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ABSTRACT

In December 1991, the first of a series of Secretary's Conferences on Improving Mathematics and Science Education was held in Washington, D.C., to discuss methods of attaining the fourth National Education Goal of being the world leader in mathematics and science education by the year 2000 as set by President Bush and the nation's governors. More than 250 state policymakers and representatives of national policymaking groups, the business community, and the federal government participated in the conference. This document reports the educational issues, key policy questions, and concrete ideas that state leaders can use to reform mathematics and science curricula. Following a foreword and an executive summary, the report is divided into seven sections. The first section identifies four areas that can be affected by state leadership and reports opening remarks made to the conference by Secretary of Education Lamar Alexander. The second and third sections identify and define what "world class standards" of education means, citing results from the National Assessment of Educational Progress (NAEP) for mathematics and science achievement and reporting remarks by the National Science Foundation Director, Walter Massey. The fourth section shares the responses to the challenge to be first made by the states of New Jersey, Vermont, and California and reports the results of panel discussions on state curriculum standards and frameworks. The fifth section describes resources available to state policymakers to help develop strategies for curriculum reform. The sixth section reports the recommendations made by the Secretary's Conference, that state leaders should: (1) continually state for the public the reasons for higher standards for all students; (2) tap the best thinking and practices across the country; (3) work with all the key players; (4) understand that systemic reform is the only way to arrive at higher standards and performance; (5) commit themselves to using whatever leverage is available for creating higher standards; and (6) acknowledge that the reforms needed to fulfill this National Goal will require time and consistent support. The final section acknowledges the presenters and moderators for their contributions to the conference. (MDH)

IMPROVING THE MATH AND SCIENCE CURRICULUM: CHOICES FOR STATE POLICYMAKERS

REPORT
ON THE
SECRETARY'S
CONFERENCE ON IMPROVING
MATHEMATICS AND SCIENCE EDUCATION

DECEMBER 1991

U.S. Department of Education
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Secretary

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Programs for the Improvement of Practice
Eve Bither
Director

October 1992

Foreword

Last December, we invited key state policymakers from around the country to share ideas about how we can move American education toward world class standards in science and mathematics. Our students have slipped badly behind students in other countries. We sought to find out what states can do to change the situation—to help our students compete with the best.

Some of what we discussed was common knowledge. For the last few decades, education in the United States aimed at keeping everybody in school for as long as possible rather than striving to reach high standards of learning. We came to believe that just spending time in school and getting a diploma was all that mattered, regardless of any actual accomplishment. This approach has harmed many students along the way—to the point where our role in the world economy is in jeopardy.

We also know that the system that produced this approach is complex and not easy to change. Many actors are involved, and they do not always share the same goals, much less agree on how to reach them. Yet, the challenge and urgency of world class standards are clear; we must now form a consensus on our goals and our strategy.

The purpose of the December Secretary's Conference on Improving Mathematics and Science Education was to advance the dialogue on school improvement and give the state participants new perspectives on their role in national education reform. It mixed some of the best ideas on curriculum improvement and grounded them in the experience of state decisionmakers.

It is not easy to capture the full value of a conference in a written report, particularly one of this scope. But I think much of the rich conversation that occurred there is accurately reflected in this report. The vital education issues, the key policy questions, and the concrete ideas state leaders can use to reform curricula in their states, especially in math and science, are presented for your use. I hope it will help move us one step closer to the high level of academic performance appropriate for this country.

Diane S. Ravitch
Assistant Secretary
Office of Educational
Research and
Improvement and
Counselor to the Secretary

October 1992

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Executive Summary

The fourth National Education Goal adopted by the President and the nation's governors states that our students will become first in the world in mathematics and science achievement by the year 2000. It is an ambitious goal. And it can be achieved only if state policymaking supports the development of world-class standards in science and math—and curriculum frameworks, assessment systems, and staff capacity that sustain those standards.

How to begin this momentous task was the focus of the first of a series of Secretary's Conferences on Improving Mathematics and Science Education. Held in Washington, D.C., in December 1991, the conference drew more than 250 state policymakers and representatives of national policymaking groups, the business community, and the federal government.

Several states are taking leadership roles in reaching higher standards by developing new curriculum frameworks. States are finding, however, that improvement depends upon reforming whole systems, affecting assessment, teacher preparation, staff development, and instructional materials, as well as content areas. The conference helped define the issues state leaders must face when recasting these pieces in a way that will produce a world-class education.

The two days of presentations and small group discussions at the Secretary's Conference led to a number of policy recommendations. Generally, state leaders should:

- Continually state for the public the reasons for higher standards and articulate a consistent vision of what *all* students should be able to do;
- Tap the best thinking and practices across the country, helping create networks to keep themselves informed of what the bellwether states are accomplishing;
- Work with all the key players—governors, their staffs, legislators, business, professional organizations, the state education agency, superintendents, principals, teachers, school boards, and the media;
- Understand that systemic reform, rather than piecemeal, disconnected efforts, is the only way to arrive at much higher standards and performance;
- Commit themselves to using whatever leverage is available for creating higher standards, especially for teacher certification and staff development; and
- Acknowledge that the reforms needed to fulfill this National Goal will require time and consistent support.

The Starting Point

American students could become first in the world in mathematics and science performance by the end of this decade. But this National Education Goal, set by the President and the nation's governors, demands a mammoth effort. It will require well-organized changes to our education system, changes that provide very high-level subject-matter content to our students using the most effective methods. It will also require a method to monitor our progress.

Only state policymakers can trigger this effort. While national efforts support and supplement what goes on in the classroom, and local educators ultimately are responsible for results, only state-level officials can bring together all of the necessary pieces for extensive structural change. These include: curriculum standards and frameworks; assessment and accountability systems; instructional materials; and professional certification standards.

The first area for change—curriculum standards and frameworks—is the anchor for the others. International comparisons show that the educational standards used in the U.S. do not emphasize challenging content. Other countries apply much higher standards and begin their efforts with younger students. If students in this country have not been expected to achieve a high level of competency in mathematics and science, or have not had opportunities to select rigorous curriculum, how can they be expected to perform well on comparisons with students who have had these opportunities? How can they gain the skills needed in a global economy where human resources are the most important commodity?

State leadership is essential in this effort. This conference helped define state roles and find necessary steps toward high achievement in the subjects. It was the first in a series of Secretary's Conferences on Improving Mathematics and Science Education sponsored by the Office of Educational Research and Improvement of the U.S. Department of Education. The December 1991 meeting brought together more than 250 state policymakers and representatives of national education and policymaker organizations, the business and philanthropic communities, and the federal government.

The conference explored four areas:

- What does it mean to be number one in the world in math and science and what does it take to achieve that status?
- How can states be part of national efforts to set high standards in math and science?
- What are states learning from their attempts to reshape curriculum standards and frameworks?
- How can states use the development of curriculum frameworks to bring about systemic change that moves schooling to world-class standards?

The Need for State Leadership:

Summary of Remarks by Secretary Lamar Alexander

Discussions about significant changes in the curriculum are already occurring across the states—but only because the public is ready for them, Secretary of Education Lamar Alexander told the opening session of the conference. In fact, he continued, "A movement is growing around betterment of education in the country." The conference's objectives are important because the public wants answers to such questions as: What do we teach? How do we test it?

State leadership needs to be out in front of the move toward higher standards, tapping the resources and the people who can lead the effort most successfully. For example, state leaders can integrate policies for higher education with the development of curriculum frameworks, because what colleges require for admission directly influences what precollegiate students study.

To create public desire for the high performance of our schools and students, the value of

high standards needs to be made clear. The National Council on Standards and Testing accomplished this in a report released in January 1992. The report said that high-level content and student performance standards in academic subjects are not only feasible but necessary. Also, new forms of assessment that measure more accurately what students know and can do should be developed, the Congressionally created council concluded. The next step is to develop challenging curriculum frameworks. "This is an exciting time," Alexander said, "and this is important work."

This report summarizes the conference presentations and discussions. It concludes with recommendations provided by selected state policymakers who participated in the conference. They present several ways to support the development of coherent, sequential curricula in math and science, making it possible for American students to achieve "world class" levels of performance in these crucial subjects.

Understanding the Problem

Goal 4 of the National Education Goals states that, by the year 2000, "U.S. students will be first in the world in science and mathematics achievement." To become first implies that policymakers know what "first" and "world-class standards" mean. At this point, those definitions are not possible, although the Office of Educational Research and Improvement is supporting public and private efforts to develop a consensus about such standards. However, state policymakers can draw upon extensive information regarding trends in mathematics and science achievement, some information on what students know and should know at certain ages, and increasingly reliable test results that compare United States students with those from other countries.

Looking only at trend and performance level information, the news is very discouraging, except for gains made by some subgroups of the U.S. student population. In international comparisons, the news is even more disturbing.

The results show that students are performing about as well as they did 20 years ago. However, our curriculum content does not compare well to what is known about content in other countries. Also, in the past two decades the knowledge base in these disciplines has expanded, and the skill level demands of the workplace have increased dramatically.

According to the 1990 mathematics achievement surveys by the National Assessment of Educational Progress (NAEP):

- Almost three-fourths of 4th-graders could solve simple addition and subtraction problems with whole numbers; only 11 percent could do multiplication and two-step problems; and none showed a consistent grasp of fractions, decimals, percents, and simple algebra.
- By 8th grade, virtually all students could do 3rd-grade work; two-thirds had mastered 5th-grade work; only 14 percent showed consistent success with fractions, decimals, percents, and simple algebra—topics generally introduced at the 7th grade. None were ready to begin studying advanced mathematics.
- Almost 10 percent of high school seniors could not handle 5th-grade content; 46 percent could do 7th-grade work; only 5 percent

Overall mathematics proficiency of U.S. students, 1990

		Grade 4	Grade 8	Grade 12
Average proficiency		216 (0.7)	265 (1.0)	295 (1.1)
Level	**Description**	**Percentage of students at or above**		
200	Simple additive reasoning and problem solving with whole numbers	72 (1.1)	98 (0.4)	100 (0.0)
250	Simple multiplicative reasoning and two-step problem solving	11 (0.6)	67 (1.1)	91 (0.6)
300	Reasoning and problem solving involving fractions, decimals, percents, elementary geometry, and simple algebra	0 (0.0)	14 (1.1)	46 (1.4)
350	Reasoning and problem solving involving geometry, algebra, and beginning statistics and probability	0 (0.0)	0 (0.1)	5 (0.6)

NOTE: Standard errors appear in parantheses.

SOURCE: National Center for Education Statistics, *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation*, June 1991.

showed an understanding of algebra and geometry sufficient for the study of advanced math.

Similarly, the 1990 NAEP *Science Report Card* shows that:

- Fewer than one-half of the nation's high school seniors demonstrated the knowledge and reasoning abilities necessary to analyze scientific procedures and data, such as interpreting data in tables and graphs and evaluating science experiments.
- About two-thirds of the 8th-graders and one-third of the 4th-graders could understand basic information in the physical sciences and begin to interpret experimental results.
- Large disparities in science proficiency existed at grades 4, 8, and 12 between white/Asian students and Hispanic and black students.
- Only one-half of seniors reported taking a year or more of chemistry, and only 29 percent reported taking physics.
- Lecturing and textbooks remained the mainstays of science classrooms; one-fourth of high school seniors reported never performing experiments in their science classes; 60 percent reported never working on science projects lasting a week or more.

In the last 20 years, the gap in performance between white and minority students has narrowed somewhat, with black students gaining considerably in math. However, performance in science dipped for both black and Hispanic students for many years. Despite recent gains, minority performance in science remains distressingly low. For example, according to the 1990 NAEP survey, 40 percent of white students in grade 4 could perform at the second proficiency level—applying general scientific information. Only 5 percent of black 4th-graders were at this level, as were 10 percent of Hispanic 4th-graders. The survey found similar disparities at the 8th and 12th grades.

In the past, international comparative studies have been suspect because of differences in student populations taking the tests and differences in the administration of the tests. The 1991 International Assessment of Educational Progress attempted to address these problems; its results are considered more comparable than any available before.

Among the 13-year-old population, American students placed next to last (ahead of Jordan) among 15 countries on the mathematics assessment. The leaders were Korea, Taiwan, Switzerland, the former Soviet Union, and Hungary. On the science assessment, Americans were third from the bottom (ahead of Ireland and Jordan) in the number of science questions they answered correctly.

Both studies indicate that more sophisticated content seems to be introduced to students earlier among the high-achieving countries than in the United States. For example, 51 percent of American schools teaching the 13-year-old population reported that they heavily emphasize algebra for this age group, compared with 96 percent of the schools in the then-Soviet Union, 90 percent in Hungary, and 86 percent in Korea. In addition, two of the top five countries do not segregate students by ability; in two others of the top five, tracking is evident in only 18 percent of the schools. In the United States, it was reported as a practice in 56 percent of the schools.

In its testing of 12th-graders, a previous international study emphasized calculus, which commonly is taken in schools in Europe and Japan. In the United States, fewer students reach the calculus level.

Other studies indicate that access to math and science content is uneven in the United States. One-third of science classrooms in grades 4-6 have no scientific equipment, according to the 1986 NAEP *Science Report Card*. A 1990 National Science Foundation study concluded that low-income and minority children have less access to science and math curricula than high-income and white children; at the secondary level, they have fewer opportunities to take the critical gatekeeping courses of algebra and geometry. Further, high-ability students in a low-income school may have less access to science and math classes than low-ability students attending more advantaged schools.

Defining "First" and "World Class"

What Does This Mean for Our Students and Schools?

Summary of Remarks by Director Walter Massey

The education and research communities, as well as policymakers, are a long way from agreeing on what it means to be number one in the world in math and science achievement. In addition, "We are even further from a detailed description of what this means for our students and schools," said National Science Foundation Director Walter Massey.

One of the challenges is to avoid the temptation of using a single measure of student performance in a given subject as an indicator of national achievement. "If the measurement issue were that simple, the task before us would be equally obvious," he added.

Also, while international comparisons of academic performance are useful for challenging the status quo, they should not be the entire focus.

Massey argued that if the students of a given country were to score at the top of every international academic exam, but that country could not translate education into jobs, failed to invent and produce products that other nations wanted to buy, or produced citizens who could not (or would not) participate in their own government, those scores would be worse than useless. They would be providing a misleading sense of complacency and a misunderstanding about why education should be a national concern.

Americans *should* be concerned about our educational system, not because some other country beats United States sixth graders on a math test, but because we have a raft of evidence that we are failing to provide many of our children with the tools needed for lifelong learning. Also, large numbers of Americans fail to complete high school, and many of those who do have not been prepared to assume the responsibilities of a citizen in a democracy.

To make the United States first in math and science, we should consider three factors:

- The effort must reflect both the diversity of our country and our democratic approach to education. Everyone must reap the benefits of an effort to produce a world-class approach to education, not just a select few. In fact, in a country with a truly world-class education system, there would be no difference in student achievement scores based on ethnicity or gender or family income.
- The education system must be sufficiently flexible to accommodate changes in technology and technique. The National Science Foundation Statewide Systemic Initiative, for example, provides grants for states to work on comprehensive rather than piecemeal changes, enabling states to become "laboratories" for changes that go beyond current thinking and traditional models.
- Many reasons exist for seeking to provide a world-class education. One is that education is important for its own sake—the life of a person with more education is richer and more rewarding than the life of a person with less education. It also is necessary to improve our standard of living, or perhaps better stated, to improve the quality of life on the planet.

Massey noted that for American students and schools, the challenge to be number one "serves the purpose of pushing our expectations to the horizon." Children, their parents, and the public at large will come to a clearer appreciation that learning is often hard work and it requires effort and commitment and persistence. Improvement will not come quickly or without controversy, even with the best of teachers, the most advanced technologies, and the most motivated parents.

Further, "being number one in the world means that we will have a fuller understanding of how to individualize instruction to accommodate different learning styles," said Massey.

This will mean relying more on advanced learning technologies.

Having a world-class educational system also means that the educational process will be viewed "not as something that is isolated from the rest of life, but as a central part of life," Massey continued. He noted the irony of a person who, after finishing school, is described as entering "the real world," as if the knowledge and habits one is supposed to learn at school are "unreal."

Finally, the U.S. cannot be number one until we recognize that we will never be better than the quality of our schools. We will know we are number one when other countries look to the U.S. for techniques to improve their own educational systems. Being the best will be marked by Americans' continuing concern for the quality of the education system and by each individual's sense that the 18th birthday marks not the end but the beginning of an educational process that will last a lifetime.

"The challenge to be number one in the world does not place us on a race track with the finish line at the year 2000. It raises the debate to a national level and provides us with an opportunity to take a hard look at our priorities," said Massey. "It challenges us to undertake the research we must have in order to make the best possible choices. It can help us develop the procedures needed to continuously improve and upgrade our educational systems."

What Becoming Number One Means to States:

Summary of Remarks by Assistant Secretary Diane Ravitch

The United States "is embarking on what may be the most important decade in educational change it has ever known. The possibility of change has never been more dramatic," said Assistant Secretary Diane Ravitch. International comparisons can be credited with "setting the alarm bells off." Without them, "I am not sure we would be here today," she added.

American parents are not receiving the right information about the schools and the curriculum. Parents think their children are doing well and that math and science are "special," not meant to be mastered by all students.

The National Science Foundation and the U.S. Department of Education are collaborating to encourage efforts to establish national curriculum standards. The National Council of Teachers of Mathematics has set math standards; the National Academy of Sciences has started an effort to do the same for the sciences, looking to the best work already accomplished by certain states as the base for standards. The U. S. Department of Education is planning at least one more Secretary's Conference, on professional development and instructional resources.

Although the American education system is very diverse, every state can be involved in setting higher curriculum content standards, based on best practices. Good state frameworks "should create coherent systems, provide touchstones for teacher education, provide foundations for adequate resources, and provide the basis for assessments," Ravitch asserted.

Math and science always have been viewed as "hard" subjects, but in the world of the 21st century, new demands will be placed on schools, society, and democracy. The ultimate test will not be if we produce scientists, but if we understand modern science and technology well enough to use them. The test will not be if science succeeds, but if society succeeds.

Dispelling Myths about Some of the Competition

Mention "world class" and one region's education performance comes to mind—that of Asia. A centerpiece discussion at the Secretary's Conference changed many participants' perceptions of how math is taught in Chinese and Japanese classrooms. It is not the rigid, inflexible, intense schedule often pictured as the Asian way of instruction. Nor are Asian children more intelligent than those in the United States. Rather, as Harold Stevenson, director of the University of Michigan Program in Child Development and Social Policy, revealed, children in these countries learn high-level content, and their teachers expect them all to perform well.

Stevenson, who studied 1st and 5th grade classes (and a sample of 11th-graders) in Minneapolis, Chicago, Beijing, Taipei, and Sendai (Japan), dispelled many of what he termed "myths" about math instruction in Asian countries:

- *Myth: the systems are too different for meaningful comparisons.* Stevenson and his colleagues made detailed analyses of textbooks and made sure their test items were on material all the children had been taught.
- *Myth: the test results are not alarming and, further, do not measure critical skills.* Among Stevenson's findings was that of the 20 schools tested in Chicago, only one matched 31 Asian schools in math performance. All others performed at a lower level. A sample of 11th-graders found that the top 10 percent of United States students were at the average level of students in other countries; further, performance of United States students decreased between 1980 and 1990. In nine categories of content, the average of students in this country came up to the average of those in other countries in only one—charts/graphs. Their performance in categories requiring application of knowledge was not good at all.
- *Myth: Asian schools create too much stress for students.* According to surveys of teachers, a much higher percentage of teachers in this country considered first graders maladjusted toward school than those in other countries. More American high school students felt stressed than those in Asian countries. And the suicide rate among youth is higher in the United States.
- *Myth: American parents are dissatisfied with their schools.* American mothers are much more positive about schools than those in Asia and more satisfied with what students are learning. Asian mothers, on the other hand, are not nearly as satisfied. Also, Asian mothers know much more about what is being taught and what should be expected of students.
- *Myth: schools are considered "a drag" by students in Asia.* About twice as many students in Beijing expressed happiness about schooling as those in Chicago; similarly, they were twice as likely to express satisfaction with school when they got home. Asian students have more "breathing" time at school than those in the United States—they have a recess after every class and a long lunch hour. Students in Chicago had 12 minutes for recess each day; students in Beijing had 47 minutes. The longer school day in Asian schools is a result of more free time and one to two hours after school each day for a number of activities. Asked what they wanted most, United States students said "money"; those in Beijing said "to do well in school."
- *Myth: children are born with the ability to do math.* The willingness to work hard is the deciding factor in math achievement. Eleventh graders in the United States said the critical factor was to have good teachers; in Taiwan and Japan, the students said studying hard was the key to success.
- *Myth: Asian classrooms stress rote learning.* "Classrooms in Japan and China are very exciting places." The teachers are alert and well prepared and show great skill in their instruction. In China, teachers instruct only two hours daily—only one if they are new. The rest of the time they work with other teachers, prepare lessons, plan together. They use a lot of manipulatives, focus on depth of understanding rather than rote learning, and strive for clarity. By contrast, 87 percent of the teachers in Chicago taught more than four classes. Student surveys indicated that students in Beijing thought clarity was the most important characteristic of a good teacher; in Chicago, students mentioned "sensitivity" as the most important characteristic. Finally, teacher training modes are quite different in Asia. For example, every beginning teacher has 20 hours of observation by skilled teachers, who serve as models and mentors for the new teachers.

Note: Harold Stevenson's book on these comparative studies, *The Learning Gap: Why Our Schools Are Failing and What We Can Learn from Japanese and Chinese Education*, was published in April 1992.

State Lessons

What are the implications of trying to become "first in the world" in math and science for schools, districts, and states? When state policymakers de-emphasize regulatory control of education and turn to setting curriculum standards and supporting local decisionmaking, what are they learning? During the 2-day conference, panels of researchers, state leaders, and professional leaders debated these questions. Two strong messages emerged from the panel discussions. The first is that states already are taking—or are willing to take—leadership roles. Second, the public's support of change has been underestimated. The immediate task is to put this support for change to work on reforming the entire education system.

How to Respond to the Challenge To Be "First"

The opening panel, moderated by John MacDonald, Assistant Secretary for Elementary and Secondary Education, responded to the remarks by Secretary Alexander and Director Massey. The panel discussion focused on what MacDonald termed "leverage" states and what they have to produce for curriculum change. Representatives of three very different states—New Jersey, Vermont, and California—explained their approaches to curriculum issues.

New Jersey

New Jersey's overall goals, according to Tom Corcoran, policy advisor on education to the governor, are to improve science instruction for all students by improving access and instruction for minorities and females, and by increasing the number of young people seeking careers in science. The state's curriculum frameworks begin by defining desired proficiencies in high school science courses and addressing the needed changes in testing. Setting these clear guidelines gives teachers and students definite goals to aim for. At the elementary level, the state is emphasizing developing a cadre of math and science specialists for instruction. This step acknowledges that not all teachers will be able to become expert in these subjects. The state also is using regional demonstration school sites to encourage best practices, professional development schools, and telecommunications networks among schools.

Other New Jersey state policy initiatives support school-site decisions. The state grants waivers from state regulations to schools with well-reasoned plans; funds curriculum planning and equipment (it recently awarded 40 grants to improve math and science instruction); supports greater access to technologies; and encourages partnerships with higher education.

"A lot of things are going on," Corcoran said, but he admitted that the programs still are fragmented. "We need state plans and forums to pull all of these things together." Corcoran also called for greater federal support in developing advanced learning technologies, especially the use of fiber optics for better communication across distances.

Vermont

Vermont has provided national leadership in assessment by piloting the use of portfolio* assessments in math and writing, noted Doug Tudhope, chairman of the Vermont State Board of Education. What policymakers and educators have learned is that any such major change takes time and an investment in people. "It takes five years of investment in a new teacher to create a good one," Tudhope said. Vermont has developed 17 networks to train teachers for the new assessment system.

Also, Vermont policymakers have realized that the goal of becoming first in science and math is inextricably linked to the first National Goal—that of school readiness. "We are not going to be first until kids come to school ready to learn."

*Put simply, a portfolio is a collection of the student's "authentic" work—projects, writing samples, etc.—as well as teacher observations and test results.

California

The California curriculum frameworks effort, State Superintendent Bill Honig told the Secretary's Conference, provides a model for a necessary "systemic strategy" at the national level. He described this strategy as:

- Defining the curriculum standards. California took the National Council of Teachers of Mathematics standards as its base for creating a coherent curriculum; it will use national efforts for a similar framework development in the sciences. The curriculum should be organized around major ideas and themes, rather than what others have referred to as "factoids"—bits of definitions, facts, and formulas.

- Aligning new assessment methods to the curriculum. The assessments should ask: "What do you want kids to be able to do? How do you define the concepts of what they should be able to do (proficiency)?" Honig favored a national system of assessments that will determine "a 10 in California is the same as a 10 in Vermont."

- Revamping the resources for teachers. Honig charged that textbooks "are very weak, but we need the books to win this war." Pressure must be put on publishers to change their products, he said, noting that science texts are getting better. However, the state is developing textbook replacement units designed by the best teachers.

- Making greater use of technology. This is important for students, but even more so as a channel to deliver new resources and knowledge to teachers.

- Paying and supporting teachers more. States need to invest in staff by building time into the system "to bring teachers up to speed." By focusing on this improvement process, California has created a network of teachers in 200 secondary schools who are beginning to use a science curriculum that integrates the sciences. A similar "math renaissance" is underway in junior high schools.

Honig said his state was covering all the bases. Its program includes a research agenda as well as a parent information and involvement agenda. The standards are high, the means are flexible, and all the necessary components are addressed. But Honig was most interested in emphasizing the use of a well-thought-out strategy. "President Kennedy not only set a goal of getting to the moon, but he had a strategy. We need such a national strategy" for curriculum standards. The public will invest in education, "but it wants a focused plan, not just money on the stump."

Discussion

The audience discussion focused on changing attitudes—primarily of the public toward public schools and toward teachers. Parents and students, said Corcoran, need "ideas about what is possible." In New Jersey's Bergen County, for example, a science/math academy that invited the public in to see what it was doing stimulated public interest. Honig mentioned a high school principal's strategy of putting 80 percent of incoming students on academic probation: "That sent a message to the elementary and junior high schools."

With three-fourths of households without school-age children, the goal should be to "become a learning community," Tudhope said. National leadership is needed, he added, "to point out what a top-notch science or math program would be." Tudhope suggested using public television as the messenger.

Moderator MacDonald added that the message about change needs to get to textbook publishers. The National Goals can provide that leverage, he said. Honig said the publishers will respond to demands for change "if they sense this is what the public wants." They know how to improve textbooks, but "it must be worth the risk."

State policymakers also must address the need to give teachers status and considerable staff development support. "The current system," Honig believes, "says that teaching is low-cost, feminized work that we can get on the cheap." Both Tudhope and Corcoran said policies should focus on rewarding high-performing teachers and holding teachers accountable for results.

What State Policymakers Can Do

- use curriculum frameworks to define desired proficiencies and address needed testing changes;
- develop a cadre of math and science specialists to make up the shortfall in expert teachers;
- use regional demonstration school sites (for best practices), professional development schools, and telecommunications networks among schools;
- grant waivers from state regulations for well-reasoned school-site decisionmaking plans;
- support greater access to technology;
- invest time;
- revamp resources for teachers and pay and support them more;
- develop strategies for research and parental involvement;
- encourage partnerships with higher education;
- link math and science achievement (goal four) with readiness to learn (goal one);
- use portfolios for assessment; and
- develop state plans and forums to pull all of the pieces together.

Lessons from the States on Curriculum Standards and Frameworks

Back-to-back panels of researchers, professionals, and state policymakers pinned down the experiences of states on developing and implementing curricula standards and frameworks. The strongest message they gave: it is false to assume that teachers will implement frameworks like automatons; frameworks are only the beginning of curriculum reform.

The power of state curriculum frameworks, said Elizabeth Stage, executive director of the California Science Project, "is that they sanction good teachers." Frameworks allow the accomplishments of good teachers—and good research-based efforts—to get recognized. What is needed beyond the frameworks, however, "is a system incorporating anything that gives teachers opportunities to learn new things."

The most important thing curriculum frameworks can do, Stage emphasized, "is provoke teachers into discussions of what students should be able to do. If you can achieve this with the frameworks, you will have done what is needed."

In California, changes in inservice education and certification are second-wave efforts. The state's higher education institutions "are taking seriously the math frameworks and adjusting their training to the scope and sequence curriculum."

The framework effort in California is providing new steps for elementary teachers every year, each one emphasizing integrated knowledge rather than fragmented information. But standards must be developed for each discipline before they can be integrated and "it will be a while before people can transform across the disciplines."

Stage noted that policymakers should understand several things. First, they need to see what is going on in classrooms in order to separate the good from the unsuccessful. Then they must realize that developing and implementing frameworks will take time. And finally, change will meet resistance from those who do not want "a thinking curriculum" and those who do not want "this curriculum for all kids."

Describing the cumulative research from the Consortium for Policy Research in Education at Rutgers University, director Susan Fuhrman commented that states "are providing more lip service for school districts than actual support." However, some are using interesting ways to involve the public in supporting higher curriculum standards, such as telephone surveys and small and large meetings/forums. But she faulted these efforts for not doing more to educate the general public. The media, for example, have not been brought into the process.

However, the main benefit of curriculum frameworks "is to give coherence to instruction." Every decade has seen overall big increases in

education spending, she said, but "what is needed now is a clear direction."

Attaining higher curriculum standards presents a real challenge to state legislators, explained State Representative Ken Nelson of Minnesota. To achieve this goal, states must avoid traditional solutions. Furthermore, the momentum for major change will run head-on into the concerns of the postsecondary sector, resistance from science and math teachers who want to create their own reforms, and the concerns of local educators, who equate change with chaos. To overcome these obstacles, it is important to encourage teachers to take ownership of fundamental change, to focus school district efforts on learner outcomes, and to provide rewards and recognition for successful efforts.

Minnesota's new framework blends policy objectives at all levels, tying national goals to local performance. The framework is both results-oriented and research-based. The hope of the Minnesota plan, Nelson said, "is to not waste students' time or continue redundant learning, such as remedial work in college." And it taps the energy of people, such as students and teachers. "They are resources waiting to be realized."

Panel moderator Frank Newman, president of the Education Commission of the States (ECS), asked how hard it was to stay with a reform plan when immediate progress is not visible. ECS studies show that reforms produce progress on some indicators, such as attendance and parental involvement, but that achievement stays even for a while before going up. Fuhrman said that structural change needs an ongoing presence, such as the long-term Business Education Committee in South Carolina. This way, the momentum can keep going "without a new policy every year."

Stage emphasized that curriculum reform must have "political strategies"—to garner political support—or it will lose out. In California, changes in the science curriculum provoked more than 300 protest letters from creationists and none from scientists in defense of the changes, she said.

A second panel on state-level curriculum reform kept coming back to the tension between top-down pressures and bottom-up efforts in policymaking. And it addressed the other recurring theme of the conference: true reform can happen only when it is systemic, affecting all areas needing change.

The state experiences so far underscore the fact that "no one has all the answers," said Marshall Smith, dean of the School of Education at Stanford University and chair of the standards subcommittee of the National Council on Standards and Testing. Agreeing on what students should be able to do is "an ill-structured problem" that is not going to be solved without a lot of hard work. For example, the Carnegie units (i.e., courses required for graduation) that dominate high school curricula will not change "until the elite colleges change their requirements." Bringing all students up to new standards will increase inequities if those needing extra help only receive it through after-school or pull-out programs, he said. And teacher training institutions "need to clean up their own act," but that will only happen if a lot of pressure is put on them, such as using teacher licensure standards as leverage.

In a discussion over how much regulation will be needed from state policymakers to ensure results, Shirley Malcom, director of education programs for the American Association for the Advancement of Science, noted that restrictions are made "to keep bad things from happening, such as inequities." She recommended that policymakers focus on a common vision involving all stakeholders that includes the following: agreement on content goals, revising assessment strategies, reordering the content, staff development, school organization, the integration of schools and community social services, out-of-school enrichment resources, alignment of resources to curricula changes, and equity issues.

Although several panelists cited the National Council of Teachers of Mathematics (NCTM) standards as models, NCTM president Iris Carl cautioned that some textbook publishers "are using the logo of the standards but not fully using their content." For teachers to stay well informed, they need support groups and inservice training that underscores how much more there is to learn, said Helen Kota, a science teacher at Westlake, California. For example,

science teachers in California have formed hub groups and are using electronic mail to build up a network resource.

Newman asked how teachers can straddle two systems—one integrating new knowledge and techniques, the other a school organization antithetical to reforms. Malcom suggested they will have to live with both environments for a while and insisted that assessments should not be used for high stakes "until every student has had an opportunity to learn under new standards." In the math area, Carl added, "it must be clear that NCTM standards are to be aligned with any national assessment."

The panelists' summaries of the policymaking environment follow:

Smith—Parents and the public need to be "retrained" about their expectations; developing visions can provide a rationale for significant changes.

Malcom—Policymakers first need to know where they are headed on curriculum reforms; they need to sustain the vision and sustain the chaos that creates change, realizing "this is a long-distance race"; they should address incentives and use outside resources, such as higher education and professional societies, to pressure the K-12 system.

Kota—Teachers need money and resources to move from lectures to hands-on instruction; policymakers need to focus on different modes for providing teachers with credentials, offering inservice training, and articulating efforts so that all players are working on common goals.

Carl—The message to educators and the public should be that there is a serious mismatch between what children can do and what they are being asked to do currently; standard-setting must have an equal purpose of increasing public expectations; much attention needs to be paid to having adequate resources for teachers.

On the whole, said Newman, state policymaking on changing math and science curricula translates into creating a different form for running public education that is "complex, not simple, and involves a lot of actors and requires a lot of time."

What State Policymakers Can Do

- set up or encourage systematic measures that give teachers new opportunities to learn;
- develop standards for each discipline before all are integrated in the curriculum;
- make themselves aware of what is good in the classroom and what is not;
- expect resistance from those who do not want a "thinking" curriculum or who do not want it for all students, and from teachers who want to create their own reforms or who equate change with chaos;
- use whatever it takes to involve the public in systemic change—such as telephone surveys, large forums, and the press;
- avoid traditional solutions;
- focus on learner outcomes and reward success;
- build in an ongoing presence to structural change to keep momentum going and policies from constantly changing;
- develop clear, workable political strategies to prevent or overcome political obstacles;
- avoid the inequities of using only pull-out or after-school programs to bring all students up to higher standards;
- use the leverage of teacher licensing standards to pressure teacher training institutions to improve their practices;
- integrate schools and community social services; and
- avoid imposing assessment using higher standards until every child has had the opportunity to learn under those standards.

Resources Available for Policymakers

From print publications to networks to technical assistance to the experiences of states—the resources are accumulating rapidly to help state policymakers develop strategies for math and science curricular reforms. Small group sessions at the Secretary's Conference presented and evaluated many of these resources. Highlights from some of those sessions follow.

National Standards for Science

The experience of the National Council of Teachers of Mathematics (NCTM) in setting new standards is held up as a model, but those in science education should not expect the process to be the same, several experts agreed.

An effort at setting science standards is underway in the National Research Council, according to Kenneth Hoffman, associate executive officer for education at the National Academy of Sciences. (The Council is sponsored by the Academy.) It will have a draft of three areas of standards by the fall of 1992—for the curriculum, teaching, and assessment. The intent, he said, is not to mimic the NCTM standards, but to provide descriptive standards, supplemented by illustrative examples.

"Everyone studies math for a large number of years, but this is not true for science," Hoffman pointed out. Also, the task in science education is not that of setting disciplinary standards but that of standards of science for everyone, which will require widespread involvement. "NCTM undertook its work in relative peace and quiet," Hoffman added. "That is not true for the current effort in science. Everyone who can spell 'science' wants to be involved." The Council has set up a steering committee of major science organizations to direct the involvement.

By calling for broad involvement, the effort to develop science standards is in danger of winding up with an average rather than a high standard, commented James Rutherford, director of Project 2061 at the American Association for the Advancement of Science. "We need something we don't all agree on, if we want the standards to be really aggressive," he said.

Rutherford suggested that state policymakers first understand how much vision matters. The technical work is not difficult, but defining what students will be able to do when they graduate is hard. Do not start by getting teams together to write standards, he advised. Instead, encourage the leaders to talk about ideas and visions, to aim for ambitious standards.

Also, policymakers should not be concerned with discrete knowledge, but "go after deep understandings." Half of the content now taught in the science curriculum could be eliminated, he said.

A third point from Rutherford was to create standards that "bite." "Do not come up with just nice things people can make speeches about," he said. It is up to states to set high expectations and let schools work out how they will meet them. States also need to be concerned with monitoring outcomes, providing incentives, and helping schools get what they need to meet the standards.

"If we are really talking about amazing new standards," Rutherford said, "all schools initially will fail to meet them. All schools will need support, but some more than others."

What State Policymakers Can Do

- start by talking about ideas and visions;
- be less concerned with breadth of knowledge and more concerned with depth;
- create standards "that bite," setting high expectations, but letting schools choose how to meet them;
- monitor outcomes, supply incentives, and help schools get what they need to meet the standards.

What is Happening in Pioneering States?

Arizona has established performance-based assessment in five areas at three grade levels, but not without encountering some pitfalls, according to State Superintendent C. Diane Bishop. Her advice to policymakers:

- Do not work in isolation. "Do not assume everyone knows what you are doing," she said. "You need to communicate with all the key players, including governors and their staffs, legislators, professional organizations, teachers, school boards, and the media." In her state, the education department was working on standards at the same time that the legislature was setting performance standards for graduating seniors. Neither knew of the other's work. Communication had broken down.
- Do not ignore work being done by national groups, such as NCTM and Project 2061.
- Do not ignore real life. Standards should be based on information about how people use knowledge and the concerns of those who employ the school systems' graduates.
- Develop an assessment system along with the curriculum frameworks.
- Do not assume the work is done when the frameworks are finished. They need to be implemented, and this means reforming the attitudes of teachers and parents, changing the preparation of teachers, using assessments for change, and developing a comprehensive reporting system.

But Bishop said the most difficult challenge of all was to develop a consensus on what an education for the 21st century should be. Fear of not being able to come up to high standards "leads to a back-to-the-basics mentality," she warned. "You have to convince people that they need to be much better."

The old mode of changing curriculum, according to Phil Daro, executive director of the California Mathematics Project, was to "analyze the table of contents of textbooks." He advised policymakers to set a process that "goes for depth, not coverage." To make that possible, school instructional practices must be allowed to change, such as enabling teachers to schedule large blocks of time around a topic rather than the standard 50 minutes. Assessments must be aligned with the frameworks. Policies should use various means of leveraging change, such as using categorical programs like Chapter 1 to force the elimination of tracking, using accreditation as a means of implementing new standards, or using college admissions to encourage changes.

Policies should allow teachers to redirect their time so that they have time together for planning. "The engine in the system is teacher time," Daro stressed. "It is too small to carry the weight that is being put on it." Student time also is not used well at present. He noted that the United States is the only country where math is taught in the afternoon. The afternoons should be set aside as block times for activity-centered learning, he said.

Connecticut tackled the issue of performance-based assessment as an essential component of curriculum reform, noted Joan Baron, project coordinator for the state's Common Core of Learning Assessment. The assessment process asks four basic questions about the learning process: What is essential? What evidence needs to be collected to know that essential knowledge has been learned? What should be considered "good work?" What are the standards?

The Connecticut effort is based on the premise that one testing system can serve at least two major purposes—for policymakers to know how the system is working, for teachers to know how well they are doing. But no matter how well thought out the assessment system may be, it is not true that a state merely has to build the system and expect immediate results, she said. First of all, policymakers need to get serious about staff development, encouraging teachers to talk about big ideas, integrate a new vision of teaching and learning, develop a repertoire of new instructional strategies, and "develop a sense of efficacy" with higher content.

State policymakers need to give schools and teachers permission to follow a practice of "less is more," going for depth, not breadth. This means establishing incentives so that teachers

and students are willing to take risks. Baron also said that time was a major issue in restructuring. Class periods need to be doubled, and teachers need time to work together.

The problem of the extra cost of curriculum reform must be looked at differently. "If you buy the idea that development of curriculum and assessment is also a staff development activity, where do you put the cost?" she asked.

What State Policymakers Can Do

- do not work in isolation;
- examine the work underway by national groups;
- use standards based on how people use knowledge and on the concerns of employers;
- develop the assessment system with the curriculum frameworks;
- follow through, after frameworks are in place, with educating teachers and parents about their meaning, changing teacher preparation, using assessments for change, and creating a reporting system;
- avoid the back-to-basics mentality;
- support changes in instructional practices, such as letting teachers schedule large blocks of time for one subject; and
- establish incentives so that teachers and students are willing to take risks.

Opportunities for States from the National Science Foundation (NSF)

The Statewide Systemic Initiative Program (SSI) of NSF fits with the conference theme—that states are the only resource for systemic reform of the curriculum. SSI requires states to involve the governor and staff in changing science and math instruction; set a vision of what education in these subjects should be in the curriculum; address instructional strategies, assessment, changes in school structures, equity issues, and the preparation and development of teachers; and create partnerships with educators at all levels—policymakers, scientists and mathematicians, business and industry, parents, and communities. Now in the second year of a 3-year initiative, NSF anticipates having 30 states involved in the program.

In the first round of grants under SSI, state planners tended to develop individual visions without forming coalitions or partnerships, according to NSF officials. The second round of grantees showed a better consensus on goals.

NSF also is developing a technical assistance effort to provide additional resources to SSI states and to those states which applied for the program but did not receive funds.

Ten Implications for State Policymakers

Certain themes and consensus building for state policymakers developed from the Secretary's Conference. The following points draw from the 2 days of discussions and debate, aided by the advice of a group of policymakers and others asked to contribute to this summary of implications.

- National and state leaders must join to **create public awareness** of the crisis in mathematics and science education. They must repeat and reinforce the message at the national, state, district, community, and school levels without blaming any sector.
- Before doing any specific planning, state leaders should establish an **ambitious, rigorous vision** for what students should know and be able to do in mathematics and science. These leaders should combine resources to inspire and stretch the expectations for their initiatives and those of others.
- In their vision, state leaders must emphasize the same **high standards for all students**, and these must be based on outcomes.
- Policymakers should focus on **long-range objectives**, showing not only an awareness of the complexity of the problems, but also the commitment to continue their support for change.
- State policymakers should understand that **systemic reform** is the basic ingredient for achieving the changes that will lead to higher standards and performance. Piecemeal, disconnected, and ultimately unaccountable reforms will not result in much progress.
- Policymakers involved in curriculum reform should **tap the highest level of resources**. They need to be aware of the best thinking and best practices from across the country, especially in the bellwether states.
- State leaders should commit themselves to using **whatever leverage exists** for creating higher standards. This leverage includes integrating policies regarding categorical programs, licensure and certification, accreditation, college admissions, staff development funding, and textbook selection.
- State policymakers must keep the **capability of teachers to deliver high content** at the heart of policymaking considerations. Staff development must occur in tandem with curriculum development so that teachers can be prepared for whatever changes the new guidelines promote.
- To create the optimum conditions for excellent performance in math and science, state leaders must require **fundamental changes in school organization**. This means states may have to be more flexible—waiving, for example, certain requirements when necessary. These changes can involve the use of time in school, the role of teachers, the use of technology, the allocation of resources, the shift from broad coverage to in-depth learning, and others.
- Policymakers must reinforce the development of new curriculum frameworks with **investments in staff development**. The results should be a constantly learning community of professionals, continued monitoring, and policies that "do not pull up the young tree to see how it's growing."

As a state senate research staff leader expressed it, state policymakers need to focus on developing new curriculum frameworks because they "clearly define what the state expects all students to know, act as an anchor for all other policies, and create an atmosphere for raising expectations both at state and local levels."

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