economy by 2008—if we can only educate our young people to fill them.[8]
- Jobs in both the health sciences and computer industries requiring science and mathematics skills will increase by 5.6 million by 2008. The Department of Labor estimates that postsecondary institutions will have to produce nearly four times as many graduates in computer science as they do now to meet the demand.[9]
- Bureau of Labor Statistics projections for 1998-2008 revealed that more than two-thirds of the 30 occupational categories expected to have the fastest growth—most of them high-tech—already had hourly earnings above the national median; 11 of those job categories were in the top earnings quartile of $16.25/hour and up.[10]
- Finance, trade, industrial production, communications, and asset ownership are becoming increasingly integrated on a global basis. So are capabilities in science and technology. Singapore, for example, reputedly has the most technologically intensive workforce in the world. Israel now produces more technology-based startups than anywhere outside Silicon Valley; its high-tech exports account for a quarter of its global sales, and the country boasts 135 engineers per 10,000 citizens—twice the U.S. ratio. Drawing on a young, skilled, and well-educated workforce, Ireland now produces 60% of all PC business-application software sold in Europe. The common denominator of these

where U.S. troops must respond quickly and operate for indefinite periods. On the ground, the modern equipment and weaponry that our troops are now called on to use in battle require mathematical and scientific skills, particularly computer-based learning. Finally, the sophisticated mathematics of encryption supports and protects our diplomatic and military communications around the world, as well as those of American corporations.

The wealth of knowledge that mathematics and science impart for understanding the world has such breadth that it is easy to overlook the dimension of depth. But teaching our children these subjects is important at a more profound level than that of their practical benefits. Above all, mathematics and science impart three qualities that define our human world and enable us to meet its challenges.

- First, mathematics and the sciences bring order, harmony, and balance to our lives. They have great explanatory power. They teach us that our world is not capricious but predictable, i.e., that it contains pattern and logic, which can be used in the service of humankind. The analytical tools of mathematics and the investigative skills of a scientific approach are also foundational skills for lifelong learning, in other words, for creating progress itself.

- Second, science and mathematics continually shape and reshape our history and culture, giving rise to new ideas and inventions. It was early astronomy that formed the knowledge base of ancient Near Eastern civilizations. The physics of Newton made the Industrial Revolution possible. In our own time, the pure science of information theory has yielded not only computers but also an incredibly useful global communications system.

- Third, as science and mathematics provide human beings with powerful tools for understanding and continually reshaping the physical world itself, they teach us again and again that Nature's secrets can be unlocked—in short, that the new is possible.

Despite the pervasiveness of mathematics and science in our lives, the sad reality is that our nation continues to renege on its *Y a 2000* promise. Our schools are not producing graduates with the kinds of skills our economy needs to remain on the competitive cutting edge. In consequence, we are bequeathing failure to our children. As they try to meet the challenge with the longest-range implications of all—securing their own and America's place in the world—they need to command the disciplines that they are only indifferently mastering today.

If this were all that could be said, then the future would be bleak indeed. But it is not. Some important factors have begun to coalesce, each adding to the others' momentum.

To say that improving the quality of teaching yields better student performance in science and mathematics makes sense, and some states have taken this wisdom to heart.[24] But in many more places, nearly the reverse is true. There, the knowledge base and arsenal of teachers' skills must be replenished:

- More than one in four high school mathematics teachers and nearly one in five high school science teachers lack even a minor in their main teaching field.[25]
- More than 12% of all new hires enter the classroom without any formal training; another 14% start work without meeting the teaching standards of their states.[26]
- About 56% of high school students taking physical science are taught by out-of-field teachers, as are 27% of those taking mathematics. These percentages are much greater in high-poverty areas. Among schools with the highest minority enrollments, for example, students have less than a 50% chance of getting a science or mathematics teacher who holds both a license and a degree in the field being taught.[27]

Thus, when the dismissal bell rings each day, untold thousands of American students depart for home having been taught by mathematics and science teachers ill-equipped for the job. Far too many are inexperienced beginners, with little or no training, and little or no mentoring by qualified colleagues. Astonishingly, in no other profession is so much of such ultimate worth entrusted to people with such uneven qualifications.

The most common solution to the shortage of qualified mathematics and science teachers is to assign those classes to out-of-field teachers. But merely being able to keep one chapter ahead of the students in an algebra or environmental science text does not a mathematics or science teacher make.

Predictably, underqualified teachers are most prevalent in urban schools. A recent survey taken among 40 large urban schools, for instance, showed that more than 90% of them had an immediate need for a certified mathematics or science teacher.[28]

teaching methods in mathematics and science classes have remained virtually unchanged. Classroom practice has still hardly begun to capitalize on the many dimensions of the learning process.

A videotape study of eighth-grade mathematics classes in the United States reveals that the basic teaching style in American mathematics classrooms remains essentially what it was two generations ago. The approach used for the lessons was numbingly predictable: (1) a review of previous material and homework, (2) a problem illustration by the teacher, (3) drill on low-level procedures that imitate those demonstrated by the teacher, (4) supervised seat work by students, often in isolation, (5) checking of seatwork problems, and (6) assignment of homework. In not one of 81 videotaped U.S. classes did students construct a mathematical proof.[29]

In Japan, by contrast, closely supervised, collaborative work among students is the norm. Teachers begin by presenting students with a mathematics problem employing principles they have not yet learned. They then work alone or in small groups to devise a solution. After a few minutes, students are called on to present their answers; the whole class works through the problems and solutions, uncovering the related mathematical concepts and reasoning. The students learn through reasoned discovery, not lecture alone.

Not incidentally, this approach is a natural outgrowth of the teaching culture in Japan, which accords teachers not only abundant time for preparation, but also for collaborative lesson planning. Fully 99% of all elementary teachers and 50% of all middle school teachers participate in lesson study groups that meet for two to five hours per week. The debilitating professional isolation of U.S. teachers stands in stark contrast to this pattern. A core conclusion from the videotape research: "The key to long-term improvement [in teaching] is to figure out how to generate, accumulate, and share professional knowledge."[30]

Instructional patterns in the United States do not yield much better results when it comes to the sciences. Tests of scientific knowledge and classroom observation indicate that most science students spend much of their time learning definitions, or the labels that apply to natural phenomena and scientific processes. In other words, much science instruction in our schools parallels what happens in a badly taught history unit on the Civil War, in which students learn nothing but the names of the generals and the dates of the battles. Seldom are students asked to master the "big" concepts that make science so powerful and fascinating.[31]

If the core of mathematics and science is about inquiry, then too many of today's mathematics and science classrooms come up short. Student are crippled by content limited to the "What?" They get only a little bit about the "How?" (or "How else?") and not nearly enough about the "Why?" Missing almost entirely is "Why should I care?" It is hard to imagine that students in these classes are gaining the conceptual and problem-solving skills they need to function effectively as workers and citizens in today's world—a world that increasingly depends on mathematics and science.

- A core premise of high-quality teaching is that the ability to teach, contrary to myth, is not "something you're born with"; it can be learned and refined over time. Specific teaching skills—for example, the ability to distinguish between what is most important for students to learn and what is hardest for them to understand—can only be acquired through training, mentoring, collaboration with peers, and practice.

- High-quality teaching requires that teachers have a deep knowledge of subject matter. For this there is no substitute.

- In high-quality teaching, the process of , not merely "giving instruction," is the very heart of what teachers do. Inquiry not only tests what students know, it presses students to put what they know to the test. It uses "hands on" approaches to learning, in which students participate in activities, exercises, and real-life situations to both learn and apply lesson content. It teaches students not only what to learn but how to learn.

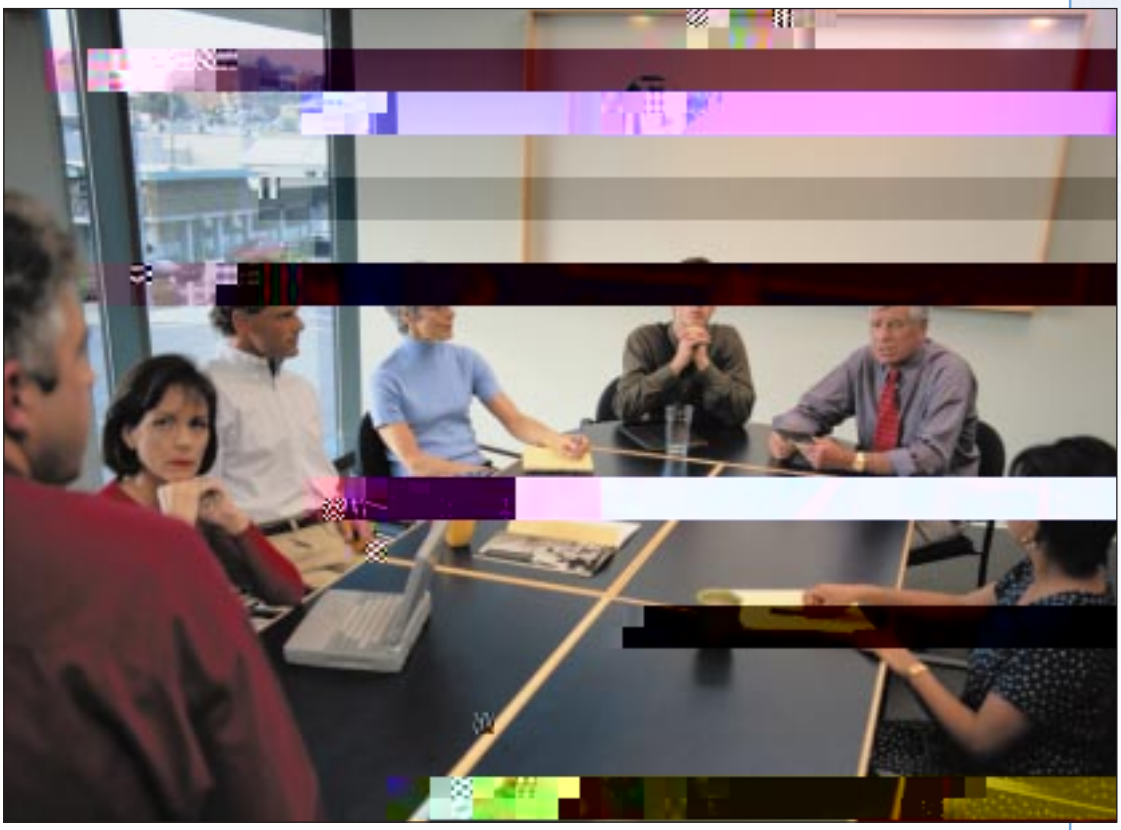
- High-quality teaching not only encourages students to learn, it they learn.

- High-quality teaching, especially in the sciences, focuses on the skills of observation, information gathering, sorting, classifying, predicting, and testing. A good science or mathematics teacher encourages students to try new possibilities, to venture possible explanations, and to follow them to their logical conclusions.

- High-quality teaching fosters healthy skepticism. It encourages students to submit their work to questioning by others, to pull things apart and put skepticism. It enrecogniz

For teachers to deliver high-quality teaching, they must be empowered to do so. Generating this kind of teaching means that school boards, administrators, parents, and policymakers must be willing to stand up for teachers as the primary drivers of student achievement. Teachers must be given the time they need within the school day to keep up with new developments in their fields, teaching aids, materials, and technology. Teachers must be encouraged to contribute knowledge back to their disciplines. They need the time and feedback necessary to reflect on their teaching, so they can get better at it.

Teacher empowerment also means according teachers the respect they deserve for their judgments about learning, rewarding their professionalism, and yes, paying them what they are worth. These concerns are addressed by the goals that follow.



national response that unifies the efforts of all stakeholders in mathematics and science education. To that end, three wide-ranging but intertwined goals focus our call for action at the local, state, and federal levels. Achieving these goals will involve the sustained efforts of legislators and other decision-makers, the business community, higher education, school boards and administrators, teachers, and parents. An intense, serious commitment to achieve these goals, through a coordinated set of well-funded action strategies, is needed immediately.

All together, the action strategies for achieving these goals nationally will cost more than $5 billion annually. Strategy by strategy, the financial responsibility must be shouldered by the governments and institutions best equipped to do so, whether at the federal, state, or local levels, by business and industry, or by higher education. The agenda laid out here details concrete steps that all Americans can take. The most important point to keep in focus is that the funds invested in mathematics and science education today can purchase a lifetime of leverage on the future of American school children and the nation as a whole.

Clearly, the cost of achieving these goals will create a noticeable line item in education budgets at every level. (An estimate of the costs associated with the first year of implementation of the goals concludes this report.) At the same time, however, the nation's balance sheet now shows a considerable surplus and the cost of delay is higher still. Those funds must therefore be put to work now, when and where they can most usefully equip our young people, and through them the nation itself, for the new century's challenges.

If high-quality teaching is the leverage point for improving mathematics and science education, and if professional development is a prerequisite for a well-qualified and effective teaching force, then teachers need a focused support and enough time to grow as professionals.

Sadly and short-sightedly, however, professional development is too often treated not as a necessity but as a luxury item on the school budget. Many people erroneously believe that teachers are not working unless they are standing in front of a classroom. In fact, preparation time, individual study time, as well as time for peer contact and joint lesson planning, are vital sources of both competence and nourishment for all teachers.

But teachers are granted precious little time for any of these activities. Equally rare are extended periods of time set aside

for teachers to have challenging educational experiences of their own. In consequence, much-needed study and preparation time is routinely sacrificed to in-service events that are no more substantive than a broad-brush overview of this semester's teaching fad. High-quality professional development ought to be the lifeblood of American teaching; instead, it is used only to provide the occasional, anemic transfusion.

Everyone connected with and touched by the U.S. education system is responsible for changing the character of professional development and its impact. *T ac* need to take responsibility for their own professionalism as they practice mathematics and science teaching and work to improve their knowledge and teaching skills. *P c , a , , -* *a c b a* must make sure teachers have the time and resources they need to prepare and collaborate. *T ac , , a a , a , a ca , a a* all have a substantive policy role in enabling teachers, schools, and districts to realize improved teaching via professional development. The support of businesses, which stand squarely to benefit from improvements made in the quality of mathematics and science teaching, is also crucial to enriching the quality of professional development. *P a a c a a b* can make their own important contributions through workshops, clinics, and new curricular initiatives.

The place to begin improving mathematics and science teaching is with a that promotes high-quality professional development opportunities for all teachers. Such opportunities should build upon one another and reinforce accountability. The system must be rooted, first of all, in a clear determination of the professional development needs of teachers in every school and school district. That determination must be followed by an immediate response to the most pressing needs; a sustained response with the necessary leadership, resources, tools and time; and a continuing system that recognizes and rewards schools that demonstrate improved student achievement.

Despite progress in some states and districts, there remains an urgent need for wide-scale self-examination, strategic planning, and rapid implementation of a system of professional development tailored to the needs of those who provide instruction in science and mathematics, K–12. Action strategies for implementing such a system are outlined below; each is accompanied by concrete suggestions on how the work can be done and who can do it.

Action Strategies: What Needs to Happen

: Each state must quickly undertake a full assessment of the professional development needs, district by district, of its mathematics and science teachers, K–12. As many stakeholders as possible must be involved in this self-

Who Will Make Them Happen and How?

- Some selected states will begin their needs assessments immediately. States should first establish criteria and protocols for conducting their needs assessment, then go on to identify and analyze state certification and recertification requirements. Once procedures and systems have been established and tested in these initial states, what is learned can be widely disseminated to all states.
- Governors, state legislatures, and state boards of education in each of the remaining states (thence districts) must work together quickly to allocate the federal, state, and local funds and staff needed to develop and oversee a similar assessment of the professional development needs of mathematics and science teachers.
- Two- and four-year colleges and universities, using their mathematics, science, and education faculties, can assist school districts and others in planning and implementing needs assessments.

reinforcement and input from experts to sharpen their skills and deepen their subject knowledge. Building- and district-level Inquiry Groups are envisioned as communities of learning. They will provide a specific venue for teachers to share ideas, gain the benefit of one another's teaching experience, engage in common study to enrich their subject knowledge, learn more about technology, and design ways to incorporate local, state, and national educational developments (e.g., subject-matter learning standards) into their teaching. While critically important during the school year, Inquiry Groups must also continue through the summer, enabling teachers to explore some issues without the pressing responsibility of daily student contact. For districts moving to 11-month salary schedules, full participation in an Inquiry Group ought to be an integral part of every teacher's responsibilities when school is not in session.

T for in-depth study through regular work with peer Inquiry Groups is a teacher's most valuable professional resource. *I* *b c* *ac a c*.

Perhaps most important, these groups can be a rich source of new knowledge about teaching itself, generated from the field. Such groups can readily take advantage of local resources (e.g., businesses, museums, laboratories), other Inquiry Groups from neighboring districts, and faculty from nearby two- and four-year higher education institutions. Inquiry Groups could also be networked electronically, via distance learning technology, for wider sharing of information, instruction, and resources.

Summer Institutes

and Inquiry Groups must be facilitated bthout thel.730Tj0 02expe1nceijT*3 Tm1 0.

Who Will Make Them Happen and How?

Who Will Make it Happen and How?

- Disseminating models for restructuring the school day and teachers' responsibilities to provide sufficient time to support a system of ongoing professional development;
- Collecting and disseminating research on improving mathematics and science teaching; developing databases relevant to teaching; identifying and promoting "best practices" in mathematics and science teaching; facilitating nationwide communication among teachers; and
- Measuring progress and making the results of implementing these action strategies widely known to the public.

Just as we do our

Who Will Make It Happen and How?

- Financial support for the Council must come from a diversified funding stream, including the federal and state governments, businesses, and foundations.
- Where appropriate, the Council will partner with existing groups to provide the necessary services and motivation to states and districts.
- Institutions of higher education will support the Council's mission by providing the training venues and the human resources needed to enact Council-brokered activities.

Who Will Make Them Happen and How?

- U.S. corporations and businesses, which have a stake in improving mathematics and science education, should provide significant funds, over several years, to support rewards and recognition programs in those states and districts that have implemented a system of high-quality professional development and assessment.
- It makes sense to gradually move rewards and recognition programs under the umbrella of state and local education agencies, although a strong business presence is needed to keep school-business relationships viable and to impart to the public the importance of the business stake in mathematics and science education.

- The federal government must support an aggressive, national outreach, media campaign to attract young npeople torincipals86 0 47 0 0.al ou

- Academies must be established through a competitive grant process

than others (40% vs. 29%).[40] The specific causes given for their unhappiness make a long list, but chief among them are these professional issues: lack of leadership and respect from principals, lack of classroom autonomy, lack of respect from students, poor support from administrators, overly

Who Will Make Them Happen and How?

- State leaders, school board members, local superintendents, and principals must act with determination, realign priorities, and take the policy initiatives needed to develop the induction programs that can foster professionalism across the continuum of teaching experience.
- Professional associations have a powerful role to play in creating and offering model professional development and induction programs, as well as model mentoring programs.
- The Coordinating Council must provide a forum for sharing information about existing and new model induction programs and reporting on the effectiveness of such programs, especially regarding issues of retention and teaching quality.
- The American Federation of Teachers and the National Education Association have an enormous stake in professionalizing teaching. Superintendents and principals need to be able to count on union members to support efforts to develop induction programs aimed at improving the quality of mathematics and science education in grades K–12.

Who Will Make Them Happen and How?

- Business/district partnerships must focus on mechanisms for sharing knowledge, expertise, and resources. Together, they must define the best match between the needs and capabilities of the two partners.
- The Coordinating Council, working with groups such as the National Alliance of Business and the Business Coalition for Education Reform, must provide models of existing partnerships and encourage the development of new ones.
- Both businesses and school districts must assign a high-level staff person as a liaison with responsibility for maintaining and improving the partnership, coordinating the assignment of business personnel to the schools and vice versa, and developing appropriate activities.

- Policies aimed at focusing a new teacher's time and energy on *ac* , e.g., by excluding or limiting extracurricular duties; and
- Policies that ensure instruction in the use of technology in general, including participation in the existing high-quality programs designed for this purpose, and in the use of the mathematics and science teaching Portal in particular.

Many businesses already serve their local communities in extraordinary ways. These enlightened companies are needed as models for others who can expand, rejuvenate, or establish new partnerships that will help strengthen professionalism in mathematics and science teaching. Acting with states, districts, and other stakeholders, business/district partnerships can take several steps to encourage teachers to stay in the classroom, continually sharpen their skills, optimize working conditions, and encourage widespread public support for mathematics and science education. Some of these steps—but not all—involve commitments of funds; all of them do involve business commitments of time and talent. Among the specific roles business/district partnerships can play are the following:

- Business/district partnerships can collaborate to provide facilities, materials, equipment, scholarship support, and other resources to enhance the learning environment in K–12 mathematics and science classrooms, and to support students preparing to become mathematics and science teachers. For example, a local business could stock a science laboratory or train teachers in the use of the Internet Portal;
- Partnerships can provide or help to generate community grants and incentives to schools that restructure time and personnel responsibilities for mathematics and science teachers, thereby enabling them to focus their energies on collaboration and high-quality teaching;
- Partnerships can help schools and school districts sustain induction programs for all teachers of mathematics and science, K-12. They might, for example, help raise funds to pay annual stipends to mentors. Local businesses might also offer new teachers and mentors opportunities for field-based learning experiences that can enhance teaching;
- Such partnerships can establish and run paid summer internship programs within companies for interested teachers, both as a means of expanding their skills and of enhancing their incomes;
- Business/district partnerships can develop "release time" programs that make employees avaicesFl to pat pa wentors oprto paxtra2stthematics and

experience and number of education units and degrees earned. More progressive salary structures—tied to increased levels of teacher responsibility and to job-performance criteria—are needed.

Teachers also need to know that they are valued. When appropriate, civic organizations ought to demonstrate the community's appreciation to hard-working, highly accomplished teachers.

Teachers in this country are scandalously underpaid, a fact that invariably affects the quality of teaching in our nation's classrooms. The fact is, many teachers experience their jobs as exercises in irony: they are expected to have high-quality qualifications and skills, but they are neither accorded professional status nor rewarded with a professional's salary. Creating high-quality teaching in mathematics and science education demands both.

The National Center for Education Statistics reports that, on average, teachers earn 29% less than other workers with a baccalaureate degree ($35,048 per year compared to $49,362 per year in 1997), a differential that has nearly quadrupled during the economic expansion of the 1990s. The demands of the economy

wor8den84 TD-

E e A e ca a a a e a e a c a d c e ce e ac f e 21 Ce . . Pa e , e ac e , ad a , c b a d e be , e ed ca . , a e, ca eade , a d b e eade a e, a c a c ca e , a e . cce . T , e . de ac e e e a e a c a d c e ce, e e e ed . f a e e e e e a a d . e a d e . a e ac .

T e C a e ed e e e a e de . , be . F e ac . , , e e a . e a e, e d d e c a e c ca . e . A c e c f , a e, e , ded def e a c , e e e, a f a K-12 a e a c a d c e ce . de ac e e e a e , d c a d c .

- ❑ Develop a common vision, with input from the community, for promoting a high level of student achievement in mathematics and science.
- ❑ Use accurate data to develop policies that will improve mathematics and science teaching.
- ❑ Commit funding to ensure that all mathematics and science teachers have ongoing collaborative opportunities to improve their skills and knowledge.
- ❑ Set a target date for hiring only fully certified teachers of mathematics and science and put in place the policies and programs necessary to meet the target.
- ❑ Aggressively recruit high-quality mathematics and science teachers from a nationwide pool, including those certified through alternative pathways (e.g., by offering signing bonuses or giving salary credit for all previous experience).

- ❑ Provide your teachers with significant professional development opportunities to improve their teaching year-round including in-depth study through Inquiry Groups with peers, mentors and outside experts and through Summer Institutes.
- ❑ Ensure that teachers and other school staff have electronic and other forms of access to the ever-expanding knowledge base ab

or

- Are your student's mathematics and science achievement levels on state and classroom assessments at an acceptably high level?
- Are you actively seeking to deepen your content knowledge?
- Are you actively seeking to learn new teaching methods for diverse student learners?

If your answers to any of these questions are at all disquieting, the following checklist can inform efforts to promote higher student achievement:

- ❑ Actively seek new knowledge about teaching in your discipline, work with your peers on a continuing basis to improve your skills, and take full advantage of the professional development opportunities offered by your district and state.
- ❑ Actively work to improve your knowledge and skills to incorporate educational technology into your learning and teaching.
- ❑ Communicate to parents the specific standards that students are to meet at each grade level and update parents on their child's progress in meeting these standards.
- ❑ Regularly work with colleagues to compare the achievement level of your students against the standards in your district and state, identify areas for improvement, set goals, and make plans for achieving these goals.
- ❑ Actively share your knowledge and experience with new teachers.

- Do the mathematics and science achievement levels at your child's school compare favorably to achievement levels in neighboring schools?
- Do your child's teachers have the necessary background to teach the courses to which they are assigned?
- How does the teacher salary schedule in your school district compare to that of neighboring districts?

If your answers to any of these questions are at all disquieting, the following checklist can inform efforts to promote higher student achievement:

- ❑ Learn about the mathematics and science standards that children are required to meet in your state and get a clear picture of how well your child's school is doing in meeting these standards.
- ❑ Support the principal's efforts at your child's school to hire well-qualified teachers and to provide them with opportunities to continually improve their skills.
- ❑ Support increased funding for programs that support quality mathematics and science teaching.

- Do your state's mathematics and science achievement levels compare favorably to achievement levels in neighboring states?
- How many out-of-field teachers are assigned to teach mathematics and science across your state?
- How do certification requirements for K-12 mathematics and science teachers in your state compare to those of neighboring states and national standards?

If your answers to any of these questions are at all disquieting, the following checklist can inform efforts to promote higher student achievement:

- ❑ Identify the critical professional development needs of the individuals teaching mathematics and science through a district-by-district assessment.
- ❑ Develop policies and dedicate funding, based on identified needs, to upgrade content knowledge and improve the skills for all those teaching mathematics and science, K-12.
- ❑ Establish and implement a professional development model that addresses the specific needs of mathematics and science teachers and their students through Summer Institutes and Inquiry Groups.
- ❑ Establish and enforce high standards for mathematics and science teachers for initial and continuing certification.
- ❑ Develop career-long incentives and rewards for effective mathematics and science teachers that encourage them to remain in teaching and to continually upgrade their skills.
- ❑ Establish alternative pathways to teacher certification that encourage recent college graduates and people with degrees in mathematics and science to pursue teaching.

- How do your graduates perform as mathematics and science teachers after graduation? How does their performance compare to those from other programs?
- What portion of your mathematics and science education graduates teach and for how long?
- Do your graduates report that your program prepared them for successful teaching? Are schools that hire your graduates satisfied with the quality of their instruction?

If your answers to any of these questions are at all disquieting, the following checklist can inform efforts to promote higher student achievement:

- ❑ Work closely with area schools to identify existing and future needs for highly qualified K-12 mathematics and science teachers.
- ❑ Ensure that your program meets criteria for exemplary math and science teacher preparation and actively contribute to the knowledge base in support of these criteria.
- ❑ Collaborate with area school districts to ensure a quality induction process for new mathematics and science teachers.
- ❑ Emphasize recruitment strategies and provide incentives for eligible students to become science and mathematics teachers.
- ❑ Evaluate and track teacher performance following graduation and use this information to improve your mathematics and science teacher preparation programs.

- Does your business encourage its employees to work as advocates in the schools, with the goal of achieving high-quality mathematics and science education?
- Do your corporate philanthropic priorities help students and educators meet higher standards in mathematics and science?

If your answers to any of these questions are at all disquieting, the following checklist can inform efforts to promote higher student achievement:

- ❑ Work to increase the supply and quality of incoming mathematics and science teachers by advocating for policies, programs and investments that will make the teaching profession a more attractive career option.
- ❑ "Lend" qualified employees to act as part- or full-time teachers in local schools, without incurring loss of pay or benefits.
- ❑ Actively participate in reward and incentive programs that recognize excellence in mathematics and science teaching in local schools as measured by improved student achievement.
- ❑ Provide support for National Board for Professional Teaching Standards certification.
- ❑ Make regular contributions of time, materials and resources to enhance instruction in mathematics and science education in local schools.

	Action Strategy	Federal	State/Local[1]	Business	Public/Private
Goal 1	Needs Assessment[2,3]	$15,340,000	$7,660,000		
	Summer Institutes[2,5]	$1,214,000,000	$606,060,000		
	Inquiry Grou				

[1] There are 56 units nationwide -- states, territories and Washington, D.C.

[2] Current authorizing legislation for the Eisenhower Professional Development State Grants (ESEA,IIB) requires that each participating Local Education Agency match every two dollars of federal funding with one dollar of its own resources. Such local resources can come from other federal programs or from non-federal sources. The same ratio is used here for those Strategies in which it is most appropriate.

[3] First year, one time cost.

[4] First year, one time cost for 15,000 leaders.

[5] One-fifth of the math/science teaching force (340,000 per year)

[6] All K-12 math/science teachers (1.7 million)

[7] Scholarships offered (1,500/year)

[8] Loans offered (6,000/year)

[9] Stipends and operating expenses (3,000 Fellow/year)

[10] Beginning in second year, an additional $30,000,000 needed for induction programs

[1]*Report of the National Education Goals Panel*, Washington, D.C.: U.S. Department of Education, 1989.

[2]T. Husen, *International Study of Student Achievement in Mathematics*, New York: Wiley, 1967, and C. C. McKnight, *et al*., *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective*, Champaign, Ill.: Stipes, 1987, as cited in James W. Stigler and James Hiebert, *The Teaching Gap*, New York: The Free Press, 1999, p. 5.

[3]David Kearns and James Harvey, *A Legacy of Learning*, Washington, D.C.: Brookings Institution Press, 2000, pp. 29-30. In general science, American fourth-grade students ranked third among 26 nations; by eighth grade they were seventeenth among 41 nations; and by twelfth grade they were tied for eighteenth among 20 nations. In general, the mathematics pattern is similar. American students were twelfth among 26 nations in fourth grade, twenty-eighth among 41 nations in eighth grade; and twelfth-graders were tied for eighteenth among 20 nations. (Students were not assessed from the same number of nations in all grades.) See also the U.S. Department of Education, *National Digest of Education Statistics, 1999*, Washington, D.C.: National Center for Education Statistics, 1999.

[4]Kearns and Harvey, *op. cit.*, p. 27.

[5]Although recent news about the rise in the average mathematics score on the SAT and the corresponding broadening of the student population taking the test is welcome, U.S. students remain behind the average performance level in mathematics attained more than 30 years ago. See *The Washington Post*, August 31, 2000, p. 1.

[6]Under Title I legislation that becomes effective in the spring of 2001, states are required to annually disseminate information, school by school, on student performance in reading and math. Anticipating the requirement, all but two states are currently

[18]National Research Council, *How Young People Learn*, Washington, D.C.: National Academy Press, 1999.

[19]Higher Education Research Institute, *T A ca F a : Na a N Fa , 1998,* Los Angeles: University of California at Los Angeles, 1999.

[20]Linda Darling-Hammond, *What Matters Most: Teaching for America's Future*, New York: National Commission on Teaching and America's Future, 1996, Executive Summary.

[21]Linda Darling-Hammond, "Teacher Quality and Student Achievement: A Review of State Policy Evidence," Teaching Quality Policy Briefs, Number 2 (December, 1999), Washington, D.C.: Center for the Study of Teaching, downloaded from http://www.depts.washington/edu/ctpmail.

[22]Linda Darling-Hammond, *Supply, Demand, and Quality in Mathematics and Science Teaching*. Briefing for the National Commission on Mathematics and Science Education for the 21st Century, Washington, D.C., September, 1999.

[23]National Research Council, *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*, Washington, D.C.: National Academy Press, 2000.

[24]Examples of two states that have produced impressive results by focusing on better teaching are Texas and North Carolina. In Texas, a study of grades 1–11 found that teachers' subject-matter expertise accounted for 40% of the difference on achievement tests. Disparities between white and minority students were almost entirely accounted for by the qualifications of their teachers. In North Carolina, students entered the 1990s near the bottom of the NAEP rankings in mathematics. After the State boosted minimum salaries, used scholarship programs to recruit more able students to teaching, invested in better teacher education curricula, created professional development academies, instituted mentoring programs for entering teachers, and created incentives for teachers to be certified by the National Board of Professional Teaching Standards, North Carolina students now score well above the NAEP averages. See "Who Should Teach?" *Education Week*, January 13, 2000.

[25]Linda Darling-Hammond, "Supply, Demand, and Quality in Mathematics and Science Teaching."

[26]*Ibid.*

[27]*Ibid.*

[28]Richard M. Ingersoll, "Turnover Among Mathematics and Science Teachers in the U.S.," Study Paper prepared for the National Commission on Mathematics and Science Teaching for the 21st Century, Washington, D.C., September, 1999; and Urban Teacher Collaborative, *The Urban Teacher Challenge: Teacher Demand and Supply in the Great City Schools*, Washington, D.C.: Council of Great City Schools, January, 2000.

[29]Steve Olson, "Candid Camera,"

AUTHORITY

The National Commission on Mathematics and Science Teaching for the 21st Century, (Commission) is established by the Secretary of Education and is governed by the provisions of the Federal Advisory Committee Act (FACA) (P. L. 92-463, as amended; 5 U.S.C.A. Appendix 2).

PURPOSE AND FUNCTIONS

The Office of the Under Secretary serves as the principal advisor to the Secretary by directing, coordinating, and recommending Department policy. Therefore, the Commission has been established in this office for the purpose of: (1) reviewing the current state of American K-12 mathematics and science education with a focus on the challenges of teacher recruitment, preparation, retention, and professional growth and (2) articulating the steps needed to strengthen the classroom practice of math and science teachers. The Commission would produce a report describing specific action steps that federal, state, and local policymakers can take to address math and science teacher

to the many individuals and organizations without whose work our own labors would have been far more difficult and far less productive.

We owe, first, an enduring debt to the Commission staff. Under the able leadership of Executive Director Linda P. Rosen, they worked long hours to organize and manage our several meetings, keep the flow of communication moving, prepare extensive and invaluable briefing books, handle travel and logistical arrangements, and attend faithfully to the myriad details that are never noticed because they are never left undone. Beyond all these very necessary tasks, however, the staff ably contributed in substantive ways to our discussions and our final report. Thanks are due to John M. Luczak, Nancy Hawthorne Mumaw, Jamila A. Rattler, Jan Solomon, Rebekah Song, and Emmett L. Wright for their excellent work.

Bruce O. Boston of Wordsmith, Inc., served as the eloquent writer/editor of *B I' T La*, building on earlier substantive work by Steve Olson and Amy Kaslow.

RCW Communications Design, Inc., created the report's layout and design and ably guided it through the production process.

A number of individuals provided support to the members and ex officio members of the Commission, attending meetings in their stead when necessary and contributing to the Commission's discussions. Our thanks are due them for helping to keep lines of communication open. They were: V.J. Ajarwal, Arthur Bienenstock, Brian Branton, Laura Chow, Kelley S. Coyner, Kate Dickens, Carlene Ellis, Peter Faletra, Karen Garr, Alice Gill, Ken Griffin, Susan Hattan, Kathy Havens, Jay Labov, Frank Owens, Danica Petroshius, Joan Rothenberg, Richard Stoddard, Lisa Towne, and Judith Sunley. Also deserving thanks are Edward T. Esty and Judy Wurtzel, whose advice and counsel were of great assistance. And, the extra hands offered by Anthony Ashton, Seth Fenton, and Wendy Goldstein were invaluable in expediting the work.

The Commission's deliberations were greatly informed by the wisdom of many experts. These stimulating views were shared with us through commissioned papers and presentations. Commissioned paper authors included Richard Ingersoll; Edward Britton, Senta Raizen, Lynn Paine, and Mary Ann Huntley; Beatriz Chu Clewell and Laurie B. Forcier; as well as Brian Lord and Barbara Miller. Presenters included Dennis Bartels, Barnett Berry, Barbara Blumenthal, Barbara Cervone, Cindy Chapman, Susan Collins,

S 2000

The e of hi doc men i in he blic domain. Feel f ee o
ho oco 021 e30 761 in of io21 h5om92 eW n66 ae e30 761 d F130 ie c mer