William R. Kincaid
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To: Daryl E. Chubin/OSTP/EOP

cc: Sarah G. Horrigan/OMB/EOP
Subject: Comments on Draft Testimony

OSTP2.CMT

Daryl--

Thanks for sharing this with me on Friday. Attached are fairly detailed comments. As you will see, I have some serious concerns with the draft. I have shared the draft with Judy Wurtzel, and I know that the Department of Education will have fairly extensive comments as well. Let me know if you have any questions.

-- Bill

Comments on OSTP Draft 10/29 Science Committee Testimony

Overall concerns:

First, the general tone of this testimony is far too negative, focusing on current problems with federal efforts in K-12 math, science and technology education, rather than progress that is being made. It isn't clear how this is beneficial to the Administration, or that it accurately portrays the current state of play. It seems that the more appropriate general approach would be as follows:

1. that federal programs and initiatives currently play an important role in supporting state and local efforts to improve math, science, and technology education,

2. that there is a highly valuable effort underway to strengthen and better coordinate federal efforts to support math and science education, focused especially on middle school math in light of the TIMSS findings,

3. that this effort is coalescing around some key areas of improving teaching, availability of high quality materials and effective use of technology, and strengthening public awareness of the importance of challenging mathematics,

4. and that there is every reason to believe that the federal investment will be even more valuable to states and school districts in the future, not just in terms of the primary investments made by the Department of Education and the NSF, but also in terms of the efforts made by other agencies like NASA.

Second, despite the negative tone generally, the testimony at times seems to overplay the importance of the federal role in math and science education, treating it as paramount rather than simply a key source of support and encouragement for state and local efforts.

Finally, the testimony appears to suggest some understandings and expectations with respect to the nature and structure of future interagency coordination on math and science education that go beyond the recommendations of the working group's draft action strategy and may not represent a consensus of the principal agencies that would be affected.

Specific concerns:

p. 2, lst ¶ -- Although there has been considerable OSTP and DPC involvement, primary staffing of the working group has been provided by the agencies co-chairing the group: ED and NSF.

Strike references to "March of 1997" and "seven months" (in third ¶) spent working on the action strategy -- these unnecessarily invite a focus on timeline and process of what was originally to be a 90 day exercise rather than substance of the group's deliberations.

Need to clarify that the primary focus of the working group has been on middle school math, in light of TIMSS findings, and that most of its recommendations will be focused on that priority.

2nd ¶, last sent. -- Insert "federal support for" prior to "systemic reform" and consider changing "systemic reform" to "standards-based reform".

4th ¶ -- Implementing the action strategy seems primarily up to the agencies, with OSTP assisting and supporting (rather than "coordinating") their efforts. Also, acknowledging that Secretary Riley and Director Lane have already testified on the substance of the action strategy to an extent, this lead-in could be strengthened with a clear and brief statement of the chief areas of focus for the action strategy, as discussed above (strengthening teaching, etc.), not just materials.

Pp. 3 - 4 -- The language on materials seems to overstate somewhat the federal role -- for example, we shouldn't assert or imply that the marketing and distribution of high-quality, federally-supported, standards-based materials "is the only way districts can make informed choices." Better language would be "can help expand districts' choices." Ditto for assertion that "it is the only way that standards-based instruction will be spread throughout the nation." Instead, getting the word out could be better described "as an important step in helping schools and districts adopt rigorous, standards-based instructional practices."

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Given where we are on the delicate negotiations on the national tests, this testimony should omit the references to the 15 urban districts that have signed on. (In particular, the testimony should not suggest that they have taken "a risk" in signing up). If there were some general statement at the beginning of the testimony about the importance that this Administration places on improving math and science education, it would be appropriate to note the voluntary national test in 8th grade mathematics as an example of that commitment.

P. 5, 3rd ¶ -- The tone here is way off the mark. This is an opportunity to positively describe the impact of ED and NSF programs and initiatives, and especially the efforts that ED and NSF are now making to work together more cooperatively, rather than to negatively characterize the programs or resource levels of either agency, or the "problems of coordinating agencies with different cultures." Taking this negative kind of tack, especially, in the closing stages of appropriations negotiations, is not beneficial to the Administration. I think Judy Wurtzel is going to suggest more constructive language here.

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Last ¶ -- Has internal agreement in WH and with affected agencies been reached the existence of or role of a working group on science education? If not, then this type of effort should not be floated in congressional testimony.

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FAX

DATE: 10/24/97

Number of pages including cover 13

TO: **Bill Kincaid**
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FROM: **Dr. Daryl Chubin**
OSTP/EOP
Assistant Director for
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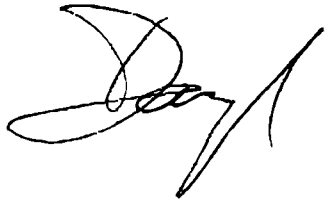
REMARKS: ☐ *Urgent* ☒ *For your review* ☐ *Reply ASAP* ☐ *Please Comment*

Bill:

Please have comments on the enclosed testimony back to OSTP by noon Monday 10/27. The final version must be transmitted to the Hill by 3 pm. FYI, Sarah Horrigan at OMB is shepherding the clearance by the agencies.

Thanks,



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U.S. HOUSE OF REPRESENTATIVES
SCIENCE COMMITTEE

Hearing on
Science, Math, Engineering, and Technology Education (SMET) in America—
Collaboration and Coordination of Federal Agency Efforts in
SMET K-12 Education

October 29, 1997
10 AM to 12 NOON
2318 Rayburn HOB

TESTIMONY OF

DR. CLIFFORD GABRIEL
Acting Associate Director, Science Division
Office of Science and Technology Policy

Thank you for the opportunity for the Office of Science and Technology Policy to testify on the Federal role in K-12 science education. In 1993, the President established within OSTP the National Science and Technology Council, a Cabinet-level body for coordinating science, space, and technology policies across the Federal Government. NSTC acts as a "virtual agency," and is a successor to the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET).

With this organizational structure in mind, there are several issues on which I would like to share an OSTP perspective – both past and future. These include the distinctive roles of the National Science Foundation (NSF) and the Department of Education (ED) as the lead agencies for K-12 science education, as well as the work of NSTC and the President's Committee of Advisors on Science and Technology (PCAST), which help to advance the national interest in what is fundamentally a state and local, public and private, community and individual responsibility.

The Department of Education-NSF Working Group

OSTP, together with the Domestic Policy Council, has been staffing a Working Group on Improving Math and Science Education, which was created by a Presidential Directive ~~in March 1997~~. The focus of this Working Group is the focus of this hearing – collaboration and coordination of Federal agencies to support state and local K-12 education in mathematics and science.

primary focus of the working group has been on math, specifically middle school math, due to the Timss results, and most of its recommendations will be focused on that grade level.

Amidst the recent debate about the Third International Mathematics and Science Study (TIMSS) and voluntary national tests in reading and math, we should recall that teaching and learning to high standards of performance has long been the goal of NSF and ED. For example, ED and NSF jointly helped to design and fund TIMSS. They know the value of research-based practices and programs. Indeed, "systemic reform" of mathematics and science education was launched in 1991 with NSF's Statewide Systemic Initiatives and solidified as a strategy for achieving the National Education Goals in all subjects through the passage of ED's Goals 2000 in 1994.

The ED-NSF Working Group on Improving Math and Science Education was created to help foster the conditions under which students, parents, teachers, schools, and communities aspire to higher academic achievement. The Working Group focused on how a dozen Federal agencies, led by ED and NSF, could catalyze local systems to motivate all students to perform in math and science at a level observed by their age-peers in other high-performing nations. ~~For seven months,~~ this interagency group has been developing an "action strategy" by taking stock of programs, activities, products, and processes to identify what is working, what looks promising, and what could help teachers, schools, and districts make system-wide improvements in teaching and learning, especially in grade 5-8 mathematics.

A Strategy Emphasizing Materials and Teachers

While the report is nearing completion, OSTP is poised to coordinate the agencies in implementing the action strategy. Building on ED-NSF leadership and experience,

there is an immediate need to disseminate efficiently the standards-based materials developed through individual agency efforts. These materials reflect the respective agency strengths while providing different means to the same end -- students who aspire to academic excellence. To cite two examples,

- A just-released ED TIMSS Resource Kit, "Attaining Excellence," contains ~~what is appropriately called~~ "starting points" for examining student achievement, teaching, and curricula, ~~and video of classrooms observed and analyzed in~~ the 8th grade TIMSS. ~~The Resource Kit is a guide for using the research findings of TIMSS to inform~~ practice. To this end, every State Eisenhower Consortium Director has received a kit. In addition, the National Council of Teachers of Mathematics (NCTM) is distributing it through ~~their~~ its network, and every school board chair in the Nation has been informed by letter about the TIMSS kit and how to order it (at a cost of about $90 per kit).

- NASA's "Mission Mathematics," subtitled "Linking Aerospace and the NCTM Standards," has been produced for grade levels K-6 and 9-12. A middle school (grades 5-8) version is about to be released. Each links curriculum, teaching, and student assessment, based on the NCTM math standards. Drafts were field-tested by classroom teachers and reviewed by NCTM's Educational Materials Committees. Mission Mathematics has been available nationally for $20 per volume through NCTM's website and journals since April 1997. Over 3000 have been sold in addition to the 1000 distributed by NASA.

Both of these examples illustrate the existence of quality materials. They serve as models of Federal agencies assisting localities by providing materials that reflect professional consensus on what constitutes high content standards in mathematics and science. The marketing and distribution of such materials ~~is the only way~~ districts' ~~can make informed~~ choices among innovative resources. They can only make a difference in student learning, however, if they find their way into the hands of teachers and ~~reform~~

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~~-minded~~ administrators. Getting the word out on availability is the first step in the dissemination process. It is the only way that standards-based instruction will be spread throughout the Nation, or "brought to scale," given the diversity of schools and districts across America.

~~It is a cliche that~~ student success flows from better prepared and professionally developed teachers. Anchoring teachers in the classroom realities of high standards is a daunting but necessary task. TIMSS results show that middle school mathematics requires teachers to have greater command of content and the opportunity through intensive, hands-on in-service experiences to teach it rigorously and creatively. Then school structures must afford all students the opportunity to learn mathematics beyond the basic levels of performance, as recent National Assessment of Educational Progress (NAEP) scores indicate.

Within this concern for excellence in the learning environment there is embedded a knottier concern. As the student population grows, it becomes increasingly ethnically diverse. Students from ethnic minorities are historically underrepresented in science -- as teachers, researchers, engineering technicians and technologists, and other "knowledge workers." We must better prepare them for careers that ~~tap their~~ scientific literacy. The one-third minority student population nationally has already approached a "majority minority" in many urban areas. Yet high school graduation rates, baccalaureate degrees, and graduate study lag for minority students.

There is a special need to attract more minority math and science teachers, especially at grades 6-12, and here the Federal government can be a facilitator. The two lead Federal science education agencies have embraced this role. ED has championed Lighthouse Schools, a concept that will connect institutions of higher education recognized for exemplary standards-based, technology-savvy teacher preparation programs with urban districts that will hire the graduates of those programs. Middle school mathematics could also be bolstered through increased support of the 15 urban

schools districts (almost all of which are NSF-funded Urban Systemic Initiatives) that have endorsed the national tests in 4th grade reading and 8th grade mathematics. Urban districts have a history of disadvantage. If these districts have taken a risk by volunteering their students and schools for the tests, the Federal government must do its part, through its partners, to improve the quality of their preparation. With reauthorization of the Higher Education Act, ED will have a pivotal role in assessing the impacts and adjusting the scope of the Lighthouse Schools model.

The Federal agencies can also influence the composition of the scientific and education workforces by supporting research and education programs at minority institutions – Historically Black Colleges, Hispanic-Serving Institutions, and Tribal Colleges – that are known for excellence in science, mathematics, and education. In consortia with majority and minority institutions alike, NSF's Alliances for Minority Participation program has begun to do just this. It is programs like this, I would add, that help nurture those individuals and organizations who become recognized through two Presidential Awards that OSTP administers (in collaboration with NSF) – awards for excellence in mathematics and science teaching and for excellence in science, engineering, and mathematics mentoring.

Opportunities for Leveraging

Through the Working Group's deliberations, OSTP has learned anew the problems of coordinating agencies with different cultures: NSF's strategically and competitively project-based approach in contrast to ED's largely formula-funded programs, which do little targeting of mathematics and science. To compound these differences, ED spends roughly 20 times more than NSF's annual investment in K-12. Combined with the agencies' separate policy and budget oversight through different OMB examiners and different authorizing and appropriations committees, the need for coordination is ongoing.

This is completely the wrong way to set this up.

Despite these structural challenges, leveraging ED's Title I program with NSF's Urban Systemic Initiatives has great potential. So far, however, the potential is unrealized. The challenge is to put resources into the delivery system so that teachers, technology, materials, and new assessments work together, not alone. That is why a systemic approach is so appealing.

Today, ED's Eisenhower Regional Consortia monies can be consolidated through local education agencies participating in NSF's Local Systemic Change projects to enhance the use of standards-based materials by well-prepared teachers. This indeed happens in certain districts, schools, and grades around the U.S. To make the practice more widespread would require: information on separate agency projects operating in a locality, endorsement by the sponsoring agencies that project staffs work together, and instructions that specify monitoring and post-award reporting jointly to the sponsoring agencies.

While ED supports the national education infrastructure, NSF seeds projects dedicated to reform. The same could be said of a half-dozen other R&D agencies – NASA, DOE, DOT, USDA, to name a few – that target their support opportunistically based on their mission requirements. They tend to focus on specific grade levels (more 9-12 than 5-8), on favorite technology-based tools (the Internet and World Wide Web), on schools located near their labs and centers, and on particular community partners (public and private) with a history of providing school-based enrichment or technical assistance. This appears to be idiosyncratic by agency, effective on the input side but whose impacts on student learning beyond the original site of intervention are difficult to measure and largely unknown.

We need to do a better job in raising the visibility of those agency programs and projects that, by some evaluative measure, have made a positive difference with students and teachers. How to identify, disseminate, replicate, and adapt these models of reform is a legitimate Federal role – as long as we remain mindful that one size certainly does not

fit all. The agencies can provide research-based, classroom-tested choices – and then make these choices known to teachers and administrators seeking intellectual and pedagogical support with some baseline experience to draw upon.

OSTP believes that if teaching and learning math and science to high standards is to become common in America, then Federal programs must be in place to catalyze local districts, schools, and classrooms, and overcome inertia. We know, for instance, that the imprimatur of an NSF award has long been used by local school systems to validate the quality of their efforts and to induce corporate and higher education partners to join them in expanding the scope and impact of innovations. In the wake of such successes, other systems could be apprised of promising practices and outcomes to help them decide whether adoption or adaptation makes sense in their pursuit of high standards for their students.

OSTP Coordination Through NSTC

When the ED-NSF Working Group was formed, each department secretary/agency director was sent a letter over Secretary Riley's and Director Lane's signatures asking that a representative be appointed. OSTP did not wish to assume that those who had served on the NSTC Committee on Education and Training were necessarily the staff best suited – four years later – for the task at hand. In the resulting action strategy, the Working Group will pledge to continue sharing, monitoring, and reporting of activities supported by the dozen R&D agencies that contribute to K-12 education across the Nation.

Under the NSTC Committee on Science, which will succeed the Committee on Fundamental Science as part of an OSTP streamlining of its coordinating mechanisms, an interagency Working Group on Science Education will provide a forum for exchange on what each agency is learning from their mistakes and successes, and in some cases, their program evaluations. However, OSTP suggests that this interagency group go further to determine how the agencies support standards-based science and mathematics.

Some brief history: In June 1993, an expert panel convened by OSTP's Federal Coordinating Council on Science, Engineering and Technology (FCCSET) – the forerunner of today's National Science and Technology Council – reported to the President the results of its review of Federal programs in science, mathematics, engineering, and technology education. The panel addressed all levels of science, mathematics, engineering, and technology education, as well as the challenges of on-the-job training and retraining and elevation of the public's scientific literacy.

Their findings were published in a report titled *The Federal Investment in Science, Mathematics, Engineering, and Technology Education: Where Now? What Next?* Chief among them were that (1) the $2 billion annual portfolio of nearly 300 federally-sponsored programs covering all levels of science, mathematics, engineering, and technology education from pre-kindergarten through graduate school were insufficiently coordinated with the private sector; and (2) this portfolio was not being guided by assessments of national need. Only about half of the Federal programs had been evaluated for effectiveness, making informed decisions about program retention or expansion difficult, and providing little real accountability.

To remedy these deficiencies, the expert panel recommended the creation of a new Federal culture of interagency communication and cooperation regarding science, mathematics, engineering, and technology education. This report, released the same year that the Government Performance and Results Act (GPRA) was passed, called for enhanced accountability for outcomes from federally-sponsored interventions in education. Agencies were exhorted by the panel to use rigorous management, monitoring, and evaluation to maximize impacts and learning from Federal programs, and connect agency missions to local education, training, and literacy efforts at the appropriate K-12, undergraduate, graduate levels and beyond.

Agency responses to the FCCSET Expert Panel Report varied. Some, like NSF, redoubled their efforts to evaluate their programs' impacts. During a time of balanced budget belt-tightening, other agencies, such as the Department of Energy were forced to reduce their investment in K-12 science education. At the same time, technology-rich, standards-based mathematics and science was being instituted throughout the independent school systems ("Dependents Schools") operated as part of DoD's Education Activity world-wide.

Clearly, the Federal Government can help determine through research, evaluation, and international comparisons of classroom teaching and learning, not only what works, but also what is reflective of international content standards of excellence. Based on the Working Group's action strategy, the NSTC can improve its vigilance over Federal contributions to improving mathematics and science education. GPRA will soon yield some measures of agency performance in the arena of K-12 science and math education. OSTP would expect any interagency working group on education to coordinate its GPRA plans and indicators, in consultation with OMB.

NSTC will continue to work toward this goal of interagency interdependency in planning, communicating, sharing, and informing what and how each agency attempts to influence the participants in 15,000 local school districts around the Nation. Through the NSTC, we can speak with a uniform Federal voice on how agencies can be responsible partners and resources for positive change in American K-12 science education.

Learning Technology in Research and Education

Since 1995, the Administration's Technology Innovation Challenge Grants program has leveraged local resources by more than three to one. Today, ED's Technology Literacy Challenge Fund helps states and local communities create and implement their own plans for integrating educational technology into their school curricula. And Goals 2000 invites states to develop their technology capabilities for classroom use. The President's campaign to connect all schools to the Internet is in fact

supported by telecommunications networks grown by the Department of Commerce, USDA, and NSF. In conjunction with NASA, EPA, Interior, and NOAA, the Global Learning and Observations to Benefit the Environment (GLOBE) project allows students to download data, share analyses with scientists around the world, and participate in an electronic learning community. GLOBE has evolved from a modest interagency experiment to a collaborative science teaching and learning phenomenon.

In the June 1997 Gibbons-Raines memorandum on FY 1999 Interagency R&D Priorities, "education and training" and "children's research" are distinguished among 15 priority research areas requiring investments across agencies. In addition, education and training technologies is one of five OMB budget crosscuts.

OSTP would like to strengthen research on learning technologies while taking stock of agency portfolios in this vital area. An interagency Working Group on Learning Technology R&D, consisting of the Departments of Defense and Education and the National Science Foundation, was created this summer to identify programs, projects, testbeds, and other activities centered on technological tools that facilitate learning. This Working Group is reviewing both the priorities of Federal sponsorship of learning technology R&D and the methods for ensuring the most effective use of these funds.

When the review is complete, OSTP will have a better sense of how these three agencies allocate their educational technology dollar and how, through research and evaluation, we can offer successful applications across subjects, grade levels, school systems. On research alone, NSF has invested over $20 million within the Learning and Intelligent Systems initiative, which is a component of its cross-directorate Knowledge and Distributed Intelligence theme. This is an effort to integrate linguistic, behavioral, biological, cognitive, and educational approaches with interactive technologies that illuminate how learning occurs.

In a related vein, a Panel on Educational Technology was organized in April 1995 under the auspices of the President's Committee of Advisors on Science and Technology (PCAST). It was asked to provide independent advice on the application of various technologies to K-12 education. With a focus on interactive computer- and network-based technologies, the Panel's review of the research literature and briefings from academic and industrial researchers, practicing educators, software developers, government agencies, and professional and industry organizations involved in the application of technology to education led to a report released this Spring.

Since Dr. David Shaw is a member of today's hearing panel, I will not belabor the Panel's recommendations. I would like to underscore the two main points of the PCAST report. First, technology is a tool embedded in a complicated system. If those in the system, especially teachers, are not equipped to integrate the tool into daily instruction, then the number of networked schools or classrooms is meaningless. No benefits will accrue to those who need it to improve teaching and learning. Second, given the huge Federal expenditures on service delivery to children, on educational technology, and on learning generally, the level of spending on research and evaluation of these efforts is far too modest and should be increased. Greater investment in such research can help better inform Federal funding decisions to take into account demonstrated effectiveness. In the realm of research, evaluation, and dissemination, the Federal government also plays a critical role in producing and transferring empirical knowledge about teaching and learning more widely. How local communities, schools, and teachers eventually adapt or use such knowledge is their prerogative.

A follow-on PCAST Panel on Education was created this summer to capitalize on – through policy translation, new research, and wider dissemination – the educational technology report and other interagency and Administration reports on children. This Panel, chaired by Dr. David Hamburg, President Emeritus of the Carnegie Corporation of New York, is developing an agenda of education and human resource activities, including implementing an experimental, longitudinal, cross-cultural program on learning

– not just by children or about science and mathematics. In addition, OSTP will use input from PCAST in crafting a human resource development policy for science and technology.

Looking Ahead

We believe that the issues addressed by this hearing deserve a more comprehensive treatment of strategies for the entire education continuum – formal and informal – over an indivdual's life course. When fully developed, the S&T human resource policy will address preschool learning, elementary and secondary schools, undergraduate and graduate education, workforce training (especially teachers), and lifelong learning (including retraining and what will make the public more attentive to and appreciative of science, if not scientifically literate and numerate in the traditional sense of what they know).

In general, the Federal R&D agencies beyond their individual missions and specialized workforces must be responsible partners in reexamining their program portfolios, helping to implement new policy, and preparing Americans for 21st century citizenship. This underscores a future NSTC role in transforming the vision of the two interagency working groups I've described into a reality that adds value to the local efforts of schools, teachers, and parents to coordinate resources and draw wisely on the lessons learned elsewhere and shared through Federal activities, projects, and media.

OSTP welcomes future discussions with the Committee about the issues on which we seek common solutions. Thank you.

Review Timss report re: funding boxes - text - ?
Flag the agency activities more prominently

PHOTOCOPY PRESERVATION

Working DRAFT; 8/6/97

AN ACTION STRATEGY FOR IMPROVING ACHIEVEMENT IN MATHEMATICS AND SCIENCE

On March 6, the President issued a memorandum (Appendix 1) directing the Secretary of Education and the Director of the National Science Foundation to form an interagency working group to develop an action strategy for using Federal resources to assist States and local school systems to meet challenging mathematics standards in the eighth grade, and for involving the mathematical, scientific, and technical communities in support of those efforts.

The Presidential directive specified that the action strategy include recommendations for the use of Federal resources to help States, local school districts, and schools improve teaching, upgrade curriculum, integrate technology and high-quality instructional materials into the classroom, and motivate students to help them understand how mathematical concepts are applied in today's global workplace. It called for the interagency group to review the current status of improvements in mathematics education and identify critical issues of need, drawing on research and input from educators and professional organizations. In addition, it called for the working group to review how Federal resources and partnerships with other organizations can help improve student achievement in science.

One of the immediate inspirations for this attention to high standards in mathematics and science education in eighth grade is the Third International Mathematics and Science Study (TIMSS), involving 30,000 students in the United States. Results released in the Fall of 1996 show lackluster performance by U.S. 8th graders, with scores a bit above the international average in science but below the international average in mathematics. On the other hand, TIMSS 4th grade data released in the summer of 1997 show that our 4th graders are above the international average in both math and science -- and in science are outperformed only by Korea. These results clearly indicate that mathematics education in the middle school years should be an important focus for national efforts to help ensure that our students meet world class standards.

TIMSS results for the 4th grade are much more positive than the results of similar international comparisons in the past. They demonstrate that it is possible to make significant progress in international comparisons over time, and that US students can compete favorably with those of other nations in mathematics and science achievement. Our National Education Goals proclaim

The Third International Mathematics and Science Study (TIMSS)

Internet address?

TIMSS is the largest and most ambitious of a series of international comparative studies of educational achievement. It includes a significant component of research about the educational environment that provides clues to how improvements in educational achievement might be made.

TIMSS involved more than half a million students in 45 countries ~~with testing in more than 30 different languages~~. The Department of Education and the National Science Foundation sponsored the U.S. testing, done in 1995, and subsequent analysis. Results for grades 4 and 8 are now available. At grade 4, U.S. students performed among the best in science and above the international average in mathematics. At grade 8, U.S. students performed just above the international average in science and below it in mathematics. The relative performance of U.S. students ~~in comparison to students of other countries~~ improved over performance on similar international comparisons of earlier years. However, the U.S. was the only country whose students performed above average at grade 4 and below average at grade 8 in either science or mathematics.

on Timss

TIMSS results show that

- U.S. student performance increases more slowly between elementary and middle school years than in most other countries;
- The U.S. curriculum is not as well focused on topics that would propel students toward more advanced levels of understanding as are curricula in other countries;
- U.S. teachers work longer hours, have less time during the day for preparing classes, and experience more disruption in their classrooms than do their counterparts in other countries; and
- U.S. teachers are often not as involved in decisions about what and how they will teach as are their counterparts in other countries.

May want to place graphics in some of the boxes that follow to break up text

PHOTOCOPY
PRESERVATION

our intent that US students will be first in the world in mathematics and science achievement by the year 2000. In the early grades, we are making demonstrable progress toward that goal.

Beyond indicating a need to focus emphasis on grades 5 through 8, TIMSS also provides a wealth of data on how and what we teach our students -- and important clues about ways to improve both. TIMSS researchers collected not only achievement data in each participating country, but also much information about teachers and teaching, about curricula and instructional materials, about classroom lessons and interactions, and about student attitudes and habits outside the classroom. Thus, TIMSS results have become a source of constructive motivation for mounting an action strategy, taking the issue well beyond the simple comparison of scores in international test taking.

Eighth grade is a critical point in mathematics education, as achievement at that stage paves the way for students to take the advanced high school mathematics and science courses that are keys to college entrance and well-paid jobs. Today, too many students enter high school without this solid grounding in mathematics and never gain it, closing doors to opportunities for further education and careers. Often, students (and their families) do not even know that the doors are closing, leading to a mismatch between their expectations for their futures and their actions in the present. For example, a 1995 survey conducted by the National Action Council for Minorities in Engineering found that over 70 percent of minority 9th and 11th graders viewed being a scientist or engineer as an interesting career , with 78 percent showing interest in taking college level mathematics. Yet 60 percent of the students planned to drop high school mathematics as soon as possible.

The President has proposed a voluntary national test in mathematics, to be taken near the end of eighth grade, as a very visible part of an ambitious, sustained drive for higher, more challenging standards of learning for all students. The test will be available by the spring of 1999 for those States and districts that wish to participate. Parents and teachers will receive an individual score for each student who takes the test. That score will be linked to national and international benchmarks, which will provide additional context. States, districts, and schools will be able to use data from the test in combination with other information on curriculum and teaching practice and with the results of other assessments to create a more complete picture of individual and aggregate performance. For more information, see Appendix 2.

Raising Achievement for Disadvantaged Students

Efforts to raise student achievement in mathematics and science must be particularly intensive in high-poverty communities and schools. The National Assessment of Educational Progress (NAEP) in mathematics shows that students from poor families perform significantly less well than other students. In 1996, the average score on the 500 point NAEP scale was 252 for 8th graders who are eligible for free and reduced price lunch as compared to 280 for ineligible students.

On July 25, 1997, fifteen urban school districts, including the three largest (New York, Los Angeles and Chicago) pledged to participate in the voluntary national test. They sent a clear signal that students in inner city schools can and should be held to the same challenging standards that are being set for all students throughout the nation. These communities recognize that setting high standards in the basic skills for all students is a prerequisite for improved teaching and learning. Research and experience shows that students can meet high standards, and that low expectations lead to low achievement. While this step alone will not improve teaching and learning for students in urban schools, it will guide and catalyze efforts to strengthen curriculum, provide training to teachers, increase parental and community involvement, and support the necessary investments at the local, state, and national levels to improve our schools.

The test is only one element of the comprehensive effort needed to accomplish the objective of having all students achieve challenging national standards for performance in eighth grade mathematics. This effort will require many individuals -- parents, students, teachers, and community leaders -- working in concert with a common understanding of what they are trying to accomplish. All parties to the effort will need a clear picture of what students should know by the end of eighth grade and what world-class performance looks like. Only then can we, as individuals and as a nation, begin to aspire to the high standards that a significant number of our students do not yet reach.

The test, in combination with a national effort to boost achievement, will provide a powerful lever to amplify the effects of existing efforts at local, State and national levels to improve K-8 mathematics and science education. This action strategy is aimed at laying the basis for such a national effort, concentrating, for the near term, on mathematics in grades 5-8, where the TIMSS results tell us we need to focus.

Response to the Presidential Directive

In response to the memorandum from the President, the Department of Education and the National Science Foundation formed an interagency working group comprised of staff experienced in the areas under review. Officials of the Office of Science and Technology Policy , the Domestic Policy and the Office of Management and Budget provided oversight. (A listing of the members of the interagency group is attached as Appendix 3).

Consistent with the directive, the interagency group immediately began a review of current Federal efforts in mathematics and science education with particular attention to mathematics education in kindergarten through eighth-grade. (See Appendix 4 for a summary of relevant programs in the two agencies.) In addition, as the memorandum instructed, the interagency group drew on research and input from educators and professional organizations, by reaching out to the broader mathematics and educational community for advice and guidance. (See Appendix 5 for a summary of these outreach efforts, including a list of organizations with which the working group consulted.) The interagency group also consulted with appropriate staff in other agencies that have, or are interested in establishing, activities in elementary and secondary-level mathematics or science ~~education~~. (See Appendix 6 for a list of the agencies consulted and a summary of their input.)

The Department of Energy's STEM Initiative

Department of Energy (DOE) Secretary Pena has launched for FY 1998 a renewed effort to support science, mathematics, technology, and engineering education consistent with DOE's energy and defense missions. The Science, Technology, Engineering, and Math Education (STEM) Initiative will coordinate DOE resources to promote the public's understanding of science and provide a diverse workforce for the Nation's science and technology infrastructure.

DOE plays an important role in science education due especially to its premier national laboratories, which have a history of staff working in cooperation with ~~the Nation's education system~~ and other agencies. By opening DOE's laboratories to students and teachers, agency staff offer hands-on research opportunities ~~and~~ technical support for developing Internet and other ~~technical~~ tools to enhance educational experiences.

~~Among~~ STEM's ~~five~~ goals, ~~two~~ are particularly relevant to this action strategy:

- Develop Internet based education technologies for elementary through college students and faculty; and
- Enhance DOE's community outreach activities in science, technology, engineering, and mathematics education at its R&D facilities and sites.

To implement the STEM Initiative, DOE will create an Education Council consisting of representatives from across DOE headquarters and all laboratory facilities. The Education Council will oversee the evaluation of education proposals that the Department will support. The Council will work directly with the Secretary to fulfill specific goals.

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Based ~~the relevant information collected, the TIMSS results, and the need to provide a strategic~~ set ~~of core activities~~, the interagency group focused on raising achievement in mathematics in grades 5-8. In support of this objective, ~~the resulting~~ action strategy challenges :

- The Department of Education and the National Science Foundation ~~to~~ mesh their disparate modes of operation and ~~to~~ draw in other agencies in a coordinated effort to strengthen the impact of Federal resources;

- Superintendents, mathematics supervisors, school boards, principals, and others in state and local education organizations ~~to reformulate~~ their ~~approaches to the~~ use of Federal resources ~~in order to make them more effective;~~

- Families to invest the time and effort to understand the importance of high standards of achievement in mathematics ~~for all students~~ and ~~to~~ support their children in attempts to ~~reach~~ these high standards;

- The Nation's colleges and universities ~~to~~ develop new standards for teacher preparation, particularly for potential teachers of mathematics in grades 5-8, and ~~to~~ take a more active role in enhancing today's teachers, in conjunction with State and local education agencies and ~~with~~ local schools; and

- Professional organizations in mathematics, science, engineering and technology ~~to work~~ with schools, parents, students, community organizations, and business and industry to develop a vibrant network of local partnerships ~~to raise~~ achievement in mathematics in grades 5-8.

Excellence in Mathematics by the End of Eighth Grade as the Core of a National Action Strategy for Improving Achievement in Mathematics and Science

Our vision is that all American students leave eighth grade prepared to pursue the higher-level mathematics and science courses that are the gateway to college, citizenship, productive employment, and lifelong learning. Whatever their status in life, all of our students deserve an education that will help them prepare for a successful future.

Reaching this vision will require:

- High expectations, held by teachers, school administrators, parents, and students themselves, for student performance in mathematics and science;

- Challenging standards for content, materials, teaching, assessment, ~~and achievement~~;

- Instructional materials and technology of high quality that incorporate these challenging standards;

- Teachers with the pedagogical skills and rigorous knowledge of mathematics and science needed to teach these subjects effectively; and

- Activities outside the classroom that reinforce the classroom experience by drawing on the support of parents, the professional community of mathematicians, scientists, and engineers, business, and the broader public.

Suggested revision of challenges section of math strategy:

Based on the TIMSS results, and other information analyzed, the interagency group focused on raising student achievement in mathematics at grades 5-8. For America to succeed in this objective, there are several national challenges which must be addressed:

- At the state and local level, Superintendents, mathematics supervisors, school boards, principals, and other educators should step back and take a fresh, critical look at their use of Federal resources in light of TIMSS and other current research -- in many cases, substantially reformulating their approach to improve effectiveness;

- In households across the U.S., families need to devote the extra time and effort necessary to understand the importance of high standards of achievement in mathematics and to fully support their children's efforts to reach high standards;

- On the nation's campuses, our colleges and universities must develop rigorous new standards for teacher preparation, particularly for potential teachers of mathematics in grades 5-8, and take a far more active role in enhancing the skills and knowledge of today's teachers, working closely with States, local school districts, and schools in the process;

- In cities and towns from coast to coast, professional organizations in mathematics, science, engineering and technology, in partnership with schools, parents, students, community organizations, and business and industry, should develop a vibrant network of local partnerships aimed at raising student achievement.

- And finally, here in Washington, the Department of Education and the National Science Foundation must work much harder to mesh their separate operating modes and partner with other federal agencies in a concerted effort to strengthen the classroom impact of Federal investments in math and science education.

While achievement of ~~our~~ vision ~~will rely on~~ each of these elements, progress in one area will often depend on and demand improvement in others. For instance, the introduction of high-quality instructional materials will have little impact if teachers are not trained to use those materials effectively. Effective instruction during the school day will have limited results if parents (and, indeed, the entire community) do not support student achievement and let students know how important success in mathematics is to their future opportunities for college and careers. We must ~~be~~ work~~ing~~ on all fronts -- high standards, effective curriculum, technology in the classroom, teacher training and licensure, assessments, and support from parents and the public -- to make progress towards this vision.

Achievement in mathematics by the end of the eighth grade is a critical factor in the ability of students to pursue advanced work in mathematics and science in high school and beyond. By moving to enable students to meet challenging national standards in mathematics toward the end of eighth grade, using the voluntary national test as an indicator of accomplishment, this action strategy provides both a model for and a key element in a broader, sustained effort to improve achievement in K-12 mathematics and science.

Improving Mathematics Education: Building on Strength

The action plan builds on the considerable efforts underway across the country to improve elementary and secondary mathematics and science education. Some of these activities began more than a decade ago in schools, colleges, States, and professional organizations. They were given impetus by the establishment of the National Education Goals, including the goal of being first in the world in mathematics and science educational achievement by the year 2000. Taken together, they provide a solid foundation for focused attention to mathematics in grades 5-8 that can catalyze improvements in K-12 mathematics and science education. Some of the most important current or completed activities include:

- The National Council of Teachers of Mathematics (NCTM) introduced standards for mathematics curriculum and evaluation in 1989, followed by standards for teaching and assessment in mathematics. States and communities have made these voluntary standards the basis of many of their efforts to improve mathematics education. (As is appropriate in any effort to raise standards, NCTM is now reviewing the mathematics curriculum and evaluation standards and plans to update them over the next few years.)

- A new generation of rigorous mathematics curricula aligned with the NCTM standards is ~~beginning to appear in~~ classrooms. By the fall of 1997, these materials will account for about 25 percent of all new textbooks purchased, and that figure should grow in succeeding years.

- TIMSS and other new assessments, coupled with in-depth research, are providing valuable information about how and what we are teaching and how students learn, and point to critical factors for improving achievement in mathematics in grades 5-8.

- Approximately 65 percent of all schools are now connected to the Internet, providing the opportunity for communication on improving mathematics education and for the use of distance learning and advanced technologies. Federal support has helped to make this possible, and the newly enacted "E-rate" will substantially reduce the cost of Internet connections for schools and allow more schools to take advantage of this learning tool.

- Many States, with support through Goals 2000, the reauthorized Elementary and Secondary Education Act, systemic initiatives, and other Federal programs, have undertaken comprehensive, system-wide education improvements geared to high standards in mathematics and science. States ~~that were~~ in the forefront of reforms are now beginning to enjoy the benefits in improved student performance.

Critical Areas for the Strategy

Consistent with the President's directive, this action strategy identifies steps that Federal agencies, along with their partners, can take to help students reach challenging mathematics standards and to ensure that Federal resources will effectively support State and local reforms. ~~It places special emphasis on mathematics in grades 5-8.~~ Through consultation with outside organizations and review of Federal programs, the working group has identified three priority areas:

- Equipping teachers in grades 5-8 with the skills and knowledge to teach challenging mathematics content in effective ways, with high expectations for their students;
- ~~Implementing~~ high-quality, standards-based curricula and instructional materials, including effective use of educational technologies, in grade 5-8 mathematics classrooms; and
- Building public understanding of what challenging mathematics looks like in grades 5-8, and gaining public support for raising student achievement toward high standards.

Accountability in the States

In March 1996, the Nation's governors met at the National Education Summit to reaffirm their commitment to school reform. They invited the voters to hold them accountable, calling for "an external, independent, nongovernmental effort to measure and report each state's annual progress." On January 22, 1997, *Education Week* published *Quality Counts*. This report presents more than 75 indicators and grades individual states on their policies and performance in four categories (academic standards, quality of teaching, school climate, and resources).

In report card fashion, the *Education Week* editors summarize in what they call "the state of the states" the progress being made toward higher student achievement. The report card shows: B, C+, C, and two C-. But these are averages around which individual states are distributed. A few states -- New Jersey, Kentucky, New Mexico, Texas, and West Virginia -- have instituted their own grade 8 accountability and reporting systems and obtained impressive results by, for example, granting or taking away districts' administrative autonomy based on state test achievement levels. As other states adapt or adopt what works elsewhere, further gains can be expected.

The core of this action strategy is making more effective use of Federal resources in addressing these priorities in light of the Federal Government's limited role in education, ~~which,~~ while a national priority, is primarily a State and local responsibility. The Federal role is to provide good information, effective tools, and financial support that will assist States and local communities in ensuring that all of their students have the mathematical skills they need to succeed in the workplace as productive citizens. This includes promoting effective partnerships that mobilize support from the community -- students, parents, educators, business people, volunteers, and concerned citizens from all walks of life -- to that end.

Strengthening the Impact of Federal Resources on Mathematics Achievement in Grades 5-8

Strategies for use of Federal resources in addressing these three priority areas are interrelated and overlapping. The bulk of the Federal resources for improvement in K-12 mathematics and science education flows from the programs of the Department of Education and the National Science Foundation. (See Appendix 3 for a summary.) Developing a coherent, coordinated approach to strengthening the impact of Federal resources used to improve mathematics achievement in grades

5-8 requires taking differences among these programs into account. Drawing in other agencies in an effective manner can then follow.

In FY 1997, the National Science Foundation is investing $377 million in K-12 science and mathematics education, including undergraduate preparation of teachers. The funds go largely to colleges and universities, State and local educational agencies, and nonprofit organizations. They are awarded through competitive review of proposals for funding of specific projects. Over the past few years, the Foundation has placed a high priority on system-wide reform of mathematics and science education. It asks local and State educational agencies to align resources of all types, including those obtained through other Federal programs, to effect change. The Foundation highlights specific areas of emphasis within broader programming, establishes clear priorities for funding within the criteria for selection of awards, and holds grantees accountable for performance. Projects in mathematics education are grounded in the NCTM standards. Experience shows, however, that projects aimed at mathematics in grades 5-8 are scarce in comparison to those in science or to those in mathematics aimed at other grade levels.

Open *CESAME!*

Northeastern University's Center for the Enhancement of Science and Mathematics Education (CESAME), through its Statewide Implementation Program (SIP), demonstrates how school districts can successfully implement specific standards-based instructional materials (e.g., *Used Numbers*; *Investigations in Number, Data, and Space*; *Seeing and Thinking Mathematically*; the *Interactive Mathematics Program*; *Science and Technology for Children*; *Insights*). Through a contractual agreement, the project provides districts in Massachusetts with multi-year funding, technical assistance, professional development guided by curriculum developers, and linkages to statewide reform efforts. SIP also conducts research to determine the most effective model for disseminating such materials. Throughout, SIP works to make districts accountable by collecting data and continually focusing on achieving a sustained, high-quality materials implementation.

Funded by the National Science Foundation's Teacher Enhancement program, SIP provides expertise in implementing high quality materials to any Massachusetts district engaged in mathematics and science reform, and leads one of the five regional centers of the Massachusetts Statewide Systemic Initiative (SSI). This five-year project, funded for over $ 4.4 million, has leveraged an additional $ 3.8 million in cost-sharing from district funds, Northeastern University, and the Noyce Foundation.

The Department of Education will allocate approximately $8 billion in FY 1997 through three primary formula-driven programs (Goals 2000; Eisenhower Professional Development State Grants; and Title I: Education for the Disadvantaged) that include improved achievement in mathematics and science education among their objectives. Goals 2000 aids States and school districts to develop and implement challenging academic standards and upgrade teaching and learning in order to reach the National Education Goals, including the goal of becoming first in the world in mathematics and science. The Eisenhower program places an explicit focus on science and mathematics; At least $250 million of the FY 1997 appropriation of $310 million must be spent in these subject areas. The 1994 reauthorization of the program requires that States and localities use Eisenhower funds for sustained professional development that makes a difference in classroom practice. The 1994 reauthorization of Title I places new emphasis on helping disadvantaged students meet the same challenging academic standards expected of all children. States are currently developing standards and plans for moving toward them. The Department of Education works actively with

Title I Schoolwide Programs

The 1994 reauthorization of Title I gave the program an entirely new purpose, namely, to teach disadvantaged students to the same high standards to which all other students are held. States are now in the process of establishing assessment mechanisms to measure students' progress against such standards, in at least reading and mathematics. In addition, the reauthorization lowered the eligibility threshold for Title I schoolwide programs. Schools with at least a 50 percent child poverty rate may now use their Title I funds (along with other Federal, State, and local funds) to make comprehensive improvements in the instructional program of the entire school, rather than providing discrete services to individual children. This change gives those schools the flexibility, for instance, to use Title I funds to upgrade the mathematics curriculum for all students.

States and school districts on identifying actions that can be taken to achieve significant change, provides information and examples, and makes technical assistance available as needed.

The programs of the two agencies have different approaches and strengths. The Department of Education generally provides large-scale, flexible support directly to State and/or local education agencies for improving teaching and learning to high standards, coupling this support with technical assistance. The National Science Foundation's portfolio is much smaller in scale, is targeted at improving mathematics, science, and technology education, and is established through competitive processes. This action strategy combines the agencies' strengths, ~~permitting~~ those involved with upgrading mathematics professional development and instruction through major Department of Education programs to draw on NSF's competitive programs to ~~initiate~~ change. This approach will increase the impact of Federal resources ~~by creating synergy among these programs, realizing~~ a ~~significant concentration of resources~~ for improving mathematics achievement in grades 5-8.

A Title I Schoolwide Example

Kenton Elementary School in Portland Oregon, and 12 other schools in the region ~~jointly hired a mathematics consultant~~. During the 1995-96 school year, ~~the~~ consultants held full-day, weekly workshops on best teaching practices identified by the school principals. ~~The principals developed a regional Title I plan and, with the help of the consultants, have all staff working together to implement~~ it. Title I staff worked with regular classroom teachers on new strategies, and Kenton staff agreed to use Title I benchmarks and assessments for all students.

Kenton's curriculum emphasizes interactive writing and vocabulary development, and uses innovative mathematics materials ~~such as *Math Their Way, Every Day Counts, and Visual Math*~~. Teachers use ~~cooperative learning~~ and peer tutoring to help students grow toward proficient and advanced levels, and students are encouraged to analyze, evaluate, and interpret information. Kenton teachers regularly meet with small groups of students outside of class to give extra help in mathematics, reading, or writing. Teachers also train the school's many volunteers to support the benchmarks while working with students. Assessments indicate some success in the early years of this effort to improve instruction. The percentage of third-graders scoring in the advanced category in mathematics increased from 15 percent to 35 percent.

The work of improving achievement must be done at the State and local level, and, most fundamentally, within individual schools. State and local educational agencies can ~~strengthen~~ the impact of Federal resources by choosing to use them in a ~~coordinated~~, concentrated way. Thus, the National Science Foundation and the Department of Education will support State and local education agencies in the ~~coordinated~~ use of all types of Federal, State and local funds toward improving mathematics achievement, offer examples of effective coordination in the use of such funds, and provide incentives to initiate ~~change at the State and local levels.~~

- The Department of Education will actively encourage and support State and local educational agencies in the coherent use of all types of Federal funds in their efforts to meet the high content and performance standards for mathematics in grades 5-8 that they have established under Goals 2000 and Title I, providing ~~information and technical assistance and~~ opportunities to pool resources originating in the Department, as appropriate.

- The National Science Foundation will support development and implementation of State and local strategies for improving mathematics education in grades 5-8 and, through its competitive awards, will provide additional incentives for effective, targeted use of Title I and Eisenhower funds. In particular, the Foundation will provide competitive planning grants to jump-start intensive, coherent efforts to upgrade mathematics instruction that use Federal, State, and local funds to sustain long-term improvements.

- School and district implementation of improvement strategies are particularly important for long-term change. The principal target for the agencies' cooperative activities will be middle schools with schoolwide Title I programs and districts with many such schools. This focus permits large numbers of disadvantaged students to benefit from the enhanced impact of Federal funding. It leverages effectively the funds awarded competitively by the Foundation to schools and districts with the large resource base of the Department's Title I program. The agencies will work with principals and superintendents to address the importance of providing their students with high-quality mathematics instruction aimed at challenging national standards; to help make more concrete their understanding of what such a program of instruction means for students and teachers; and to consider mechanisms to implement such instruction in their schools.

Texas Statewide Systemic Initiative

Early in its history, the Texas Statewide Systemic Initiative (SSI) secured the contract to operate the U.S. Department of Education's Comprehensive Assistance Center for Elementary and Secondary Act Programs in Texas. This brought into one unit the state's leadership both in science and mathematics education and in Title I technical assistance. In the past two years, the SSI has provided incentive grants and technical support in integrating their Title I, Eisenhower, and professional development activities in mathematics and science to more than 100 Title I schools serving more than 100,000 Title I students. In July, 1995, the SSI held an intensive summer institute designed to support Title I schools in (1) reconceptualizing the use of entitlement funds, (2) adopting standards-compatible mathematics curricula, and (3) adopting effective schoolwide program models. As a result of the SSI/Title I collaboration, state mathematics and science leaders are now active members of school support teams engaged in mentoring over 700 Texas Title I schools. At the same time, increasing numbers of teachers in high poverty/high minority schools are being trained as SSI mathematics, science, and technology specialists.
→ Achievement data. Internet?

- ~~As a first step,~~ the Department and NSF ~~The two agencies~~ will convene a national conference of State and local leaders of Eisenhower, Title I, Goals 2000, and State, urban and rural systemic initiatives, and other key actors to help participants maximize the impact of federal ~~funding~~ resources in improving mathematics education in grades 5-8.

- The two agencies will undertake a coordinated set of research and informational activities around mathematics in grades 5-8. These activities ~~will~~ include ~~release~~ of a TIMSS Toolkit that contains specific tools for professional development, curriculum analysis, and achievement benchmarking; readministering TIMSS in the spring of 1999 to get updated information on our international standing; a program of research informing ~~evolution~~ of the eighth grade national test over time; and a sustained agenda of basic research in teaching and learning of mathematics.

TIMSS Resource Kit

The release of results from the Third International Mathematics and Science Study (TIMSS) has generated a strong interest among policy makers to use TIMSS as a benchmark to compare their systems to those of other countries. The Department of Education has supported development of tools (~~expected completion: Fall, 1997~~) to assist officials in answering the question: How do mathematics and science achievement, teaching, curriculum, and assessment frameworks in my state or district compare to other countries? The Resource Kit contains four modules; the first provides an overview of TIMSS while the other three focus on the critical issues of achievement, curriculum and teaching. The Overview Module describes TIMSS and what can be learned from it about American education. The Achievement Module examines what was expected of students on TIMSS and how to understand U.S. results. It contains an analysis of student performance by content ~~domain~~ area, shows how students performed on representative items, and compares student performance in the U.S. and other nations. The Curriculum Analysis Module considers how to evaluate curriculum and instructional materials in relation to state, local and voluntary national standards as well as to the TIMSS framework. It contains a guidebook with four tested procedures for evaluating curriculum and instructional materials, including that used in TIMSS. The Teaching Module examines how teaching differs in the U.S., Japan and Germany and offers ways for teachers to reflect on their own classroom practices. It contains a 75-minute video of eighth grade mathematics lessons filmed in conjunction with the TIMSS study along with a moderator's guide for using the video in professional development activities.

This [will the Department and NSF hold a conference to ~~introduce~~ familiarize [state/local math/science educators?] with the kit and are conducting a broader dissemination nationally, [something to this effect] ~~to explain the resources~~ so curriculum experts, teachers/others can learn from and benefit from the TIMSS findings.
Internet?

- The Department and the Foundation will work with other agencies to enhance the impact of Federal resources by upgrading their activities to reinforce a standards-based approach for mathematics in grades 5-8.

Each of the specific items above will be aimed at mathematics in grades 5-8, reflecting the urgent need to raise achievement at this stage of the educational process. However, the activities described above can also serve as models for more effective approaches to educational change in the broader arena of mathematics and science education. The working group strongly endorses the idea of future efforts that would encompass all of K-12 mathematics and science education.

Mathematics Education and the Department of Defense

Two agencies within the Department of Defense (DoD) represent contrasting approaches to introducing rigorous national standards in their education activities.

Unique among the agencies are the DoD Dependents Schools (DoDDS), which ~~run as essentially autonomous school systems~~ operate overseas and on military bases in the U.S. They certify teachers and develop leader-teachers, tutors, and mentors who, like the DoDDS math curriculum used world-wide (K-8 and 9-12), embrace the NCTM standards.

The National Security Agency established a Mathematics Education Partnership Program (MEPP) in 1991. MEPP provides over a thousand talks per year to schools and colleges through its Speakers Bureau. It donates excess computers to classrooms, sponsors seminars and inservice teacher training, and conducts extended summer workshops for teachers at all levels (for a description, see www.nsa.gov.8080/programs/mepp). These MEPP activities, including projects such as collaboration with the University Corporation for Atmospheric Research's Project SkyMath, are all informed by the NCTM Standards, which are an explicit subject of study and reference at MEPP's Summer Institutes for Teachers.

Equipping teachers in grades 5-8 with the skills and knowledge to teach challenging mathematics content in effective ways, with high expectations for their students

In grades 5-8, students should begin to move from mastering arithmetic to using arithmetic in complex problems and learning the foundations of geometry, algebra, probability, and statistics. Teachers must know substantial mathematics and have strong pedagogical skills if they are to be effective in helping their students make this transition and meet high standards. Practices in teacher education, licensure and certification and in-service teacher enhancement do not always reflect these needs.

Quantitative Literacy Program for Alabama K-12 Teachers

The Quantitative Literacy Program for Alabama K-12 Teachers, a project administered by the University of Alabama and supported by the Eisenhower Professional Development Program, assists elementary and secondary teachers in implementing the probability and statistics goals for grades K-12 as outlined in the ~~National Council of Teachers of Mathematics~~ standards. The program's workshops teach quantitative concepts in the context of solving meaningful problems, with content taught in reference to teaching strategies that participants use when they return to their classrooms. The program includes a pre-workshop orientation, an intensive one-week training workshop, and two follow-up sessions. In the follow-up sessions, teachers describe how they planned, taught, and assessed their own Quantitative Literacy units. They also present examples of their students' projects. The project is currently operating in 14 of the 67 counties of the State.

Over the next ten years, approximately 2 million new teachers will enter the workforce. It is essential that these future teachers receive adequate preparation in mathematics content and pedagogy and in the use of contemporary technological tools before they enter the classroom. And many of the approximately 320,000 teachers who are already teaching mathematics in grades 5-8 would benefit from upgrading their math content knowledge and teaching skills in order to better help the Nation's students achieve high levels of excellence in mathematics.

Because of these critical needs, this action strategy addresses both the professional development of teachers who are already in the classroom and the preparation of new teachers. In order to assist current teachers, the strategy promotes sustained and intensive professional development activities that are based on mastery of mathematical content and tied to high-quality instructional materials and technology. Teacher preparation activities will aim at preparing future teachers of grades 5-8 to teach effectively challenging mathematics content geared to national standards of excellence, such as the NCTM standards.

PRIME in Pittsburgh

The Pittsburgh Reform in Mathematics (PRIME) project supports teachers in the classroom implementation of standards-based mathematics instruction and assessment in grades K-12 through the use of exemplary materials (e.g., *Everyday Mathematics* in grades K-5 and *Connected Mathematics* in grades 6-8). PRIME provides teachers with a broad knowledge base in both the mathematics content and the successful mathematics pedagogy needed to implement the new materials successfully.

Funded under National Science Foundation guidelines as a project of *Local Systemic Change through Teacher Enhancement in Mathematics*, PRIME provides all 924 Pittsburgh Public School teachers of mathematics with a range of experiences that include summer workshops; release-day professional development workshops; and individualized, in-class support provided by demonstration teachers within each school. Teachers of grades 6-12 receive 234 hours of professional development, and teachers of grades K-5 receive 102-132 hours. By equipping *all* Pittsburgh mathematics teachers with the knowledge, skills, and support necessary for using exemplary materials and assessment, PRIME will ensure that *all* students experience a coherent mathematics program that is expected to yield high achievement at *all* levels.

This four-year project, funded for over $ 3 million, is a model for its ability to leverage an additional $ 6.7 million in cost-sharing from district funds and commitments from Eisenhower and other Federal dollars.

The coordinated efforts of the Department of Education and the National Science Foundation described above should stimulate greater use of Title I and Eisenhower resources for high-quality professional development for grade 5-8 teachers of mathematics. However, the increased demand for high-quality professional development could, without action now, exceed the capacity of those individuals and organizations currently supplying it. Thus, an essential component of fully equipping teachers will be ensuring the presence of a sufficient cadre of individuals and institutions skilled in providing professional development. ~~The two agencies~~ will work with the mathematics communities, institutions of higher education, and other Federal agencies to ~~help ensure the capacity to respond effectively, particularly by~~ supporting the development of exemplary materials and by providing training opportunities for those who will become leaders in teacher professional development and teacher preparation.

To address professional development needs of current teachers, the National Science Foundation and the Department of Education will:

- Support sustained, intensive, high-quality professional development of teachers of mathematics in grades 5-8 as the cornerstone of their cooperative efforts to enhance the impact of Federal resources. These efforts will emphasize professional development for all teachers of mathematics in grades 5-8 in schools or districts, focusing on middle schools with Title I schoolwide programs and districts with many such schools. This focus will permit professional development for a significant fraction of the approximately 320,000 teachers of mathematics in grades 5-8, with particular attention to those who teach the largest numbers of disadvantaged students. (#) See next page

- Initiate a short-term effort to strengthen the pool of talented, committed individuals able to provide exemplary professional development for classroom teachers. The agencies will support projects that will provide intensive training ~~experiences~~ for those who will lead future ~~teacher training~~ efforts.

- Support the creation of materials for professional development of teachers of mathematics in grades 5-8 that are grounded in the NCTM standards, tied to newly emerging educational materials and technologies, and assist teachers to link mathematics to real-world skills and applications.

- Support opportunities for teachers to help one another with content knowledge and teaching skills through activities such as ~~dissemination of information about effective forms of professional development;~~ encouraging the development of master teachers (including those recognized through Presidential Awards for Excellence in Mathematics and Science Teaching or National Board for Professional Teaching Standards Certification), ~~mathematics specialists,~~ and teacher networks.

To promote improved preparation of future mathematics teachers for grades 5-8, the Department of Education and the National Science Foundation will:

- Prepare and disseminate widely a study on State licensure requirements, focusing particularly on requirements for middle school teachers of mathematics, comparisons to other nations, and the impact of licensure requirements on the knowledge of mathematical concepts that teachers bring to their work in the classroom.

Teacher Preparation in Louisiana

What began as a movement to change the way mathematics is taught in grades K-8 in the Louisiana State Systemic Initiative has grown into a program that addresses the way in which teachers are taught. The NSF-funded Louisiana Collaborative for Excellence in the Preparation of Teachers is resulting in a set of future teachers who will transform teaching practice in the state.

In the first three years of the program, over 100 faculty (both mathematics faculty and education faculty) on 15 campuses across the state have been involved in the project, 69 courses for future teachers have been revamped, and approximately 20,000 students have been affected.

The central principal is to ~~model~~ demonstrate in the education of future teachers the new methods of teaching mathematics that they will be expected to implement in the classroom, for example, working in small groups on challenging problems and using technology resources such as calculators or the Internet. One student at Northeast Louisiana University who is preparing to teach third grade said he will never take another course that does not similarly challenge him to think things through and discuss his ideas with others.

- Challenge the Nation's colleges and universities to step up to the needs for preparing a new generation of teachers for the 21st century by encouraging and supporting the development of teacher preparation approaches that:
  - more tightly link college departments of mathematics and schools of education;
  - include mathematics courses focusing on the deep concepts in mathematics related to the mathematical content that future teachers of mathematics in grades 5-8 will teach;
  - demonstrate effective classroom practices; and
  - involve local K-12 schools in the design of teacher preparation requirements.
- Support the development of materials for preparation of K-8 mathematics teachers that are grounded in the NCTM standards and tied to newly emerging instructional materials and educational technologies.

New Initiatives in Teacher Preparation

President Clinton has proposed a $350 million initiative to attract talented people of all backgrounds into teaching at low-income schools across the U.S., and to dramatically improve the quality of training and preparation given to our future teachers, with an emphasis on mathematics and reading. Under the initiative, new scholarships would help bring nearly 35,000 outstanding new teachers into high-poverty schools in urban and rural areas over the next five years. These scholarships could cover costs of tuition, room, board, and other teacher preparation expenses -- and could help fund additional preparation during the first two years of teaching.

The initiative will also provide competitive five-year grants to 10-15 national lighthouse models of excellence -- institutions of higher education that operate the highest quality teacher education programs. Each institution receiving a lighthouse grant will use a majority of these resources to help several other institutions of higher education improve their teacher preparation programs, helping to improve the preparation of future teachers at an estimated 150 institutions of higher education across the nation.

Internet?

Improving Teaching Through Distance Learning Internet?

The Department of Education's Star Schools Program ~~provides~~ supports quality, cost-effective instruction through distance education technologies to more than 1,640,000 learners annually in 50 states and U.S. territories. Although the program began with small rural schools in 1988, it is now equally valuable to schools in large urban areas.

The *Star Schools: The Next Generation* project of Oklahoma State University and Northern Arizona University delivers the "Getting Ready for Algebra" program, which provides simultaneous student instruction and teacher training to middle school students and teachers. Its units are student-centered and activity-oriented and emphasize learning by discovery. They focus on the big ideas common to arithmetic and algebra. Similarly, the United Star Distance Learning Consortium project led by Education Service Center--Region 20 in San Antonio, Texas, offers the *Algebra and Geometry Applications for Teachers* program, inservice training that models worthwhile mathematical tasks and helps teachers improve their ability to develop these tasks. The focus of the project is on mathematical topics that illustrate connections to real-life problems and exciting mathematics.

Implementing high-quality, standards-based curricula and instructional materials, including curricula that use educational technologies, in grade 5-8 mathematics classrooms

The TIMSS results showed that the content of curricula and instructional materials used in US classrooms in the middle school years in 1995 differed from those in high performing countries in significant ways. The content taught in most U.S. eighth-grade mathematics classrooms would be found in the seventh grade in high-performing nations. Our low expectations for student performance are also shown by the fact that only about 25 percent of U.S. eighth grade students are enrolled in algebra courses, while in high-performing nations virtually all students have the opportunity to master the foundations of algebra and geometry by the end of eighth grade.

In addition, TIMSS noted that middle school mathematics materials covered more topics and were less focused in the U.S. than in leading countries. For example, typical American eighth grade mathematics textbooks in 1995 covered as many as 35 major topics compared to as few as 10 such topics in Japanese textbooks, leaving little time for teaching for student mastery and depth of understanding.

In a nation as large and diverse as ours, it is not surprising that ~~there is a very large number of different text books and other instructional materials available to schools or that~~ textbooks tend to include a wide variety of topics in order to appeal to the greatest number of teachers and schools. However, ~~alternatives to these widely used traditional materials are now available.~~ New, comprehensive mathematics instructional materials, linked with high standards for mathematical content and pedagogy and aligned with the NCTM standards, are now emerging from development and reaching the market. These newer materials provide a range of different approaches to classroom instruction, generally focusing on 15 or fewer topics per year.

Everyday Mathematics

The University of Chicago's *Everyday Mathematics* materials for K-6 classrooms are designed to promote the success of all students. They are based on research showing that students can learn much more mathematics than typical [traditional] curricula contained. Students explore mathematics concepts, experiment with ways to solve everyday problems, learn essential skills, and perform mental mathematics.

The materials are being used in over 50,000 classrooms nationwide, affecting over one million students. Extensive evaluation with standardized tests shows that students using these materials outperform their peers using [traditional] typical/standard materials. For example, a recent study, based on items developed for an international comparison of elementary school students in 1990, showed that students in today's *Everyday Mathematics* classes score significantly higher than did the U.S. students in the 1990 study and performed as well as the 1990 students from Japan and Taiwan on a majority of the questions.

Many schools supplement their comprehensive instructional materials -- incorporating, for example, the use of instructional technologies -- in ways that permit teachers to tailor instruction to particular classrooms. Supplementary materials can facilitate a transition to the newly emerging comprehensive materials and help take advantage of new and emerging learning technologies. They can be particularly important in grades 5-8 where students develop the conceptual foundations for the study of more advanced mathematics.

To assist schools, districts, and States in choosing and implementing effective curricula and instructional materials for mathematics in grades 5-8, the National Science Foundation and the Department of Education will:

- Make upgrading of mathematics instruction easier, particularly for middle schools with Title I school-wide programs, through encouragement and support for coordinated planning and action aimed at:
  - purchase of appropriate new instructional materials;
  - necessary professional development aimed at their implementation; and
  - employment of highly skilled mathematics specialists who are prepared to teach the new materials and guide others in their implementation .

- Develop and disseminate guides to help schools and school districts select instructional materials and software most appropriate for their local needs and undertake the necessary steps to effective implementation. This effort will include reviews of instructional materials and software designated by experts as promising or exemplary.

- Provide technical assistance for schools and school districts in putting updated mathematics instructional materials to work in the classroom. This effort will link NSF-supported implementation sites dedicated to mathematics materials for grades 5-8 with broader technical assistance providers, including the Department's Eisenhower Regional Consortia and National Clearinghouse.

- Continue to support development of supplementary materials, with new priority for efforts aimed at mathematics in grades 5-8, to assist schools and districts in making the transition to standards-based comprehensive materials.

Eisenhower Regional Consortia for Science and Mathematics Education

The mission of the ten regional consortia is to provide a field-based ~~national infrastructure for systemic~~ improvement of science and mathematics education. Projects provide information on curriculum, assessment, and teaching practice; conduct workshops and training; and serve as advisors to the field.

One example of the work of the consortia is the 1996 publication by the WestED consortium of Tales From the Electronic Frontier. This is a collection of ten teachers' narratives regarding their use of the Internet to enhance science and mathematics instruction and create opportunities for their own professional growth. The accounts describe using this resource for project-based learning, for making abstract scientific principles more concrete, and for promoting deeper understanding. Each story provides information on related resources and programs, and concludes with a section of questions and issues to stimulate further thought and discussion.

"Hoop Happenings" was the tale of a math communication project between students at the Drexel Hill School in Philadelphia, Pennsylvania, and senior education majors at Iowa State University. During their teaching methods class for elementary mathematics, each ~~student~~ is paired with a group of students at an elementary school with whom she interacts (via e-mail) over a math problem she defines each week. The interactive discussion provides the education majors with insight into children's thinking; for the children the project strengthens their abilities to solve problems and to discuss their problem solving approaches.

Tales can be found on WestED's WWW site at http://www.wested.org/tales.

- Seed research and development of powerful models for integrating technology into classroom practice and informal learning environments. This will include support for critical expansion and evaluation efforts preceding commercialization of these models. K-8 mathematics will be a high priority in the near term.

Beyond the Department of Education and NSF, while several other Federal agencies have long worked to support state / local education improvement efforts, as described in Appendix ——.

~~Few other agencies have,~~ however, in the past, few have contributed to the development of standards-based instructional materials in mathematics and science. This is changing, and ~~the working group feels~~ there are significant contributions that other agencies can make in this area, consistent with their primary missions. The development of supplementary materials ~~with mission-oriented~~ and the delivery of such materials through technology are key potential contributions.

?

- Agencies will work in cooperation with NASA and NCTM to develop standards-based materials along the lines of NASA's "Mission Mathematics." These materials illustrate the use of mathematics in real world examples related to the agency mission.

engaging,

NASA's Mission Mathematics

The recent production of "Mission Mathematics" by NASA demonstrates how an agency can base its educational work on national standards. These three volumes of problems and activities are the descendants of NASA's first mathematics curriculum supplement, "Space Mathematics: A Resource for Teachers," published in 1972. That popular title was updated repeatedly over the years. "Mission Mathematics," however, is totally revamped to accord with national standards. Indeed, the subtitle is now "Linking Aerospace and the NCTM Standards." The three volumes are divided into K-6, 5-8, and 9-12 to accord with the Standards, and the contents of each are keyed not only to NCTM's curriculum standards, but also to those for teaching and for student assessment. Examples of activities include calculating orbits, collecting and analyzing specimens, planning for spaceflight needs, etc.

This linking to standards was accomplished by making "Mission Mathematics" a joint project of NASA and NCTM. Writing teams included teachers, supervisor, and university professors working in consultation with NASA representatives. Their drafts were field-tested by classroom teachers and reviewed by NCTM's Educational materials Committee. The results are attractive and modestly priced, with publicity, marketing, and distribution through NCTM's established network.

Internet address ?

- The Department of Education is chairing a Federal Government-wide working group that has already begun to promote and develop -- and make it easier for teachers and others to find -- high-quality educational materials, including instructional units and related materials, for use on the Internet. (A) The first priority of this group will be to identify materials that support teaching of challenging mathematics.

what is status of this?

- The Departments of Defense and Education and the National Science Foundation are leading an interagency review of Federal activities related to research in learning technologies.

purpose?

Each of these efforts could make new types of materials and capabilities possible in the future. Activities that enable students to achieve to high standards play an important role in all these Federal activities.

The Math Forum

on Internet site

The Math Forum is a virtual center and Internet community for mathematics education. It provides teachers with high-quality classroom mathematics materials and expertise, with a special emphasis on new educational strategies. It provides structured access for teachers to an expansive, but well-organized and indexed array of on-line resources that enable responses to mathematics questions coming directly from the classroom. The Forum guides and supports teachers as they become more proficient in helping their students attain deeper and more powerful mathematical abilities. It also provides students with engaging materials to explore opportunities for interactive conversations and mathematical projects. It provides parents with a fuller understanding of the nature of ~~the NCTM Standards~~ and ~~facilitates their inclusion in a broad, national community of informed partners who insist that high-quality mathematics instruction should be available to all students.~~ The Internet community supporting this effort includes teachers, college faculty, research mathematicians, mathematics education researchers, education administrators, and policy leaders. The Internet location for the Math Forum is: forum.swarthmore.edu.

and helps them to ensure that high quality math instruction is available to their children

challenging math standards

(A) The purpose of this group is to take the rich informational resources of organizations like Census Bureau NOAA and the U.S. Geological survey, and make them easier for teachers / others to find and use.

Building public understanding of ~~what~~ challenging mathematics ~~looks like~~ in grades 5-8, and gaining public support for raising student achievement toward high standards.

~~Our vision is that~~ all American students should leave eighth grade prepared to pursue the higher-level mathematics and science courses that are the gateway to college, good citizenship, productive employment, and lifelong learning. In realizing this vision, it is ~~also~~ essential that educators, parents, and students themselves understand what high standards in mathematics look like and why they are important. This outcome requires activities and information that reinforce the classroom experience and convey the importance of mathematics achievement. Such activities should ~~might~~ draw on the support of parents, the professional community of mathematicians, scientists, and engineers, business, and the broader public.

This section of the action strategy includes two complementary aspects. ~~pieces~~. The first consists of efforts to make standards fully and clearly understood. If you don't know where you are trying to go, it is hard to get there. This is true if you are driving a car, building a house, or running a small business. To succeed, you need a vision of ~~what~~ success ~~looks like~~ so you know how to work to achieve it. The same is true in education. If parents and students and teachers don't know where they should be headed -- what they agree students should know and be able to do -- it is hard to pull together to get there. Schools must have a clear sense of what they are doing and be able to communicate effectively with parents as well as work to invite active parental participation.

The second aspect ~~piece~~ builds on the first through partnerships that bring together the many groups that can contribute to ~~the effort of~~ helping students achieve high standards in mathematics. These partnerships will elevate the importance of mathematics achievement and provide clear avenues for interested members of the mathematics, science, business and education communities, as well as parents and interested citizens, to contribute to efforts to raise mathematics achievement.

The Federal government will foster the partnerships by promoting a national dialogue on improving mathematics, acting as a clearinghouse for information and proven approaches to action, working with partners to develop exemplary materials that can be used in their State and local efforts, and mobilizing staff and resources to support local partnership efforts. Effective partnerships must build upon and complement what goes on in the schools, and teachers and school administrators will be vital participants, either formally or informally.

Saturday Schools Provide Tutoring Boost

The George B. Thomas Sr. Learning Academy Inc. (known as Saturday School) has provided free tutoring and mentoring to minority students in Montgomery County (MD) for nearly 11 years. Spearheaded by members of the Mu Nu chapter of the Omega Psi Phi fraternity, the program began in a public housing community's day-care center, but is now located at Sherwood High School (Olney, MD) and Springbrook High School (Silver Spring, MD).

About 180 students and 100 tutors--engineers, mathematicians and others (including high school students fulfilling Maryland's community service graduation requirement)--are registered at the centers; there is often a waiting list of pupils because there aren't enough tutors. Saturday School views itself as a partner with the students' schools; principals refer students to the program and teachers advise tutors on where students need help. Montgomery County Public Schools contributes classrooms, supplies, and training for tutors and parents. The sessions last 2 or more hours; tutors work with students on a wide range of mathematical topics and help students prepare for the Scholastic Assessment Test. Parental participation is required; about one-fifth of the parents tutor.

In order to support these strategies, the Department of Education and the National Science Foundation will:

- ~~Convene~~ Sponsor a national convocation on middle school mathematics to initiate a continuing dialogue on:
  - what we should expect our students to be able to achieve in mathematics by eighth grade and beyond;
  - exemplary practices in professional development, curricula, instructional materials, and technologies; and
  - opportunities for parental involvement and community support to help students meet high expectations.

- Seed the continuing national dialogue by providing a wide variety of sample items illustrating the level of standards, examples of student work, and information on curricula, instructional methods and technologies that support high standards.

- Make widely available materials on how teachers and other educators can use assessment in planning instructional improvement strategies. These materials will include information on how best to use results from the voluntary national mathematics test in efforts to interpret them to students and parents, place them in appropriate context, and improve mathematics instruction.

- Create an easy-to-use mathematics Web site providing information on ~~the~~ national standards; standards-based instructional units for teachers; information on the national test, including sample problems and examples of student solutions; and all the other materials developed or identified as part of this action strategy.

Partnership activities would be focused at State and local levels, with the Federal Government fostering their development, largely by drawing on the strengths of national organizations that would then work through their State and local affiliates. The Department and the Foundation will:

- Connect national organizations ~~with interests~~ interested in helping to raise levels of achievement in mathematics and science (for example, professional societies of mathematicians, scientists, and engineers) with State, local and community-based organizations having similar purposes, ~~particularly~~ including those already linked to on-going agency activities.

- Arrange for the development and dissemination of a weekly series of high-quality, engaging mathematical exercises for students in grades 5-8 that can be used as a common core activity in State and local partnership efforts. Exercises would appear in a recognizable format in many different places. ~~Each would be introduced by a different celebrity figure who would provide a motivation for the exercise.~~ Guides for use of the exercises ~~within the partnership efforts~~ and information on how to find hints, help and related materials would also be provided.

The partnership activities themselves might take many forms, with each dictated by the needs of the State or locality in which they are active. See Appendix 7 for some examples.

Conclusion

The interagency cooperation stimulated by the effort to produce this action strategy should have a lasting impact on the effectiveness of Federal funds in support of improving achievement in mathematics and science education. In addition to bringing the two agencies with the most ~~influential~~ programming in this area together, it spurred further contact with other potential Federal partners, both those that have a tradition of strong presence in mathematics and science education and those who are new to such efforts.

The effort has been particularly timely in view of the growing interest among mathematicians, scientists and engineers in helping K-12 schools to improve the performance of their students in mathematics and science. The Department of Education, with its links to State and local education agencies and community groups, and the Federal science and technology agencies, with their ties to mathematicians, scientists, and engineers and their national professional organizations, can help make important connections to spur the development of effective partnerships.

But the action strategy is only the beginning of the effort. The interagency cooperation must continue and move to the substantive agenda of implementing the strategy. The Department of Education and the National Science Foundation are committed to meeting the challenge of continuing cooperation so that their programs work in concert. They will enable the development of appropriate mechanisms to keep other agencies and the professional scientists, mathematicians and engineers with whom they work actively involved in improving achievement in mathematics and science education. Perhaps most importantly, they will keep the goal of raising the achievement of all American students in mathematics and science at the forefront of their attention.

A New Federal Education Partnership Program at the Department of Transportation

Magnetic levitation trains, highways that provide constant updates on traffic conditions ahead, tollbooths subtracting tolls automatically from encoded stickers on cars, and geopositioning satellites that enable travelers to determine where they are anywhere on earth at any time: these are transportation "dreams" well on their way to becoming realities, dreams that can lead to highly-paid jobs for those with the appropriate skills. Too many students, ill-prepared for such jobs, must leave the dreaming to others.

Through the new Garrett A. Morgan Technology and Transportation Futures Program, the Department of Transportation (DOT) will stimulate public-private partnerships to help students and their families understand the importance of mathematics and science for future careers and to make math and science relevant and exciting for students in and outside the classroom. Such partnerships will encompass interagency collaboration, government-industry cooperation and community involvement. Sample activities include

- With the Department of Education and its business and community partners, DOT will encourage the transportation community to participate in the America Goes Back to School program, to build support for mathematics, science, and technology achievement.
- Help to ~~change public perceptions about~~ enhance public understanding of the importance of studying mathematics and science by ~~creating~~ awareness of the wide variety of exciting jobs in transportation that require those skills.
- Build upon DOT's 300+ adopted schools to provide mentors, tutors, career information, and other forms of support for math literacy;
- Encourage staff to support student mathematics achievement in their local communities, by supporting summer, after-school and weekend activities that help students learn or by serving as "telementors," helping students with homework over the Internet.
- Bring together private sector sponsorships and expertise and nationally recognized teachers to develop exciting materials with a transportation focus for teaching mathematics, science, and technology.

APPENDIX 6

FEDERAL AGENCY ACTIVITIES THAT SUPPORT K-12 MATHEMATICS EDUCATION

The Department of Education (ED) and the National Science Foundation (NSF) have principal responsibility, among the Federal agencies for K-12 education and for science and mathematics, respectively. However, a dozen other departments and agencies sponsor activities that relate to, and could promote, standards-based education that improves students' mathematics and science learning and overall academic performance.

Executive Order 12821 of November 16, 1992, instructs those Federal departments and agencies with scientific missions, employees, or laboratories to "assist in the mathematics and science education of our Nation's students, teachers, parents, and the public by establishing programs at their agency to provide for training elementary and secondary school teachers to improve their knowledge of mathematics and science." Many agencies had such programs in place even before this Order was issued. The Eisenhower National Clearinghouse catalogues current programs in its "Guidebook of Federal Resources for K-12 Mathematics and Science" (see www.enc.org/reform/guidebk).

The Working Group met with designated agency representatives from 11 agencies (the Departments of Agriculture, Commerce, Defense, Energy, Interior, Transportation, and Veterans Affairs, EPA, NASA, NIH, and the Smithsonian) to discuss relevant programs and activities sponsored by their agencies. In general, the agencies focus far more on science than mathematics, and commit modest resources to improving K-12 education. Most offer staff and facilities, often on a volunteer basis, to support local schools and teachers. And all have developed and are sharing supplementary instructional materials on their Web sites.

that leverage the projects, ~~[illegible]~~ resources, and facilities of the agencies' core missions

Some examples of works in progress can be cited (for more extended, specific examples, see sidebars in the report). NASA has completely revamped its educational programs to reflect the development of the National Council of Teachers of Mathematics' (NCTM) standards for mathematics and the more recent standards for science developed through the National Research Council (NRC). They have developed supplementary instructional materials in conjunction with NCTM that provide sample problems based on space-related examples. The Department of Defense schools have redesigned curriculum and teacher professional development to incorporate standards-based approaches. Other parts of DOD have outreach programs that stress the importance of mathematics to national security.

The Department of Energy, NIH, and USDA are conducting an inventory of their activities, identifying their impacts and exploring opportunities to expand. Among ideas that warrant further consideration are virtual teacher training based at DOE's Lawrence Berkeley Lab in partnership with the University of California system; USDA's 4-H Clubs as an after-school, weekend, and summer vehicle for promoting math skills; EPA's use of ~~the~~ its intensive training ~~of trainer~~ model for teacher development in environmental education; and NIH's middle-school curriculum supplements, to be developed among three Institutes and the NRC.

The Department of Transportation is about to embark on an extensive effort to improve K-12 education in mathematics and science, including participation of staff as volunteers. The Smithsonian Institution has both formal and informal ties into schools. Other agencies are ready to play an appropriate role in improving K-12 education, and are looking for guidance on how best to proceed.

We must learn more quickly and more systematically about approaches and innovations that support students and teachers of mathematics both in and outside of schools, taking into account high standards like those of the NCTM and the NRC to reference, guide, coordinate, and set priorities among the many educational programs managed by Federal agencies. Continued coordination among all of the agencies involved in the Working Group's deliberations, and others that might be brought in over time, can set the stage for more effective use of Federal resources. The Department of Education and the National Science Foundation will work to ensure such coordination in the future.

MIKE — You or Bill should consider going? Rec'd 9/24/97 BR

Erwin

Bruce Reed — you need to be aware of this. The topic will be discussed at the PCAST meeting on 9/29 (mon). I'd be pleased for you or an associate to attend the discussion (at the WH Conf. Center). (Call Angela Philips-Diaz 6-6101 for info.) Jack 9/24

EXECUTIVE OFFICE OF THE PRESIDENT
PRESIDENT'S COMMITTEE OF ADVISORS ON SCIENCE AND TECHNOLOGY
WASHINGTON, D.C. 20502

September 23, 1997

The Honorable Richard W. Riley
Secretary
United States Department of Education
400 Maryland Avenue, S.W.
Room 4181
Washington, DC 20202

Dear Dick:

The President's Committee of Advisors on Science and Technology (PCAST) Education Panel, which I chair, had a meeting on September 2, 1997. At that time we discussed a number of issues preparatory to our PCAST meeting at the end of the month. 9/29 AM. (10:10 – 10:55 AM) WH Conference Center The draft ED - NSF Working Group Report on Math and Science Education, in response to the President's March 1997 directive, had been received by the panel members and we found it of great interest. Clearly, this is a constructive, farsighted initiative. The panel had several concerns that could usefully be addressed in further work on the initiative.

1. Concern about a decoupling of science and mathematics education in the draft. While the President's interest in a national 8th grade test in mathematics provided much of the impetus for the working group and the report, PCAST panel members were concerned about the absence of any substantive comments about science education in the report. The intimate relationship of science and mathematics education is acknowledged in the name of the group and the charge to it but not yet reflected in the draft.

2. Concern about the lack of a clearly articulated role for each agency and for a clear signal of areas of overlap in which cooperation might occur. Both the Department of Education and the NSF have signaled their support for high standards for all students and their concern about improving the achievement levels for poor and minority students. Yet there is little clear language about the mechanisms for cooperation across programs that will enable these goals to be reached, such as the articulation between NSF's Urban Systemic Initiatives and ED's Title I programs. In fact, most of the federal money available for mathematics improvement is in Title I, but no goals are stated that would provide direction and assistance toward standards-based efforts.

3. Concern about the separateness of the ED and NSF efforts conveyed in the document. There is little in the document to suggest cooperation (past, present or future) across the two agencies in general. This reads as though efforts are on parallel tracks that do not converge. We urge whatever actions are necessary from the leadership of the agencies to improve working interactions and foster cooperative efforts at all levels.

4. Concern about problems associated with assessment. Regardless of the outcome of the current debates on a mathematics test, we need to invest in R&D related to assessment technologies. We need to learn how to develop tests aligned to standards. We also need to develop comprehensive frameworks that link standards, assessment, professional development, teacher preparation, pedagogy, and appropriate incorporation of technology at national and local levels. In the same way that the PCAST Panel on Technology in Education emphasized the elements that must surround hardware and software, frameworks must be developed that focus on those issues that surround assessment. This vision is not yet present in the document.

This need to develop a comprehensive vision also suggests a place for joint initiative in the area of teacher professional development. Aligning existing resources and efforts, with each agency involving its closest constituencies around a common vision, has the potential for big payoff. There is the opportunity for a shared focus on teacher preparation and continuing education and re-invention of the role of the university in this regard.

Perhaps by working together, ED and NSF can help communicate to the public and the Congress the new realities of the workplace, how much more our children will have to know and be able to do for the U.S. to remain competitive in a global marketplace. Perhaps together we can communicate that education and training are top-priority national issues, and make clear the need for high standards for all in mathematics and science education.

In its present form the draft report is not yet fully responsive to the President's directive. We stand ready to assist you in any way we can to develop a report that moves us toward our shared goals of enabling our children to live, work, and prosper in the 21st century.

Sincerely,

David Hamburg/yc

David Hamburg

cc: Neal Lane
Dr. John H. Gibbons
PCAST Education Panel Members

Judy_Wurtzel @ ed.gov
09/21/97 09:32:00 PM

Record Type: Record

To: Michael Cohen, William R. Kincaid

cc:
Subject: NCTM National Convention

Bill and Mike--

The National Council of Teachers of Mathematics (NCTM) national convention this year is April 2,3 and 4th in DC. The meeting brings together 20,000 math educators (mostly teachers). They have asked me whether the President will do a keynote. The room that the keynotes are given in hold 2400.

It is a great opportunity to make a case about the national test (depending where the politics on that are in April), the importance of math education, and, if we are ready for it, the launch of "America Counts" (our working title for a problem of the week/pubic outreach effort).

Don Hastings, the convention program chair (203-261-9568), says that practically anytime the President can do it would be ok (although they have expressed some preference for April 2 after 6 or April 3 after 5 since those times would be less disruptive of the pre-scheduled program)

They would like a commitment by mid-November but I have explained to them that the WH will not be able to give any commitment until a couple of weeks before the event, if that. Can you pass this on to whomever needs to see it to get it into the mix.

(Note: I am working with Regan Burke on the Secretary's schedule, but I think it likely he will attend).

Thanks.

Judy

jsunley @ nsf.gov
08/06/97 06:35:00 PM

Record Type: Record

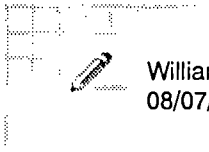
To: Daryl E. Chubin, William R. Kincaid

cc:
Subject: action strategy, with appendices

I have finally completed the final draft of the working group's action strategy. I am attaching electronic copies of the document and all appendices. I was able to drop the sidebars directly into the text. I don't know that they will print properly on your machines, so I am also going to send you hard copies by courier tomorrow. Sometimes the placement of the sidebars is awkward. That can be taken care of in final clean-up. The base document with sidebars is 19 pages. The appendices add about 15.

I think this is the time to get final agency sign-off -- I'm sure there will be edits, but we need to agree on substance -- so that we can move this to the President before the end of the month. I suggest we try to get agency clearance (and OSTP and DPC) by the end of next week. Tom, I would appreciate it if you would share copies with the other ED members of the working group. I will take care of the NSF members. I will also send copies to Mary Cassell and David Radzanowski at OMB.

There are undoubtedly things that could be made more precise in the draft. We also need for ourselves some sense of what this means in terms of the FY99 budget. I think I know, and I could outline that, if anyone would like. We also need a cover letter from Riley and Lane to the President. Daryl drafted one a month or so ago. Perhaps, Daryl, you could send us all a copy so we can think about how it might be edited.



William R. Kincaid
08/07/97 02:30:33 PM

Record Type: Record

To: William R. Kincaid/OPD/EOP

cc:
Subject: old draft transmittal letter for WG report

---------- Forwarded by William R. Kincaid/OPD/EOP on 08/07/97 02:30 PM ----------

Daryl E. Chubin
08/07/97 12:31:31 PM

Record Type: Record

To: jsunley @ nsf.gov @ inet, Thomas_corwin @ ed.gov @ inet, judy_wurtzel @ ed.gov @ inet

cc: William R. Kincaid/OPD/EOP
Subject: old draft transmittal letter for WG report

As per Judy S.'s request, below is the letter I drafted two months ago. It is at least a starting point. Hope it helps. Best, Daryl

**

June 6, 1997

The President
The White House
Washington, DC 20500

Dear Mr. President:

We are pleased to transmit the report of the interagency working group, created by the Presidential Directive of March 6, on preparing students to meet national standards of excellence in eighth grade math and improving math and science education. Staff from the Department of Education (ED) and the National Science Foundation (NSF) have devoted the past 90 days to developing an action strategy that builds on Federal programs – in partnership with professional, business, and community organizations – to invigorate teaching and learning based on widely-accepted, challenging national standards in mathematics.

The interagency group began with the four components of standards-based educational

achievement identified in your directive: improving preparation of new and veteran teachers alike, enhancing access to and implementation of curriculum and instructional materials, integrating technology into the classroom, and motivating the public to help students understand how math concepts are applied in the real world.

To respond to your directive, the interagency working group coordinated with the Domestic Policy Council and the Office of Science and Technology Policy. It reviewed ED and NSF programs, consulted with more than a dozen other federal agencies and departments to learn about their activities, met with representatives of professional mathematics and math education communities, talked with mathematics and science teachers and researchers, and took stock of the research literature on innovative practices and successful efforts to support challenging standards-based teaching and learning of mathematics. The process yielded examples of what is working, identified gaps in knowledge, and revealed some emerging or persistent issues that require renewed attention.

The report both summarizes what the working group found, and outlines the main policy recommendations to support an action strategy. The key word is "policy." The details on how to make this strategy operational are still being developed. The working group's recommendations have been organized into a program action plan, an information action plan, and a partnership action plan. We look forward to your participating in an exciting event in July announcing the action strategy and how it will unfold over the next 3-12 months.

Teachers, materials, and technology are indispensable classroom ingredients of raised expectations and improved student achievement. Partnerships with organizations outside the Federal sector are essential if national and local resources are to be strategically applied in making larger segments of the public attentive to standards-based mathematics and science education as the link between school and work in the 21st century.

Finally, we would like to thank the members of the interagency working group, especially its co-chairs Judith Sunley of the National Science Foundation and Thomas Corwin of the Department of Education. Thank you, too, for your leadership in forming a collaboration that holds promise of enhancing the impact of what two agencies support separately in reforming K-12 mathematics and science education.

Your call for voluntary national tests in 4th grade reading and 8th grade mathematics symbolizes our country's concern for the larger issue: how to make wise, long-term investments in the cognitive, emotional, and social well-being of our youngest citizens. This report supplies some ideas for brightening the educational future of America's children.

Sincerely,

Neal Lane
Director
National Science Foundation

Richard W. Riley
Secretary of Education

MEMORANDUM

Thank you all for agreeing to come to Virginia Wednesday September 24 at 3 PM through Thursday September 25 at noon for a meeting to give us your insights about how to create a set of strategies and activities that will build public understanding of what challenging mathematics looks like and gain public support for raising student achievement toward those standards.

The President's Mathematics Initiative Working Group devised a three-pronged strategy for improving mathematics achievement, particularly at the middle grades:

ú equipping teachers with the skills and knowledge to teach challenging mathematics;

ú implementing high quality standards-based curricula and instructional materials, including educational technologies; and

ú building public understanding of what challenging mathematics looks like and gaining public support for raising student achievement toward high standards.

The first two items are considered in the portfolios of the National Science Foundation and the Department of Education already and we intend to enhance those efforts by additional funding and cooperation, but item three is not directly addressed in any of our programs. It is the strategies and activities surrounding this item that we would very much like to discuss with you. Included in this area are such things as problem development, production of problems of the week to excite teachers and students and to help them get ready for the 8th grade test, guidebooks for volunteers who would assist students in learning mathematics at a high level supplementing the school activities, media spots, print articles, web activities, meetings, etc.

Since this will be the most public part of the whole action strategy, it is critical that it be done right and that the processes be free of conflicts of interest, bias, etc. Thus we would appreciate your input as we develop our thinking further and attempt to secure the help needed to accomplish the mission.

Thank you for assisting in this important activity. We will be in touch with more details later. The Wednesday afternoon meeting will be at NCTM in Reston, Virginia and the Thursday morning meeting will be at the Hyatt in Reston, the site of the Gateways Meeting, for the convenience of those of you who are attending the Gateways meeting.

Midge Cozzens, National Science Foundation

Judy Wurtzel, Department of Education

Copy of Riggs radio address transcript

Laura Capps 196
- 6-2554

MS ≡ Birthd
4:30 tomorrow

- Papers went up Wed or Thurs
  - Kerry staff called Fri
  - MS met w/ College President in VT
  -

Wurtzel -
- Allison -
- General like - along lines asked -
-

Calculus - cut both ways
- Definitely algebra -
  - text spec graphs didn't show -
    how done -
    23rd / 24th @ NSF/HQ

Terry Tolson

- Math Ed pr
  - Olivia Lapin
    LETM incoming
  - Bon
  - Urban Teaching
  - B Rut in Ed
    Nat Council + Parks in Ed

- Children's Telev. Network

Meg Cossell
- Copy of DC Youth amendment
- Library/Learning office fund
- 5-4875 Pg

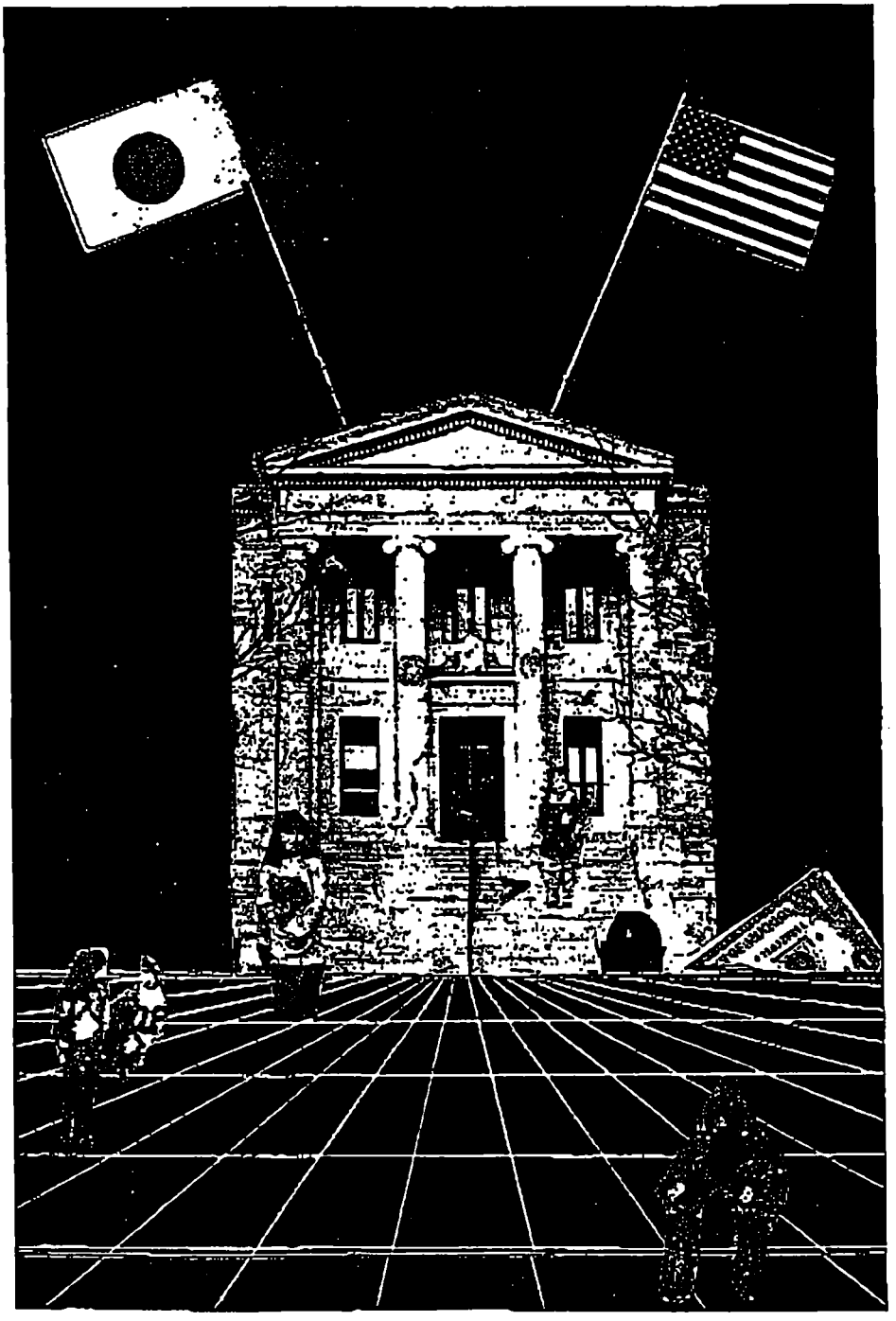
Senator Cook - 401-(037)
- OMB -
- DC Approps
- Veto

DC - Mayor has to decide
Ken to brief
- Decided to be silent -
- tell DC how to spend its $ -
- Council committee on education -
- Very much a local issue
- Richard Wenning -
earmarks
- Offset proposed from DOC -
- PAD who
- Michael Dyckman has signed off on my silent - initially opposed
- Alice Rivlin in Chuck Kieffer's

Policy Perils of International Comparisons

The TIMSS Case

BY J. MYRON ATKIN AND PAUL BLACK



Just as there is no magic bullet for improving an education system, so there is no clear path to be found by trying to imitate "successful" neighbors, Mr. Atkin and Mr. Black conclude.

IN LATE 1996, the Third International Mathematics and Science Study (TIMSS) began to release the results of its 1995 examination of the status of science and mathematics education in 45 countries. TIMSS measured student achievement. It also analyzed curricula, instructional practices, and certain teacher characteristics. The study found that U.S. student performance on the TIMSS eighth-grade tests was about average — comparable to Germany and other countries of northern Europe but markedly below Korea, Singapore, and Japan. At the time the initial data were released, the U.S. National Research Center for TIMSS launched a major effort to provide analysis of the results and to suggest policy recommendations.

J. MYRON ATKIN is a professor of education at Stanford University, Stanford, Calif. PAUL BLACK is an emeritus professor of science education at the Centre for Educational Studies, King's College, London. *An earlier version of this article was presented at a National Research Council Symposium on TIMSS in February 1997.*

Coincident with the TIMSS research, the Organisation for Economic Cooperation and Development (OECD) initiated a somewhat different study of science, mathematics, and technology education.[1] Thirteen countries, all of which were part of the TIMSS analysis as well, participated. While TIMSS centered exclusively on the current status of education in the subjects in question, the OECD study focused entirely on *innovations* — changes that the countries are trying to make in their existing programs. The importance of the distinction for policy purposes is this: among the 13 countries that participated in the OECD study, there is universal unhappiness with the present state of science and mathematics education. Much of the dissatisfaction runs deep. Furthermore, its intensity is independent of the rank order of these countries in the TIMSS scores. All 13 countries (including Japan, the only Asian country in the OECD study) are trying to make changes in their existing programs. Some of these changes are profound.

The purpose of this article is to compare and contrast the policy messages that can be inferred from these two studies. They differ. Neither study can confirm or disconfirm the other. Moreover, as we shall point out, the strong policy recommendations advanced by the TIMSS group find little basis in the TIMSS data themselves (at least those reported so far) and raise far more questions than the research can answer.

The OECD Study

The 13 countries that participated in the OECD study were Australia (Tasmania), Austria, Canada (British Columbia and Ontario), France, Germany, Ireland, Japan, the Netherlands, Norway, the United Kingdom (Scotland), Spain, Switzerland, and the United States. They generated 23 case studies of innovations, with Canada, Japan, and Norway producing two each and the United States, eight.

The OECD is an intergovernmental agency of 26 countries (24 when the examination of innovations in science, mathematics, and technology began in the early 1990s) that conducts studies of interest to its members. No large investigation is initiated without approval of the relevant OECD governing body. These governing bodies are constituted of officially designated representatives of the participating countries. Thus OECD activities are linked closely to government policy concerns.

Each participating country selected the specific innovation or innovations it wanted to examine. Since the context for reform differs from country to country, research approaches were chosen to illuminate those differences and their impact on innovations in content selection, strategies for change, teaching strategies, and student assessment. Because countries, not individuals, belong to the OECD, innovations with the strongest relevance for government policy makers tended to be chosen.

In most instances, the education ministries, as the appropriate governmental bodies, made the choice. In some federal systems, such as Australia and Canada, the responsibility for selection was delegated to states and provinces. In Germany, the federal government selected a particular innovation that had originated in one of the states and was gradually spreading. In the United States, which invested sufficient funds to develop eight comprehensive case studies, the job of selecting the specific innovations was given to an advisory committee of education professionals, scientists, and mathematicians appointed by the grantee agency for the project, the National Center for Improving Science Education, located in Washington, D.C.[2]

A nine-member writing team prepared the final cross-national report.[3] Almost all the countries published their own case studies in the home language for internal distribution. The American studies, the largest single-country undertaking, resulted in three separate volumes.[4]

Some Findings

What drives reform? There were some clear findings. One of the surprises, mentioned at the beginning of this article, was that no country that chose to participate was satisfied with its existing programs in science or mathematics education. The American public often assumes that countries whose students score high on international comparisons of educational achievement are pleased with their existing programs. They are not. In our study, Japan, Australia, and the Netherlands, each of which scored higher than the United States in the TIMSS studies, seemed no more satisfied with their programs than Scotland, Norway, and Spain, each of which had scores below the United States. Even in some of the countries whose education systems are most admired from afar for the apparent achievements of their students, notably Japan and Germany, the changes under way are profound in their conception of a desirable education and radical in their departure from past practice.

Less unexpectedly, each country was reacting to a somewhat different set of conditions and perceptions in its reform. Several countries, including the United States at the time the study was conducted, regarded the national economy and international trade as being in decline. They wanted to increase productivity and believed that the improvement of science, mathematics, and technology education was central. Almost all countries with relatively high rates of unemployment were concerned about preparing youths for jobs that required technical skills. Again, science, mathematics, and technology education received priority.

A significant number of countries were distressed about social and community-based issues, such as adolescent health and environmental deterioration. Several of them had developed new curricula to educate students about the importance of protecting natural resources. Japan is such a nation. So is Germany. Some countries viewed their students as uncreative, despite high scores on examinations. The reforms called for schools and teachers to encourage problem solving and first-hand, original investigations. Again, Japan is an example.

It is clear from the OECD study that reform is driven by somewhat different concerns in different countries. In a late 20th century marked by a distrustful and even an angry electorate in many countries, educational change is advocated and supported in considerable measure to correct perceived ills. Each country is fighting its own demons.

Nevertheless, despite significant differences in the reasons for the innovations, the new programs have strong similarities. Virtually everywhere, the curriculum is becoming more practical. Topics are chosen that have an impact on the daily lives of the students and on the communities in which they live. In one of the American cases — a precalculus secondary school course that teachers designed in North Carolina — a necessary condition of including *any* topic in the new curriculum was that it have an application. In the German case — a science program for

We seem to be entering a period of even greater pluralism in the curriculum than we have seen in recent decades.

students in grades 5 through 8 (and eventually grade 10) — the topics in the lower grades revolve around the students and are presented to emphasize their own connections to the topics of study. The aim is for students to understand that common substances like water are not distinct objects of inquiry but parts of a system in everyday life.

An emphasis on practical work and applications has led several countries to pursue innovations that accent cross-disciplinary approaches, often called "integrated" science. When studying the environmental effects of acid rain, for example, no one discipline is adequate. There is chemistry, which helps students understand the effect of pH levels on concrete and other substances. There is physics, which explains the effects of acid rain on the strength of structures. There is biology, which helps the student understand how life is affected in an acid environment. There are the earth sciences, which help to explain how weather patterns produce differential effects of acid rain in different locations. There is much more, of course. How do communities react to the challenge of reducing pollution? What happens if the smokestack industries that generate acidic gases are required to comply with new environmental regulations? What different interest groups are involved? What public policies about environmental protection make sense? If students are to study acid rain with a view both to understanding the phenomenon and to doing something about it, it is considered necessary in many of the reforms to relate the sciences to one another, to "integrate" them.

The focus on applications and the resulting cross-disciplinary work reflect developments in science itself. Scientists — especially those in industry, but many in universities, too — increasingly find it necessary to traverse disciplinary boundaries to engage in their own research. New cross-disciplinary fields are proliferating at an impressive rate: geophysics, biostatistics, materials sciences, biomechanics, and many more.

The most dramatic and distinctive development in the 13 countries that reflects the educational goal of making the curriculum more practical was the creation of an entirely new school subject: technology. Students not only learn about technological processes in such a course but are also introduced to the challenges of designing objects and procedures. To make a somewhat simplified distinction, science represents human effort to *understand* and *explain*. Technology reflects an attempt to *alter the human condition*, to create something that people want or that makes their lives more productive. Moreover, technology does not usually offer only one answer or solution to a problem. There is no one best way to build a bridge, prevent heat loss from a house, or power a vehicle. If scientific reasoning is directed toward understanding, technological reasoning is directed toward action. Students are expected to defend their proposed line of action. A key test of practical reasoning is how it works. Note that the aim is not primarily or even necessarily to introduce technological devices into the curriculum. Rather it is to teach students about technology, broadly defined, often by creating situations in which they design and make various objects to meet specific human needs and wants.

Who owns science and mathematics education? If the OECD project is any indication, almost all the countries are moving out of a 40-year period in which university-based scientists and mathematicians were the primary arbiters of the content to be taught to students in grades K-12. Only one innovation among the 23, as a matter of central principle, accorded scientists exclusively (and academic scientists primarily) the task of deciding on the essential content to be taught at elementary and secondary school levels. The newly influential players in determining what is to be taught to today's students include the public at large, scientists outside academia, and — especially — teachers themselves. The latter are asserting the right to play a relatively new role as curriculum designers and developers. This development is relatively new. It has always been assumed that teachers are the experts in devising pedagogical strategies but that they have no particular expertise or authority when it comes to selecting content. This belief is being challenged. In several of the cases, teachers assert that, because they know the students and their local conditions best, they have an important role in choosing the topics that meet their needs.

Scientists and mathematicians will always be the final arbiters of accuracy, but the possibilities for actual curriculum choices are vast, and the number of players is multiplying. We seem to be entering a period of even greater pluralism in the curriculum than we have seen in recent decades. There is a paradox here. The early Nineties have been marked by the development of national standards in some countries that never had them. Yet the actual curricula being designed gravitate toward locally determined content in an attempt to make the subjects relevant to student and community life.

Assessment. In some places, new opportunities for learning are being accompanied by matching changes in techniques used for assessment. There is, however, a strong tension between an uneasy public's demand for evidence that the education reforms are working and the need to support teachers who are willing to be innovators. Teachers are frequently the ones who carry the burden of striving for new and often unfamiliar aims and then justifying them to parents and the public.

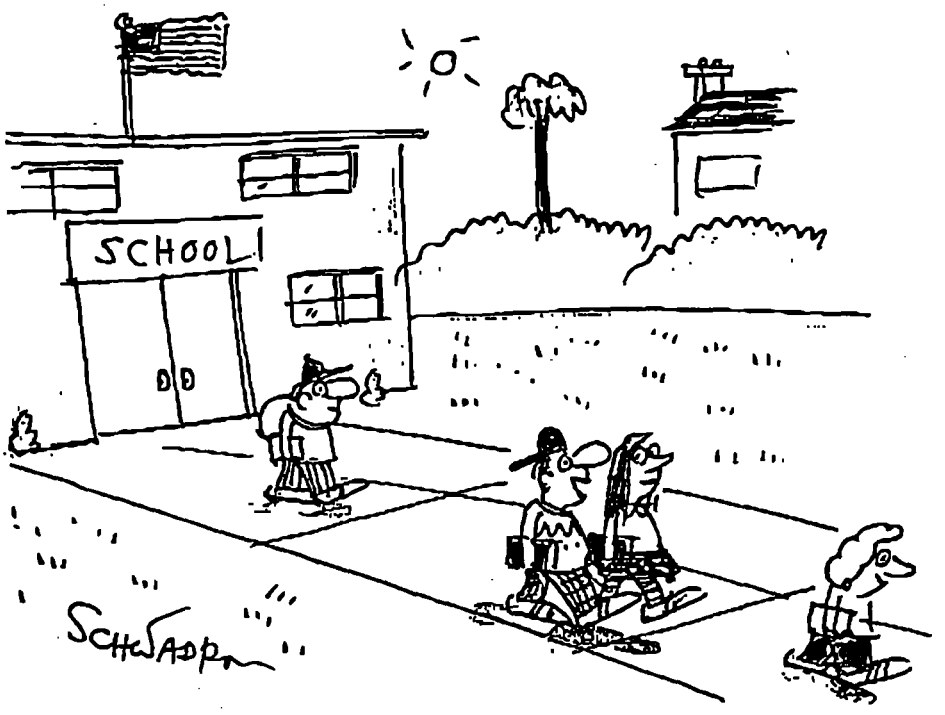
External assessments in particular, whether statewide or national, have traditionally exerted powerful control over what teachers feel obliged to do. Yet the impact of such assessments on efforts to engage students in original and complex work can be devastating if the tests measure only memory. In such cases teachers' efforts to do more than teach to the test are discouraged, and public support for changes becomes more difficult to generate.

However, even tests that measure such thought processes as the formation of hypotheses, the design of investigations, and assessing the correspondence between conclusions and evidence are not very helpful if they are given at the end of a course and do not provide feedback to the teacher while teaching is in progress. A trend in assessment in some of the participating OECD countries has been to use tests as guides throughout the instructional process. This trend grows from the recognition that in cases where concept development

is highly sequential, as in some mathematics courses, many students lose their way and have little hope of learning anything of consequence unless their basic difficulties are diagnosed and addressed promptly.

In France, large-scale assessments are now being used for diagnostic purposes in mathematics. The tests are given at the beginning rather than at the end of the school year so that teachers know at the outset what their students must learn. The assessments are also intended to serve as models for teachers as they prepare their own tests.

Norway offers another new approach to testing. In that country, teachers involve their students systematically in *self*-assessment. As self-evaluators, students must develop a far deeper grasp of what their learning is supposed to achieve. They must understand the aims of the learning and the criteria for success. Self-assessment of this sort meshes closely with other efforts to help students take greater responsibility for their own education.



"Could I have your number in case I start liking girls?"

U.S. Policy Links With the TIMSS Study

Standards and comparisons. As was his predecessor, President Clinton is an avid supporter of national education standards, and the federal government has financed the development of standards in many subjects, including science. The National Research Council of the National Academy of Sciences produced *National Science Education Standards* for grades K-12. In the section on standards for student assessment, the document calls for less emphasis on what is easily measured and more on what is highly valued; less on assessing discrete knowledge and more on assessing rich, well-structured knowledge; less on assessing scientific knowledge and more on assessing scientific understanding and reasoning.[5]

In the 1997 State of the Union address, however, the President suggested that TIMSS-type tests be given across the United States. He noted that students in a group of north suburban Chicago schools compared well with those in Korea and Japan on the TIMSS tests, seemingly implying that they reflect high international standards. (For a report on these districts, see the article by Mark Hawkes and his colleagues, page 30, this *Kappan*.) Let's take a look at the tests the President wants to use. First, 75% of the items are multiple-choice questions. All the others call only for a short, closely defined response. Even within some of the TIMSS items themselves, the limitations of multiple choices are apparent. For example, in the TIMSS mathematics report, Item 15 is said to be about solving linear equations but can be answered by substituting the options in turn to see which fits.[6] No algebraic procedure is needed.

It is well-known that such tests assess a limited range of student abilities. They certainly do not reflect the emerging standards in the countries that participated in the OECD project. They do not even correspond closely to the tests administered in the United States by the National Assessment of Educational Progress (NAEP). The most recent NAEP science exams consisted of only 20% multiple-choice items. Many of the questions entailed assessment of students' real performance. Students were given the apparatus to design and conduct an actual investigation, and there was a heavy emphasis throughout on the applications of science. And all the countries in the OECD study are revising their standards toward applications, toward practical work, toward increasing students' capacity to see real-world relevance, and toward enhancing students' enthusiasm for further study of the subject. There is little in the TIMSS tests to measure such outcomes. If these goals are important, then it becomes harder to know which countries to imitate.

It is interesting to look at several of the trends that have emerged from the OECD study in light of the TIMSS study. Given the focus in many of the American discussions on comparisons with Japan and Germany, it may be instructive to examine some of those comparisons. The relevant document here is the TIMSS science report for the eighth grade.[7] Since Japan ranked well above the United States in the science scores (third compared with 17th) and Germany was just below (18th), we shall also quote some results for Hungary (ninth).

The move we saw in the OECD study toward greater emphasis on the practical can be checked against the TIMSS students' reports on the frequency of practical work in their classrooms (p. 154). On this index, Japan is ranked about sixth, the U.S. 11th, Germany 21st, and Hungary 39th. To move toward Japan would be to move away from the other two. The OECD study also showed a marked effort to enhance emphasis on real-world prob-

lems. TIMSS has two indicators here. One is the importance teachers give to the understanding of how science is used in the real world (p. 137), where Hungary is fifth, the U.S. 11th, Germany 15th, and Japan 33rd. The other is the students' reports on the frequency of using things from everyday life (p. 155), where again the U.S. is well ahead of Germany and Japan, but Hungary drops to 32nd, between Germany and Japan.

Two other trends apparent in the OECD study were the prominence given to environmental studies and the attempts to help students understand more about the nature of science. These priorities are only weakly reflected in the TIMSS data. There were just 11 multiple-choice and three free-response items under the heading "Environmental Issues and the Nature of Science." This category seems to be a strange combination of two different domains, giving low priority to both and no clear information about either.

Nevertheless, given this caution, it can be noted that, for this domain (p. 41), the U.S. ranked higher (seventh) than Japan (10th), Hungary (21st), and Germany (26th). Two relevant sample questions are quoted, on acid rain (p. 89) and on the ozone layer (p. 57); here the U.S. scored below the other three countries. However, across all four of the countries, the success rates do not exceed 50% on acid rain and do not exceed 66% on the ozone layer. Thus no country can be satisfied that it has achieved scientific literacy for all on these issues at this grade level.

Is a "splintered vision" the American problem? Much of the public commentary since TIMSS data started to be released has centered on the apparent lack of common vision in science and mathematics in the United States. Here the argument can be split to two components, the first concerned with the overall pattern of existing curricula and the second with the potential advantages of national standards and a national curriculum.

A central part of the argument the report by the U.S. National Research Center for TIMSS, led *A Splintered Vision*, is that the coverage of topics in American schools lacks focus and concentration. TIMSS uses the phrase "a mile wide and an inch deep" to describe the U.S. curriculum.[1] This description does represent a feature of American practice, and insofar as rapid treatment of many topics might well lead to shallow understanding, the argument might be cogent. However, the document goes beyond the evidence in implying that this argument is supported by the TIMSS data. Many different indicators for focus and concentration are examined. On most of them, Germany is close to Japan, with both far from the U.S. In a smaller number, Japan lies between Germany and the U.S. In a very few, Germany is closer to the U.S. than to Japan. However, in the TIMSS eighth-grade scores in mathematics, Japan is well ahead of Germany and the U.S., which are statistically tied. The position in science is similar. To make even a *prima facie* case from the evidence, a clear correlation would have to be established using results from a large number of countries and allowing for intervening variables using an analysis of covariance. None of this has yet been done, and to the extent that an analysis of only three countries can indicate anything, it seems to show that it is unlikely that a clear relationship will be found.

Turning to the second issue, the potential advantages of national standards and a national curriculum, what do TIMSS and the OECD study say about the role they play in a country's education system? Three major messages seem to emerge. First, there is some form of national science standards in many of the countries to which the United States usually compares itself, but by no means in all of them. Second, national standards, where they exist, differ from country to country on at least two dimensions: the concepts they identify for students to learn and the actual influence they exert on teachers and students. Third, no country is satisfied with the condition of its existing programs of science education, even those that have adopted national standards and that score near the top in comparisons of educational achievement.

There is no strong evidence from the TIMSS data that the existence or absence of nationally prescribed standards leads to improved performance. It is hard to make comparisons here, but one index is that the median rank order in science scores at eighth grade is 17 for countries whose curricula are not centralized, 19 for those regionally centralized, and 22 for those nationally centralized. These figures reflect the fact that, although eight of the top 10 countries all have national curricula, so do eight of the bottom 10. In mathematics again, eight of the top 10 and nine of the bottom 10 have national curricula. Of course, whether or not a curriculum is centrally directed is part and parcel of the historical and cultural tradition of a country, and the question of whether or not a change in a particular country would produce a benefit cannot be answered by comparing the status quo across different countries. On this point, the one of us with close experience of the imposition of a national curriculum in England and Wales sees little evidence that this approach has yielded improvement and much evidence that it has damaged the status and morale of those on whom improvement most depends, the teachers.

"That's the bad news. There isn't any good news."

If we look more closely at the significance of formally specified national standards in different countries, a complex variety is revealed. Usually the term "standards" means the content goals toward which science and mathematics teaching should be directed — what students should know and be able to do.[9] In England and Wales, those goals form the core of a new national curriculum that dates from the late 1980s (and that represents a sharp departure from a 125-year practice of leaving curriculum to local education authorities). In Japan, nationally developed "courses of study" embody the desired standards, on a grade-by-grade basis. There is a regularized process whereby the course of study is sent to regional authorities (prefectures) for translation into curriculum. As part of this procedure, teachers in each school deliberate extensively about how their own programs should be made to correspond with the courses of study. In Australia, "National Statements and Curriculum Profiles" are prepared by the Australian Education Council, which is a joint effort of the states, territories, and federal government. Based on the statements and profiles, the regional authorities — working closely with teachers — produce curriculum frameworks. Those frameworks are then transformed into curricula at the school level. In the end, there is not necessarily a tight coupling between the programs in classrooms and the national statements and profiles.

There are differences internationally in what the standards stipulate. In England and Wales, technology is a separate, required subject for all students, but not in Japan. In Scotland, technology is prominent but embedded in the environmental education curriculum. Japan incorporates environmental issues in its science curriculum for elementary schools and, in this context, emphasizes "the ability of problem solving and a rich sensitivity to love nature." "Love of nature" is much less prominent in standards statements in other countries. In some countries, the science is integrated across the distinct disciplines; in other countries, not.

On the other hand, there are no official statements of national subject-matter standards in many countries, including Germany, Switzerland, and Canada. The prerogatives for curriculum construction in these places lie almost entirely with cantons, states, and provinces — sometimes with individual schools and teachers. In Spain there are guidelines, but only for those schools under direct control of the national ministry. Such schools, however, are not the norm because education is commonly a responsibility of each of the autonomous regions.

There are also significant differences in the legal standing and informal influence of standards statements. In Japan the course of study carries ministerial weight, which is considerable. Textbooks are expected to conform closely to the nationally determined standards, as is the curriculum for each school and prefecture. This is not so much true in Norway, though, where there is a strong movement to devolve greater authority to local communities, and it is even less true in the Netherlands. Even in some countries where authority in central ministries is legally strong, as in Austria, considerable autonomy resides informally at the local level — often with individual teachers. The topics chosen for emphasis vary considerably across the country.

These findings suggest a somewhat different picture from the one proffered by *Splintered Vision*, whose authors seem to ascribe mediocre student performance to the lack of standardization of the goals of education in these subjects. "There is no one at the helm of mathematics and science education in the U.S.; in truth, there is no identifiable helm. No single coherent vision of how to educate today's children dominates educational practice in either subject, nor is there a single, commonly accepted place to turn to for such visions."[10] While a "coherent vision" may well be associated with optimal student achievement, as the document says, it is by no means clear from experience in other countries that the vision need be a "single" one or national in scope. When it is, the apparently common goals do not necessarily translate into strong levels of consistency across local education authorities, even in such a small country as Austria.

Nor is it clear that common topics in science and mathematics translate into a less splintered vision. Much depends on the approach to those topics — as the new national standards for science education in the United States suggest by placing "inquiry" *first* when listing *content* standards in such subjects as physical and biological sciences."

The U.S. is second in the world in the frequency of giving class quizzes to students (p. 168) and might reduce this practice substantially to be on a par with the other three countries. Should it do so? In relation to broader aims of teaching, the importance that teachers give to developing creativity (p. 136) is comparatively high in Hungary, lower in the U.S. and Japan, and much lower in Germany (and lower yet in the highest-scoring country, Singapore). Here, as elsewhere, no clear direction can be formulated if one adopts the naive impulse of trying to imitate the high-scoring countries.

Are there other important messages? One possible drawback of giving strong emphasis to the issues of uniformity and coherence of curricula is that other important messages may be overlooked. For example, a different message about possible causes of variations between countries might be inferred from data about teachers' work. In terms of the hours per week that teachers devote to professional reading and development (p. 141), the U.S. at a mean of one hour is well behind the other three (1.7, 1.9, and 2.1 hours), and it is similarly behind on time that teachers spend on planning lessons by themselves (2.2 hours, compared with 3.0, 3.7, and 4.1). However, it is not possible to assess from the data published so far anything about the extent to which teachers have been able to take responsibility for working together in formulating curriculum, pedagogy, and assessment strategies — all issues that were of importance to those involved in the innovations studied in the OECD work.

Another important issue centers on the views of students. For students' reports about liking the sciences, the U.S. response produced 71% liking or liking a lot, whereas Hungary was at 62% and Japan and Germany at 56%. Thus it may be that, in order to achieve high scores on the particular types of test used for TIMSS, U.S. students will have to be taught in such a way that they will like the subject far less than they do at present. Of course, this proposition cannot be proved from the data, but the point does illustrate a more general feature. As already stated, given the diversity of the indicators, no clear direction for achieving high scores can be inferred by any simple analysis. This is not a criticism of the TIMSS data. Rather it is their very richness that makes clear the complexity of comparisons for policy purposes — complexities that the

U.S. interpreters of TIMSS seem to ignore.

Conclusions

It is all too easy for a discussion such as this one to be driven by a model of international competitiveness. It is notable that, in the OECD studies, international comparisons of student scores were only one of the demons driving reform — and then in just a few countries. Our general conclusion is that there is no clear link between success on test scores and some of the other goals for improvement and no clear indication that the top-scoring countries are outstanding in meeting other criteria that many people consider important. But there are two reasons for caution here.

First, it may be that complex multivariate analyses of the data collected will indicate some clearer correlations between performance scores and other indicators. Even then, of course, the status of the result would be that of a complex correlation, leaving open a logical gap to be crossed only by a qualitative judgment as to causality — complicated profoundly by the leaps across cultural contexts.

Second, in the drive for excellence, the TIMSS scores can be only part of the picture. If it were to be the case that the cost of high scores is to incur or exacerbate weaknesses on other important criteria, then there are some difficult choices to be made. The problem is that we do not know whether or not such tradeoff costs are unavoidable.

Even if the competitiveness ideology as a route to educational improvement were less problematic conceptually, there are inconsistencies in the way it is embraced in the *Splintered Vision* report. As one example, Belgium, Italy, Norway, Ireland, and Greece are mentioned disparagingly as the apparent "peers" of the United States (with respect to student test scores) in a way that asks, "Are these the peers we want?" The strong implication is that they are not. Yet, on the same page, the report suggests that we would do well to emulate the European Union. Of course, Belgium, Italy, Norway, Ireland, and Greece are all members of the European Union. The "peers" to which the authors would have the United States compare itself include Japan, Korea, and Singapore. We might well ask, "Are these the exemplars we want?"

Such arguments lead back to a familiar general point. Just as there is no magic bullet for improving an education system, so there is no clear path to be found by trying to imitate "successful" neighbors. There is no substitute for hard argument to formulate the standards of quality that each country values and to work out the policies that can help achieve those standards. The TIMSS data can provide no more than a few clues. Our OECD data provide different clues, which are arguably more relevant to the business of improvement because they are about directions and procedures for change, whereas TIMSS provides a historical snapshot.

With all the variation in standards and their use, it is not obvious what Americans can learn from practices elsewhere. Americans are told that we need "world-class standards." The research cited here, however, suggests that they do not exist, at least not in the sense of documents one can turn to that specify what students in all countries should learn. Standards are real enough in many places. "World-class" standards, however, seem to be more a slogan than an operational reality. The slogan suggests the need for a high-quality and rigorous curriculum, which may be inspirational. But each country is moving toward this general objective by emphasizing somewhat different specific goals. Some employ official statements of standards, while others do not. Consequently, the message for Americans is far from obvious with respect to the role of officially constructed standards in the improvement of science education. They are central to the improvement of education in many countries (though they operate in a variety of ways), and they are virtually nonexistent in others.

However, there does seem to be one common element in successful educational improvement everywhere: teachers are deeply involved in figuring out what high-quality science education actually looks like at the classroom and school levels if significant change is to take root. Japan is an excellent example of a standards-driven system that creates large blocks of time for teachers to deliberate about the education they consider desirable for students. On the other hand, Germany is a country where teachers are expected to — and do — take the opportunity seriously to meet with other teachers to figure out the kind of science education they believe is best for the students. But these deliberations take place without the benefit of official national standards.

We have tried to demonstrate that it is risky to come to policy conclusions on the basis of a perceived relationship between student scores in a particular country and other aspects of that country's education system, specifically whether or not it has formal national standards for subject-matter content. For policy purposes, there may be greater value in examining what the various countries do not like about their current practices in mathematics and science education and are investing large sums to change. Such an approach may help to avoid problems that have arisen not only in countries to which the United States does not usually compare itself, but also in those countries that Americans might otherwise be tempted to emulate.

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1. The authors of this article were co-chairs of the steering committee for the OECD project.

2. The American studies and some of the coordination of the overall project were supported 50/50 by the U.S. Department of Education and the National Science Foundation. Senta Raizen of the National Center for Improving Science Education was the project coordinator.

3. Paul Black and J. Myron Atkin, *Changing the Subject: Innovations in Science, Mathematics, and Technology Education* (London and Paris: Routledge and the OECD, 1996).

4. Senta Raizen and Edward D. Britton, eds., *Bold Ventures*, Vol. 1: *Patterns of U.S. Innovations in Science and Mathematics Education*; Vol. 2: *Case Studies of U.S. Innovations in Science Education*; Vol. 3: *Case Studies of U.S. Innovations in Mathematics Education* (Boston and Andover, Mass.: Kluwer Academic Publishers and The Network, Inc., 1996).

5. National Research Council, *National Science Education Standards* (Washington, D.C.: National Academy Press, 1996).

6. *Mathematics Achievement in the Middle School Years* (Chestnut Hill, Mass.: TIMSS International Study Center, Boston College, 1996), p. 77.

7. *Science Achievement in the Middle School Years* (Chestnut Hill, Mass.: TIMSS International Study Center, Boston College, 1996). Subsequent references to this volume are given parenthetically in the text.

8. U.S. National Research Center for TIMSS, *A Splintered Vision: An Investigation of U.S. Mathematics and Science Education; Executive Summary* (East Lansing: Michigan State University, 1996), p. 3. See also William A. Schmidt, Curtis C. McKnight, and Senta Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education* (Boston: Kluwer, 1997).

9. The United States is an exception because the National Research Council's standards encompass teaching, professional development, assessment, program, and system standards as well as content.

10. U.S. National Research Center for TIMSS, p. 3.

11. National Research Council, op. cit.

APPENDIX 1

PRESIDENTIAL DIRECTIVE

March 6, 1997

MEMORANDUM FOR THE:
SECRETARY OF EDUCATION
DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

SUBJECT: Preparing Students to Meet National Standards of Excellence in Eighth Grade Math and Improving Math and Science Education

Since the early 1980's, U.S. elementary and secondary school students have begun taking tougher courses, and we are starting to see the results. National Assessment of Educational Progress scores have improved in math and science, with gains in mathematics equal to at least one grade level. On the SAT, average math scores are at their highest in 25 years, even as the number and diversity of test-takers have increased. However, the eighth-grade results of the 41-Nation Third International Math and Science Study (TIMSS), released this fall, show that the U.S. is below average in math and just above average in science. That isn't acceptable; in this technology-rich information era, our students need to perform much better in both subjects, but especially in math, if they are to excel at higher level math and science courses that are the gateway to college and to citizenship, productive employment, and lifelong learning.

The first step in raising achievement is lifting expectations and setting high standards for what students should know and be able to do. TIMSS, our National Assessment of Educational Progress, and the standards developed by the National Council of Teachers of Mathematics give us a solid framework to build on. Last month, to help parents and teachers learn who needs help, what changes in teaching to make, and which schools need to improve, I asked the Secretary of Education to develop a voluntary national test for individual eighth-grade students based on widely-accepted, challenging national standards in mathematics. The national test will be available to states and local school districts to give to their students in the spring of 1999, and will measure whether students have reached a high level of mathematics proficiency.

The primary responsibility for achieving high standards rests with students, teachers, parents, and schools in local communities across America. However, it is imperative that we work to ensure that federal resources support student success as well. We must ensure that federal programs, research, and human resources are used as effectively as possible to help improve teaching and learning.

Therefore, I direct the Department of Education and the National Science Foundation, together with other agencies identified in cooperation with the Office of Science and Technology Policy and the Domestic Policy Council, to develop an action strategy for using key federal resources to assist states and local school systems prepare students to meet challenging math standards in eighth grade, and for involving the mathematics, scientific, and technical communities in support of these efforts.

The action strategy should include recommendations for the use of federal resources to help states, local school districts and schools to improve teaching, upgrade curriculum, integrate technology and high-quality instructional materials into the classroom, as well as motivate students and help them understand how math concepts are applied in the real world. The strategy should identify significant federal programs, activities, and partnerships available to improve teaching and learning, ensure that these resources are appropriately focused on helping students reach challenging math standards, and determine how these resources can best support state and local reforms. In developing this strategy, the inter-agency group should review the current status of improvements in math education, and identify and address critical areas of need, drawing on research and input from educators and professional organizations.

Because teaching and learning in math and science are so integrally related, and because success in both subjects is vitally important in this information era, the working group should also review how federal resources and partnerships with other organizations can help improve student achievement in science.

The working group should make its recommendations and submit its action strategy to me within 90 days.

WILLIAM J. CLINTON

cc: ASSISTANT TO THE PRESIDENT FOR DOMESTIC POLICY
ASSISTANT TO THE PRESIDENT AND DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

APPENDIX 3

MEMBERS OF THE WORKING GROUP

Co-Chairs

Thomas Corwin
Director, Division of Elementary, Secondary, and Vocational Analysis
Budget Service
Department of Education

Judith Sunley
Assistant to the Director for Science Policy and Planning
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Carol Chelemer
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Larry Suter
Acting Director, Division of Research, Evaluation, and Communications
National Science Foundation

Judy Wurtzel
Director of the Mathematics Initiative
Office of the Acting Deputy Secretary
Department of Education

With the Help and Assistance of:

Marshall Smith, Acting Deputy Secretary of Education; Joseph Bordogna, Acting Deputy Director, National Science Foundation; Luther Williams, Assistant Director, Education and Human Resources, National Science Foundation; Michael Cohen, Domestic Policy Council; Clifford Gabriel, Office of Science and Technology Policy; Mary Cassell and Anne Tenney, Office of Management and Budget; and Daniel Goroff, Office of Science and Technology Policy.

APPENDIX 2

Voluntary National Tests in Reading and Math: A Strategy to Master the Basics and Reach High Standards

Clear standards of achievement are essential to help instill the skills, American values, and encouragement for hard work that our children need to succeed in school and in life. Toward that end, meaningful standards for what students should be expected to learn and achieve in the basic subjects of reading and mathematics are critical. Reading well by grade 4 and mastering mathematics -- including the foundations of algebra and geometry -- by grade 8 are the gateways for further learning and achievement.

Parents need to know that students have mastered the basics no matter where they live or move ~~in this country~~. And they have the right to know how well their children are doing compared with students in other schools, states, and countries. To help give parents this information, ~~the U.S. Department of Education is offering~~ every state and school district the opportunity to use voluntary national tests of 4th grade reading and 8th grade mathematics, beginning in 1999.

These rigorous tests will provide parents, for the first time, scores for individual students, measured against widely accepted national and international standards of excellence. They will give states, local communities, teachers and parents the kind of accurate information they need to help students master basic and advanced skills and strengthen academic performance. Most importantly, they can galvanize a national effort to improve the odds for students and help ensure that all students master reading and math.

The tests will be modeled on the National Assessment of Educational Progress (NAEP) in 4th grade reading and 8th grade mathematics, and in the case of mathematics will be linked to the Third International Math and Science Study. The NAEP standards reflect a national consensus of what students should know and be able to do when they reach these crucial stages of learning.

The current NAEP is designed to assess how well a sample of students across the entire nation and individual states perform in reading and mathematics. A very small percentage of students participate in NAEP, and no parents know how their own children do on this test. In contrast, the voluntary national tests will provide students, parents, and teachers with meaningful scores to compare individual student performance to widely accepted national and international standards and to identify students and schools that need extra help. These standard measures of excellence will help parents hold schools accountable for improved performance, help teachers and principals improve curriculum and instruction, and give students a guide for charting their own progress.

The ~~U.S. Department of Education will contract with independent test developers to produce the~~ new tests, which will be available for the first time in the spring of 1999 and updated each year. ~~Guidance for test development will come from the most successful mathematics and reading teachers, parents, governors, and local and state education, civic and business leaders.~~ Individual test scores will not be collected by the federal government; state and local school districts will decide how to use the data. Each test will require approximately 90 minutes of total testing time. States and school districts can administer the tests as part of their local testing programs.

APPENDIX 4

RELEVANT ACTIVITIES OF THE DEPARTMENT OF EDUCATION AND THE NATIONAL SCIENCE FOUNDATION

DEPARTMENT OF EDUCATION

The Department of Education provides flexible support, technical assistance, and research-based materials to assist state and local education agencies in improving teaching and learning. This year, the Department has identified seven national priorities that will guide its activities building on President Clinton's Call-to-Action over the next four years. The first three focus on specific results that all students should achieve: reading independently by the end of third grade; mastering challenging mathematics (including the foundations of algebra and geometry) by the end of eighth grade; and being prepared for and able to afford college by 18 years of age. The remaining four priorities address key strategies to enable students to achieve these goals: challenging standards and accountability for every school; a talented, dedicated, and well-prepared teacher in every classroom; Internet access in every classroom with technologically literate students; and strong, safe, and drug-free schools. The following programs provide valuable support to States and schools in their efforts to reach the goal of providing high-quality education in mathematics for all students.

Flexible Support to States, Communities, and Schools to Improve Teaching and Learning:

The **Title I Education for the Disadvantaged** program is the Federal Government's largest program that supports elementary and secondary education, with current funding of almost $7.2 billion for grants to ocal educational agencies. Title I provides funds to help low-achieving children, particularly those in high poverty schools, learn to high standards. Title I can give disadvantaged children the benefit of, for example, more individualized and accelerated instruction, extended-day programs, and learning laboratories in mathematics, science, and computers. Mathematics has always been a major focus of the Title I program: according to the most recent data, 48 percent of 9 million participating children receive some instruction in mathematics.

The 1994 reauthorization of Title I emphasizes holding students participating in Title I to the same high standard as all students. By the 1997 - 1998 school year, all States must adopt challenging standards in reading and mathematics. By 2001, States must implement high-quality assessment systems aligned to the standards to assess the performance of Title I schools in relation to State standards.

Schools that serve an area in which the percentage of children living in poverty exceeds 50 percent may use their Title I funds, in combination with other Federal, State, and local funds, to upgrade the school's entire instructional program. These programs are called "school-wide programs." Other schools use the money to help those children most in need of supplementary services. In addition, the Title I statute emphasizes the professional development of educators; every local educational agency participating in the Title I program must provide high-quality professional development, geared to challenging State standards, to improve teaching of academic subjects.

Goals 2000: Educate America Act --currently funded at $476 million, is the primary Federal program supporting standards-based state education improvement. All 50 States now participate. Goals 2000 provides flexible funding to the States to enable them to

develop and implement their own strategies for achieving the National Education Goals (including the goal of becoming first in the world in mathematics and science). With funding from the program, States are establishing challenging academic standards with which they are aligning their student assessment programs, teacher preparation and licensure requirements, parental and community involvement, and other aspects of their education systems.

Professional development is an important component of Goals 2000. Program funds allow States to make competitive subgrants for activities to improve pre-service teacher education and support intensive, sustained professional development for educators and other school personnel. Many States and school districts are also using Goals 2000 funds to support effective use of educational technology.

Professional Development in Mathematics and Science:

Eisenhower Professional Development State Grants, currently funded at $310 million, support a wide array of professional development activities in the core academic subjects. By statute, at least $250 million of the Eisenhower funds must be spent on professional development in mathematics and science. The strengths of the program are its reach -- funds flow to States and school districts by formula, and the vast majority of local educational agencies participate -- and the flexibility it provides to State and local administrators to carry out program activities that meet particular State and local needs. The 1994 program reauthorization established requirements that the program fund only professional development that is tied to challenging State content standards and is of sufficient intensity and duration to have a positive and lasting impact on teachers' classroom performance. In fiscal year 1998, the program should reach almost 350,000 educators.

The **Eisenhower Professional Development Federal Activities** program supports an array of national professional development initiatives. The Eisenhower program supports the National Board for Professional Teaching Standards (NBPTS), which establishes national standards of excellence in teaching and recognizes teachers attaining these standards through a rigorous assessment process. The Department has requested increased funding to enable 105,000 teachers to become board certified by the year 2006 on average, one for every elementary and secondary school in the nation. The Department's proposed budget would also speed the development of certification frameworks and assessments so that by 2002, certificates for 25 teaching fields will be available. Eisenhower also supports nine state-wide projects across the nation that are working on improving preservice education, licensing requirements and the experience of teachers during their first three years of teaching.

The **Telecommunications Demonstration Project** (PBS Mathline) uses the professional teaching standards of the National Council of Teachers of Mathematics (NCTM) as the basis for its year-long professional development program called the Elementary School Mathematics Project. This project, which complements Mathline's already-successful Middle School Mathematics Project, allows teachers to learn at times and locations they find convenient. It uses a series of 20 videos, each accompanied by a guide that includes lesson plans, ideas for extending the lesson, additional resources, and discussion topics relating the video content to the NCTM standards. Teachers also participate in a year-long, online learning community of 25-30 fellow teachers, with an accomplished practicing teacher serving as mentor and facilitator. Over the course of three years, PBS Mathline has provided more than 4000 teachers of K-8 mathematics in 36 states

with in-depth, standards-based training and has been recognized by the NCTM as an effective professional development program.

Technical Assistance and Information Sharing:

The **Eisenhower Mathematics and Science Regional Consortia** provide professional support to help teachers teach to high standards. The ten Regional Consortia have three primary objectives: 1) to collaborate and form coalitions with other organizations involved in mathematics and science education improvement; 2) to provide technical assistance and facilitate the use of technology as a tool for instruction and professional development; and 3) to identify and disseminate materials on exemplary instruction in mathematics and science.

The **Eisenhower National Clearinghouse for Mathematics and Science Education** (ENC), funded under Eisenhower Federal Activities, collects a wide range of materials in mathematics and science and makes them available on-line and on CD-ROM. As of September 1996, which concluded its fourth year of operation, ENC had collected a total of 7,055 records and was in the process of identifying over 4,500 more. Between October of 1995 and June of 1996, the Clearinghouse reported over three million "hits" to its Web site. ENC Online (www.enc.org) has been recognized as an exemplary Internet site by Classroom Connect, Syllabus Magazine, Geometry Forum, Education Index, and Multimedia Schools. ENC also works with the Regional Consortia to create demonstration sites throughout the country, where educators can interact with the latest technological developments.

Information is also disseminated through the **Educational Resources Information Center** (ERIC), a national system of specialized clearinghouses that maintain and provide access to the world's largest electronic database of education-related materials.

Research, Statistics, and Assessment:

The **National Research Center on Achievement in School Mathematics and Science** is housed at the Wisconsin Center for Education Research at the University of Wisconsin. The Center is a collaboration with the Technical Education Research Center (TERC), Vanderbilt University/Peabody College, the University of Pittsburgh, and the University of Massachusetts-Dartmouth. The Center's mission is to create and validate a set of principles for designing classrooms that promote student understanding in mathematics and science.

Data relating to education is collected, analyzed, and reported by the **National Center for Education Statistics** (NCES). In collaboration with the National Science Foundation, NCES is currently reporting the results of the Third International Mathematics and Science Study (TIMSS), and providing follow-up information on those results. Other NCES studies collect detailed, reliable information on the conditions of schools, teachers, and students throughout the nation. The National Assessment of Educational Progress (NAEP) measures the progress of the nation's students in core subjects, including mathematics and science.

NATIONAL SCIENCE FOUNDATION

Since its inception in 1950, the National Science Foundation (NSF) has served the Nation by investing in research and education in science, mathematics, technology, and engineering. NSF's goals for education and training require attention to needs at every level of schooling and access to quality science, mathematics, engineering, and technology educational opportunities for all members of society.

PreK-12 Systemic Reform

Systemic refers to fundamental, comprehensive, and coordinated changes made in science, mathematics, technology, and engineering education through attendant changes in policy, financing, governance, management, content, instruction, and assessment. Systemic reform occurs when all essential features of institutions and systems are engaged and operating in concert; when policy is aligned with a clear set of goals and standards; when the improvements and innovations become an intrinsic part of the ongoing educational system for all participants and are incorporated in budgets.

PreK-12 systemic reform is supported through NSF state, urban, local, and rural systemic reform initiatives. The implementation of high-quality, standards-based instructional materials, assessment systems, and professional development are keys to success of all initiatives. Development and administration of coherent policies and legislation to support science and mathematics education; convergence of resources to support a single, unitary program; promotion of effective partnerships with the private sector and higher education institutions; achievement of support from the community, parents in particular; collection, interpretation and effective use of data, including student achievement; and cohesive, coherent strategic planning to ensure the improvement of all students' achievement are essential components to the immediate and long-term sustainability of reform activities. Since 1996, the systemic initiatives have begun to make the transition from building an infrastructure to supporting science and mathematics education reform to the classroom implementation of standards-based curricula, instruction, and assessment. Extensive leveraging of funds from business, industry and other federal agencies occurs in all systemic initiatives, in some case as much as 4 to 1 with NSF dollars.

The Statewide Systemic Initiative (SSI) Program has supported a total of 25 states and the Commonwealth of Puerto Rico to establish comprehensive changes in mathematics and science education through the implementation of K-12 standards-based instructional programs, professional development, and assessment systems; new policies, and effective partnerships. A total of 20 eligible cities with the largest numbers of school-age children living in poverty have been funded under the Urban Systemic Initiative Program (USI). A total of four rural, economically disadvantaged regions are implementing programs to promote high-quality science, mathematics, and technology education through the Rural Systemic Initiatives (RSI). RSI programs have focused on the implementation of instruction through the use of advanced telecommunications networking and distance delivery of quality programs and professional development.

Building Blocks of System Reform:

Systemic reform is built on a foundation of quality instructional materials, initial education and professional development of teachers in both content and pedagogy, new strategies for the assessment of student learning, a diverse teacher population, and appropriate use of

technology. Thus a major focus of activities and budget at NSF is assuring that these building blocks are available and in place.

Teacher Education: Teachers must have a high level of content knowledge and pedagogical skills and be prepared to utilize the most effective instructional materials, assessment strategies, and educational technologies. Teacher education includes both preservice and inservice education.

Over 40,000 teachers in 1,930 schools, impacting over 1.3 million students annually, participate in intensive professional development activities through the **Local Systemic Change (LSC) Initiatives**, K-8 in Mathematics and Science and 7-12 in Mathematics. These teachers receive a minimum of 100 hours for K-8 or 140 hours for 7-12 of professional development and receive ongoing support through the academic year. They implement quality standards-based instructional materials and reform the mathematics and science programs in their schools as a whole. Extensive leveraging of Title 1, Eisenhower, district, and industry funds occurs in at least an amount equivalent to the NSF award in each LSC project. In addition to the Local Systemic Change projects, the Teacher Enhancement Program supports **leadership projects** that train teachers and other professionals to deliver quality professional development. ESIE supports the enhancement of approximately 60,000 teachers annually, of whom, at this time, fewer than half are teachers of mathematics. Only about 10,000 are middle school teachers of mathematics.

Comprehensive Partnerships for Mathematics and Science Achievement projects provide students and teachers with standards-based curriculum reform for K-12, teacher enhancement, strategic use of resources, student enrichment activities, and summer research experiences and related activities. Approximately 5,000 teachers are impacted annually.

The **NSF Collaboratives for Excellence in Teacher Preparation** (CETP) support efforts to achieve comprehensive change in the undergraduate education of future teachers and to increase the quality and number of teachers in science and mathematics. All of the activities are characterized by strong collaboration between discipline-based faculty in schools of science/engineering and faculty from schools of education. Participating institutions of higher education vary from tribal colleges to major research institutions. CETP projects will affect 78,000 future teachers in 110 particpating institutions over a five year period, and approximately 30% of the CETP collective effort is focused on future teachers of K-12 mathematics.;

Instructional Materials: Instructional and assessment materials influence what students are taught and how teachers and faculty teach. An innovative, comprehensive, and diverse portfolio of instructional materials and assessment tools that implement standards-based reform in mathematics, the natural and social sciences, engineering, and technology education are required for preK-12 education. These materials must be of sufficient quality to be widely adopted and used in schools nationally.

The development of sixteen sets of comprehensive standards-based mathematics instructional materials for K-12 students was begun in 1990. These materials were completed and became available for use beginning in 1996. A report describing the success of these materials in field test sites was released by the University of Chicago, The Success of Standards-Based Mathematics Curricula for all Students, a Preliminary Report in FY1996. Extensive evaluation data of student achievement in the field testing of these new materials demonstrates improved performance for students using them.

Assessment: ESIE supported research and development in assessment of student learning during the middle 90's through 20 projects. Each of these projects has come to completion and the tools developed and understandings about student learning are being implemented in schools throughout the country. Additional assessment projects continue to be funded. The Balanced Assessment in Mathematics Project was among the projects funded in the middle 90's to develop assessment tools for middle school mathematics. These tools and test items have become the central component of the New Standards Mathematics assessments now used in numerous schools throughout the country.

Technology: Research efforts in technology are developing new methodology and pedagogy for improving the ability of students in science and mathematics, especially those who have not been well served by the education system. The new methodologies will make use of scientific advances in technology (visualization and simulation, for example) that build on different learning styles among students. Funded projects successfully create new forms of visualization of scientific and mathematical concepts. NSF has supported more than 20 projects that successfully create new forms of visualization such as graphics, and simulations. Full and sustainable integration of technology into the fabric of the educational system is required for these to have wide impact on education systems.

Informal Science Education: The Informal Science Education sector reaches out to all segments of population to engage them in self-directed learning in the areas of science, mathematics, and technology. Because, over a lifetime, people spend more hours learning out of school than they do in school, a strong informal science education program is critical in the comprehensive education of our citizens. Members of the public who participate in informal science education learn about the process of science and scientific thinking; are motivated to participate in science and mathematics activities; are aware of the relevance of science, mathematics, and technology in their everyday lives; and increase their knowledge about specific topics and about scientists and careers in the sciences.

Support is provided for informal learning science, mathematics, and technology projects designed to reach large numbers of the general public through television and radio series; public films on the process and substance of science and mathematics; exhibits or other educational activities at science and natural history museums, science-technology centers, aquaria, nature centers, botanical gardens, arboreta, zoological parks, and libraries; and educational programs and activities at community and youth centers. Approximately 40% of the funding went to museum activities, 405 to media activities, and 20% to community activities.

APPENDIX 5

CONSULTATION WITH EXTERNAL ORGANIZATIONS

In the course of developing this action strategy, the Working Group solicited input from a wide range of interested organizations. The mathematics and mathematics education communities are well-organized to respond to the President's challenge. The Working Group met with two umbrella organizations that provided access to many sources of input from these communities: the Mathematical Sciences Education Board (MSEB) of the National Research Council (NRC) and the Conference Board of the Mathematical Sciences (CBMS), Each organization includes stakeholder representatives ranging from school teachers to university mathematicians and from educational researchers to mathematical workers in industry. Their recommendations to the Working Group are summarized below.

In addition, both the National Science Foundation and the Department of Education consulted in the course of their business with a wide range of potential stakeholders, including informal discussion with winners of the Presidential Award for Excellence in Mathematics and Science Teaching, meetings with the Eisenhower Regional Consortia. meetings of advisory committees, and meetings of professional organizations of teachers, principals, superintendents, mathematicians, scientists and engineers.

While the Working Group focused its information gathering on strategies to support improving achievement toward high standards in mathematics, many of the individuals and organizations that provided input were keenly interested in the nature of the voluntary national test. Thus, the discussions with these groups included exchange information about the test of mathematics in eighth grade as well as about the Working Group's objectives. This interest in the test is reflected in the recommendations made. The Working Group was reminded, both implicitly and explicitly, that the test is only a means to an end. The end must be kept in sight, both in test development and in the strategies the Working Group might develop.

In addition to meeting with these groups, the Working Group asked MSEB for a letter report addressing the issues raised in the President's Directive. MSEB offered three overarching recommendations:

1. Construct and sustain a Federal effort that brings together, in a coherent framework for decision-making, the various National Science Foundation and U.S. Department of Education programs that will significantly influence K-8 mathematics education.

2. Devise a long-term plan (8-10 years, offset from political cycles) of interactive development involving test redesign and strategy adjustment, with ongoing monitoring and oversight.

3. Invest in a sustained agenda of basic research to better understand what mathematical thinking is, how to foster it through curricular choices and instructional practice, and how to support teachers in doing so.

Under the broad categories for consideration of the Working Group as found in the President's Directive, all groups emphasized the importance of teacher education (both initial preparation and subsequent professional development), with both MSEB and CBMS highlighting this area in their written input. CBMS and MSEB emphasized the need for

establishing certification programs for middle school teachers in mathematics. They cited the importance of an enhanced role for higher education in preparing teachers and in providing support for teachers through on-going professional development.

MSEB and CBMS also pointed to the emergence of new and innovative middle school mathematics curricula. They urged that the Action Strategy include ways to publicize, promote, and provide adoption guidance concerning model programs. They also agreed that technologies ranging from the Web to calculators have potential to help improve mathematics education. However, MSEB noted the importance of technical support for use of technology in the classroom and of equity issues in the use of that technology.

The outside groups also recognized the value of a public information campaign that can, in the words of the MSEB letter report, highlight "the importance of mathematics in applications, the beauty of mathematics as a field, and the role of mathematics as a gateway to careers and to higher education," Several of the mathematics and mathematics education organizations stand ready to assist in the development of such a campaign. MSEB recommends that public information efforts address coordination of the national test with associated action strategies.

APPENDIX 6

PARTNERSHIP ACTIVITIES

Partnership activities should be aimed at drawing together the broad resources of the local community, engendering a community understanding of the importance of challenging mathematics standards for the children of the community, and providing support to the schools outside the direct confines of the school system. In addition, partnership activities can help address considerations of equity, particularly in the use of technology.

Examples of partnership options that currently exist, might be expanded, or might be incorporated in newly forming partnerships at local, State, or national levels include:

- Institutions of higher education or Federal agencies partnering with local K-12 schools and their parent organizations to build understanding and support for teachers and administrators implementing reform activities;

- Professional societies in mathematics, science, and engineering providing guidance for their members on interacting with schools and teachers productively;

- Summer mathematics efforts that keep students growing mathematically, modeled after the Department of Education's successful summer reading effort;

- Public service information campaigns;

- Mathematics fitness circles or networks taking advantage of the weekly problems, including discussions of how these problems illustrate the standards and the importance of mathematics for future education and work;

- Support for students via telementoring by adults actively using mathematics in their work;

- After school and evening use of facilities (such as space or computers) of local businesses, academic institutions, local government, and community organizations for mathematics-oriented activities for students and their parents

- NAEP - Times Tests
- 12th grade Times results
- Printing Budget
  - use for study only
- Memo to Zotos re: Times & Pricing
- CC: Johnson paper to Chicago
- MS - Journals
- Exec Summary

All Students Master Challenging Mathematics by end of 8th Grade

Our Long Term Goal:

All students will master challenging mathematics, including the foundations of algebra and geometry, by the end of 8th grade.

Indicators: All students perform at at least the basic level and many more above that level in mathematics by the end of 8th grade as measured by NAEP and the national test.

All students perform at at least the average international proficiency level, and many more above that level, by the end of 8th grade as measured by future administrations of the TIMSS and/or by NAEP-TIMSS link, as well as by the national test.

Our Objectives:

1. **Build Public Understanding and Support**

2. **Improve Preparation of Future Teachers of Mathematics**

3. **Upgrade Content Knowledge and Skills of Current Teachers of Mathematics**

4. **Upgrade Curriculum**

5. **Increase Capacity of Federal Programs to Improve Mathematics Instruction**

6. **Build a Research and Evaluation Base for Improving Mathematics Performance**

7. **Volunteer Engagement and Support for Improving Mathematics Achievement**

Draft 5/8/97

Strategies to Meet these Objectives:

Objective 1: Public Understanding and Support -- Increase understanding by students, parents, business, teachers and policy makers of importance of mastering challenging mathematics by 8th grade, how the national test supports this goal, and what changes in expectations, curriculum, and teaching are necessary to meet that level of excellence.

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Key strategies:

1.1 Partnerships. Build partnerships with key education, mathematics and professional organizations, including NCTM, NASBA, AASA, PTA, MSEB, CBMS, Engineers, and others. Mechanisms include:

(1) "steering" committee for mathematics initiative involving key groups (May)

(2) conferences, leadership sessions, etc.... (on-going)

(3) encourage and support association initiatives (on-going)

1.2 Materials. With partners, develop and widely disseminate to policy makers, teachers, parents and business high-quality materials that place the national 8th grade math test in the context of a larger goal of improving mathematics instruction and build understanding of that goal and steps parents, schools, teachers, universities, and others can take to improve mathematics achievement (beginning in June and on-going). Materials will include:

(1) information about the test that explains its purpose, shows what mathematics is important for students to know and be able to do, shows what level of performance is necessary to be proficient on the 8th grade test, and provides examples of items and student work;

(2) tools to start a "national conversation" about mathematics (e.g. questions for school board members to ask superintendents);

(3) why mastering the essentials of algebra and geometry by 8th or 9th grade is important for college and career opportunities;

(4) how to know if a student is "on track"to reach the 8th grade goal with examples of items and student work from grades K-8;

(5) information about exemplary programs and key elements of successful mathematics instruction;

(6) lessons from TIMSS and other research about content and pedagogy;

(7) how to create a district and school process for review and improvement of mathematics program; and

(8) as appropriate, materials will address special issues of urban and minority communities, students with disabilities, and students with limited English proficiency.

1.2 Press. Generate favorable press coverage, including articles in key education outlets (e.g., professional journals and national and state level newsletters), favorable opinion pieces and in-depth reporting from non-education press (both science/technology press and general interest magazines). (on-going)

1.3 TIMSS. Use up-coming TIMSS releases to build public awareness of U.S. performance in mathematics and need for improvement. (June 10 - 4th grade results; July 1 - NAEP/TIMSS link)

1.4 Develop mathematics website. (September)

1.5 Other important possible strategies exploring via NSF-ED working group and other mechanisms: major public awareness campaign on importance of mathematics with examples of math problems and student work.

Objective 2: Improve Preparation of Future K-8 Teachers of Mathematics -- Most new K-8 mathematics teachers enter the workforce with only 3 to 9 credit hours of college mathematics preparation, and often with little instruction in the content they will be asked to teach. This objective focuses on increasing the number of new K-8 mathematics teachers who have the content knowledge to teach challenging mathematics.

2.1 Mathematics courses for intending teachers. Spur the development of high-quality courses in college math departments (including 2 year colleges) for intending K-8 teachers that rigorously address the content and skills they will need in the classroom. Build support via "bully pulpit," partnerships with key higher education groups (AACTE, ACE, MAA, MSA) and invitational priority in FIPSE.

2.2 Highlight good models. Publish "What Works" guide on exemplary pre-service programs and strategies (by October).

2.3 Title V. Work with Title V reauthorization team on effort to produce legislation that supports better linkages between teacher preparation programs and schools of arts and sciences, particularly in mathematics.

2.4 Other important possible strategies exploring via NSF-ED working group and other mechanisms: state licensure requirements for K-8 mathematics teachers; promoting mathematics teaching as a second career.

Objective 3: Upgrade Content Knowledge and Skills of Current Teachers of Mathematics. This objective focuses on increasing the number of current teachers who have the content knowledge and skills to teach more rigorous mathematics, particularly in grades 4-8.

Key Strategies:

3.1 Eisenhower. Strengthen capacity of Eisenhower Professional Development program to provide high-quality professional development. Strategies include: (1) issuing principles of effectiveness; (2) presentations and training on TIMSS toolkit for state coordinators at July meeting; (3) providing information on best practices.

3.2 TIMSS Toolkit. Release and promote widespread use of TIMSS Toolkit. Training in use of toolkit includes: June session for Eisenhower Consortia staff; July session for Eisenhower State Directors; sessions at each NCTM regional meetings for math supervisors and teachers; sessions at other key organization conferences (e.g., AFT). (Summer)

3.3 Developing and disseminating additional good materials on exemplary professional development and instructional strategies in written, video and CD ROM formats. Materials to include: "What works" on exemplary professional development (September); "What works" on instructional strategies (mid-fall).

3.4 Teacher Networks. Promote use of materials around test (portfolio of extended response questions, examples of student work, scoring rubrics, etc...) by teacher networks.

3.5 Other important possible strategies exploring via NSF-ED working group and other mechanisms: encouraging increased attention to mathematics in Title I, promoting professional development tied to implementation of new instructional materials, role of NASA and Energy in providing professional development, use of technology in professional development.

Objective 4: Upgrade Curriculum -- A new generation of curriculum materials aligned to the NCTM standards (much of it funded by NSF) is just coming to the market. The

challenge is to provide schools with good information about existing materials, guidance in how to select curriculum materials, and to identify selected areas where new materials development makes sense.

Key Strategies:

4.1 Identifying exemplary curriculum. OERI expert panel to review range of mathematics curriculum materials, including textbooks, and identify exemplary and promising mathematics curriculum materials. Disseminate widely, including via Eisenhower state coordinators, Eisenhower clearinghouse and consortia, Laboratories and Comprehensive technical assistance centers. (First publication late fall with bi-annual updates)

4.2 Analytical tools. Develop and disseminate tools to assist states, districts and schools choose curriculum. (1) TIMSS Toolkit -- Curriculum analysis module will provide various models for analyzing curriculum to see if aligns with state or district frameworks (July); (2) NSF to develop guide on how to choose K-8 instructional materials (within 12 months).

4.3 Internet. Work with ED working group implementing Presidential directive on developing instructional materials (with a math and reading focus) for the Internet. (on-going)

4.4 Software. Meeting with commercial software developers, developers of high quality curriculum and state instructional leaders to explore ways of accelerating bringing high quality software to market. (July)

4.5 Other important possible strategies exploring via NSF-ED working group and other mechanisms: working with American Publishers Association; supporting development of supplemental materials (particularly technology-based materials); provision of technical assistance in selection and implementation of new curricula; developing tools for professional developers to use in training teachers to use new curricula.

Objective 5: Increase Capacity of Federal Programs to Improve Mathematics Instruction.

5.1 Interagency Working Group. NSF-ED working group to produce "action strategy" with specific suggestions on ED, NSF and other departments' programs.

5.2 Key Department programs. Work with Title I, Eisenhower, comprehensive technical assistance centers, School-to-work, vocational education, adult

education and IDEA programs to develop specific strategies, including presentations at IASA conferences, better dissemination of information. (on-going)

5.3 Eisenhower Consortia. Continue to use Eisenhower Consortia to provide technical assistance and professional development and link their efforts closely to this initiative. (on-going)

Objective 6: Build a Research and Evaluation Base for Improving Mathematics Performance

6.1 Research. Develop a research agenda on key issues of mathematics instruction. (August and on-going)

6.2 Background surveys. Explore developing survey instruments to accompany test that will assist states and districts in analyzing the reasons for their mathematics performance, such as their curriculum and teacher preparation.

Objective 7: Volunteer Engagement and Support for Mathematics Achievement.

7.1 Volunteer effort. In consultation with key constituencies, develop a large-scale effort to engage volunteers in an effort to support mathematics achievement.

7.2 Transportation. Continue to coordinate with the Department of Transportation's "Garrett Morgan" Initiative.

KEY ACTIVITIES IN THE NEXT 6 MONTHS

1. NSF-ED Working Group Report -- Mid June Presidential event

2. Form Steering Committee

3. Build on momentum of TIMSS Releases
   June 10 - 4th grade results
   July 1 - NAEP/TIMSS link

4. Toolkit release and training - July 1

5. Refining the message -- Focus groups

6. Engage Foundations in effort

7. Commitments from universities on pre-service

8. Launch volunteer effort

9. Development and dissemination of key materials:
   Examples of items and student work
   National conversation tools
   Importance of mathematics by 8th grade
   Expert panel review
   What works in professional development
   What works in pre-service

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Math Stat

William R. Kincaid
10/28/97 12:41:12 PM

Record Type: Record

To: Daryl E. Chubin/OSTP/EOP
cc: Clifford J. Gabriel/OSTP/EOP, Sarah G. Horrigan/OMB/EOP, Mary I. Cassell/OMB/EOP, Judith_Wurtzel @ ed.gov
bcc: Records Management
Subject: Re: revised testimony

Daryl--

Revisions are still warranted on a few items, most importantly in the discussion of addressing the low participation and achievement of minorities in math and science, in the discussion of NSF and Department of Eduction programs, and in the discussion of next steps on math and science education. My comments are in bold below.

Thanks.

Daryl E. Chubin

Daryl E. Chubin
10/27/97 12:33:09 PM

Record Type: Record

To: William R. Kincaid/OPD/EOP, Judy_wurtzel @ ed.gov @ inet

cc:
Subject: revised testimony

Thanks again for feedback.

U.S. HOUSE OF REPRESENTATIVES
SCIENCE COMMITTEE

Hearing on
Science, Math, Engineering, and Technology Education (SMET) in America—
Collaboration and Coordination of Federal Agency Efforts in
SMET K-12 Education

October 29, 1997

10 AM to 12 NOON
2318 Rayburn HOB

TESTIMONY OF

DR. CLIFFORD GABRIEL
Acting Associate Director, Science Division
Office of Science and Technology Policy

Thank you for the opportunity to testify on the Federal role in K-12 science education. I would like to share an Office of Science and Technology Policy (OSTP) perspective on the distinctive roles of the National Science Foundation (NSF) and the Department of Education (ED) as the lead agencies for K-12 science education, as well as the work of National Science and Technology Council (NSCT) and the President's Committee of Advisors on Science and Technology (PCAST).

I would note at the outset that the Federal role in providing financial resources to K-12 education is modest relative to the states and localities. Yet Federal programs extend across the Nation in support of local initiatives to improve science and mathematics education. A case in point is the current interagency Working Group on Improving Math and Science Education created by a Presidential Directive in March 1997. **Again, should delete the date.** Led by ED and NSF, the Working Group has been examining how a dozen **Strike "a dozen" -- looks inconsistent with discussion of "half dozen" later on and unnecessarily raises specter of tons of agencies focusing on education rather than core mission.** Federal agencies are helping foster the conditions under which students, parents, teachers, schools, and communities aspire to higher academic achievement.

In light of the 4th and 8th grade findings of the Third International Math and Science Study (TIMSS), the Working Group has sought ways of strengthening and better coordinating Federal agency support for math and science education, focused especially on middle school mathematics. The Working Group's "action strategy" has coalesced around the key areas of improving teaching, increasing the availability of high-quality materials, illustrating effective uses of technology in the classroom, and strengthening public awareness of the importance of challenging mathematics as a gateway skill to higher learning and the 21st century workplace. (OSTP, together with the Domestic Policy Council, has been participating in the Working Group with an eye toward assisting ED, NSF, and all the agencies in the implementation of the action strategy. That, of course, is part of the coordinating function of the NSTC.)

Secretary Riley and Director Lane testified this summer to kick off the Committee's deliberations on the Federal role in K-12 science education and the existing collaboration represented by the Working Group's activities. They indicated that the Federal role is catalytic. Today, over 40 states have revised frameworks for teaching challenging mathematics, which localities take into consideration as guides to classroom practice. The quality materials that

Federal agencies help to develop likewise can serve as models that reflect professional consensus on what constitutes high content standards in mathematics and science. The marketing and distribution of such materials helps districts make informed choices among innovative resources. **Strike "The marketing and distribution of", replace with ", and their availability"**. They can only make a difference in student learning, however, if they find their way into the hands of **add "well-prepared"** teachers and reform-minded administrators.

Within this concern for excellence in the learning environment, there is embedded the issue of increasing student diversity and the educational challenges this presents. Students from ethnic minorities are historically underrepresented in science – as teachers, researchers, engineering technicians and technologists, and other "knowledge workers." We must better prepare them for careers that tap their scientific literacy. The one-third minority student population nationally has already approached a "majority minority" in many urban areas. Yet high school graduation rates, baccalaureate degrees, and graduate study lag for minority students. **Strike remainder of paragraph and replace with the passage below:** Therefore, a special need exists to attract more minority math and science teachers, especially at grades 6-12, and here the Federal government can be a facilitator. Promising examples include ED's proposed Lighthouse Schools model and NSF's Alliances for Minority Participation program.

New language: Therefore, we need to to attract talented people of all backgrounds, but especially minority Americans, into math and science teaching in low-income urban and rural schools across the nation, and dramatically improve the quality of training and preparation given to our future teachers. The federal government can be a facilitator here. Promising initiatives include the President's new proposal on teacher recruitment and preparation, and NSF's Alliance for Minority Participation program.[NOTE: testimony should make clear that this is the President's proposal, not strictly the Department of Education's and that it includes both teacher recruitment and preparation components. We should also make clear that we need to address the low achievement of many minority students not just by recruiting minority teachers, but by doing a better job of recruiting and preparing all teachers who teach in low income, largely minority schools].

Through the Working Group's deliberations, OSTP has faced the reality of coordinating agencies with different cultures: NSF's strategically and competitively project-based approach in contrast to ED's largely formula-funded programs, which aside from Eisenhower Professional Development, do little targeting of mathematics and science. Yet ED and NSF should be recognized as the only two agencies with programming across all levels of education, K through graduate study.

The tone of the preceding paragraph still comes across as unnecessarily negative. The following language, which stresses strengths, would make a lot more sense as a substitute:

The working group's deliberations have helped participants focus on how best to leverage the unique strengths of Department of Education and NSF programs. Department of

Education K–12 programs, many of them formula funded, tend to reach a much wider range of districts, and provide considerable flexibility to states and local school districts. The program with the strongest direct focus on math and science education is the Eisenhower Professional Development program, but other programs, such as Title I and the Goals 2000 program, also provide resources that can be used to strengthen standards–based math and science teaching and learning. In contrast, NSF's K–12 programs, such as its systemic initiatives, provide funds exclusively on a competitive basis, and focus squarely on fostering models of excellence in math and science education.

The working group has also reviewed the contributions of a half–dozen R&D agencies....

Another half-dozen R&D agencies – NASA, DOE, DOT, USDA, to name a few – concentrate their support opportunistically in keeping with their mission requirements. They tend to focus on specific grade levels, on favorite technology-based tools, on schools located near their labs and centers, and on particular community partners with a history of providing school-based enrichment or technical assistance. The impacts of these investments on student learning beyond the original site of intervention are difficult to measure and largely unknown. We need to do a better job in raising the visibility of those agency programs and projects that, by some evaluative measure, have been shown to make a positive difference with students and teachers.

The challenge is to put resources into education delivery systems so that teachers, materials, technology, and new assessments can work together, not alone. Coordination of the agencies efforts can, in turn, help support state and district efforts. We know this from experience. In many states with Statewide Systemic Initiatives and districts with Urban Systemic Initiatives or Local Systemic Change grants, Eisenhower state grants and Title I funds have become important elements of an overall math/science reform strategy. TIMSS data focuses on the importance of middle school (grades 5-8) mathematics as a priority. By partnering, ED and NSF will expand the reach of their programs, leveraging funds, and accelerating the opportunity for introducing new incentives, teachers, and approaches for upgrading math instruction and student learning.

Under the NSTC, a new Interagency Working Group on Science Education will be established provide a forum for exchange on what each agency is learning from their mistakes and successes, and in some cases, their program evaluations. This NSTC IWG will use the action strategy developed by the ED-NSF Working Group as the basis of its terms-of-reference. In addition, OSTP suggests that this interagency group go further to determine how the agencies support standards-based science and mathematics. Clearly, the Federal Government can help determine through research, evaluation, and international comparisons of classroom teaching and learning, not only what works, but also what is reflective of international content standards of excellence.

As stated in the last round of comments, until there is more internal agreement of how to move forward on the basis of the working group's efforts, the OSTP "suggestion" is clearly premature. The language Judy Wurtzel has suggested would be ok.

OSTP would also like to strengthen research on learning technologies while taking stock of agency portfolios in this vital area. Another interagency Working Group on Learning

Technology R&D, consisting of the Departments of Defense and Education and the National Science Foundation, was created this summer to identify programs, projects, testbeds, and other activities centered on technological tools that facilitate learning. This Working Group is reviewing both the priorities of Federal sponsorship of learning technology R&D and the methods for ensuring the most effective use of these funds. When the review is complete, OSTP will have a better sense of how these three agencies allocate their educational technology dollar and how, through research and evaluation, we can offer successful applications across subjects, grade levels, school systems.

In a related vein, a Panel on Educational Technology was organized in April 1995 under the auspices of the President's Committee of Advisors on Science and Technology (PCAST). It was asked to provide independent advice on the application of various technologies to K-12 education. With a focus on interactive computer- and network-based technologies, the Panel's review of the research literature and briefings from academic and industrial researchers, practicing educators, software developers, government agencies, and professional and industry organizations involved in the application of technology to education led to a report released this Spring. Since Dr. David Shaw is a member of today's hearing panel, I will not belabor the Panel's recommendations.

A follow-on PCAST Panel on Education was created this summer to capitalize on – through policy translation, new research, and wider dissemination – the educational technology report and other interagency and Administration reports on children. This Panel, chaired by Dr. David Hamburg, President Emeritus of the Carnegie Corporation of New York, is developing an agenda of education and human resource activities, including implementing an experimental, longitudinal, cross-cultural program on learning – not just by children or about science and mathematics. In addition, OSTP will use input from PCAST in crafting a human resource development policy for science and technology (as was signaled in the Administration's August 1994 science policy blueprint, *Science in the National Interest*).

We believe that the issues addressed by this hearing deserve a more comprehensive treatment of strategies for the entire education continuum – formal and informal – over an individual's life course. An S&T human resource policy, as a component of U.S. science policy, must address learning from preschool through elementary and secondary education, undergraduate and graduate education, and lifelong learning (including retraining) that will make the public more attentive to and appreciative of science, if not scientifically literate and numerate in the traditional sense of what they know.

Still pretty unclear what is being suggested here or who would be involved.

In general, the Federal R&D agencies – beyond their individual missions and specialized workforces – must be responsible partners in reexamining their program portfolios, helping to implement new policy, and helping to prepare Americans for 21st century citizenship. Therefore, the agencies must coordinate scarce resources, draw wisely on the lessons learned elsewhere, and share the expertise marshaled through activities, projects, and media with as many audiences dedicated to educational excellence as possible.

OSTP welcomes future discussions with the Committee about the issues on which we seek

common solutions. Thank you.

Math/Nat Tech

87. Los Angeles Times

* 05/11/97; Edition: Orange County Edition; Section: Metro; Zones Desk; Page B-6

Dean's Reasoning Doesn't Add Up

Orange County Superintendent of Schools John Dean tried to set the record straight regarding math scores (Orange County Voices, May 4). Now I'm doubly concerned.

I don't mind that he personally doesn't know the theory behind the operation of dividing a fraction by a fraction. It's his belief that only professional mathematicians need to know this that's nonsense. Our math teachers have to know it! One can't help but wonder about their competence if the perspective of the administration is so seriously flawed. If that's the prevailing mind-set it's no wonder our colleges and universities need to provide remedial math courses.

The theory behind division of a fraction by a fraction is no more complicated than the fact that if both numerator and denominator are multiplied (or divided) by the same quantity the value of the fraction is unchanged. Any competent instructor can make that point and drive it home with a variety of well-chosen examples. It is necessary to understand this concept as subsequent math, technology and science courses often contain algebraic equations presented in the form of complex fractions.

We need to give our children the best education we can deliver. Testing our students for what they've been taught has validity only if they've been taught what they need to successfully further their education.

PHILIP CUTLER
Costa Mesa

Superintendent of Schools John F. Dean offers us the reassurance that our fourth- and eighth-grade students really are not doing as poorly in mathematics as we might conclude from the results of the recent National Assessment of Educational Progress tests.

He cites results from a variety of other tests to back up his claim that students really are doing OK. Is it any wonder that 53% of the freshmen who enter the California State University system are unable to pass a simple test on high school algebra?

Dean admits that he is unfamiliar with the NAEP mathematics test even though NAEP has been in use since 1973 and is widely regarded as the only nationally representative, continuing assessment of what elementary and secondary students can do in a variety of subjects.

Given that this test has such a prestigious pedigree and that it forms the basis of our "National Report Card" on the quality of K-12 education, I'm more than a little surprised that our county superintendent of schools doesn't seem to have a clue about it.

The NAEP math test examines a student's conceptual understanding, procedural knowledge and problem solving ability at a very basic level.

This is not rocket science! The test examines the basic mathematical knowledge that a person needs to function in society: to be able to balance a checkbook, to decide if the interest on that credit card you are thinking about signing up for is more than you can afford, or to figure out if you are getting a good deal on your home mortgage.

The fact that California students do so poorly on the NAEP is an indication that both our curriculum and our teaching techniques are out of step with the rest of the country, and that our students are not learning the mathematical skills they need to be able to function in a society where the good jobs require at least some number sense.

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* As a volunteer tutor of community college mathematics students I wish to disagree with John Dean.

Our students are bad in mathematics. Many students from Orange County high schools are graduated without a useful understanding of basic mathematical concepts. If a student cannot explain his reason for using a particular procedure, how does he know that the result is correct? Dean treats the learning of "how and why" as exercises in committing facts to memory.

One person can only commit a few facts to memory. We compensate for that limitation by generalizing, by combining many facts into one concept. Mathematics is generalization. Learning and applying concepts requires much more than a good memory.

The process builds on previous concepts and expands the range of problems to which the concepts apply. Even history, which is often perceived as a study of facts, finds the reasons behind actions that produced historic events. We don't serve our students well if we don't have a system that teaches concepts, reasoning from concepts and applying concepts to problems.

To decide whether we are successful we must test the ability of every student to reason and explain. Our measure of success must withstand comparison with other states.

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I was dismayed to read John Dean's "defense" of mathematics education in Orange County schools, doubly so when I realized that these words were coming from the county schools superintendent. This type of trashing of mathematical reasoning is the precise reason test scores are low.

Dean belittles mathematical education altogether by implying that simple division is useless knowledge for the general public. He then suggests that only "serious, professional mathematicians" need to know how division works. I expect this sort of rationale from Talking Barbie, or perhaps Beavis, but not from an education professional.

We live in a technological society. Tools such as computers and calculators require more knowledge from the user, not less. The ability to divide a pair of fractions is a good thing to have; understanding why we "invert and multiply" is what separates a student from an electronic calculator; the ability to express that knowledge is what separates a good student from an average one (or from a superintendent of schools).

The purpose of tests such as the NAEP is to determine the depth of knowledge students are attaining. If a child can divide twelve by three, but can't set up and solve a word problem requiring the same level of arithmetic skill, what has the child learned? The ability to recognize the nature of a problem is inherent to solving that problem.

JAMES REPKA
Laguna Beach■

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L.A.'s School District Doesn't Deserve to be Called a Failure

By Richard Rothstein
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The Los Angeles School Board sought a superintendent who could "save a failed system." But Ruben Zacarias should repudiate such terms as the basis of his appointment. The Los Angeles Unified School District needs a leader who will boast about its successes and try to rebuild public confidence—and the self-confidence of teachers, students and administrators—in its mission.

To do so, Zacarias should explain truths rarely discussed in polite company nowadays: The general academic performance of LAUSD students will always be considerably below national averages. William E.B. Siart, a candidate for the district's top job, said his goal, as superintendent, would be to bring test scores up to the national average. This was irresponsible. If taken seriously, it guarantees the system will always be judged a failure. Were LAUSD ever to meet this standard, it would prove American public schools dysfunctional.

Unreal ways of talking about public schools have origins in a 20-year-old insight. In the 1970s, educators realized that many minority students were poor achievers because teachers expected them to fail, and when teachers didn't believe in their students, students stopped believing in themselves. If challenging course material was considered beyond poor children's abilities, it was not taught. In turn, children without opportunities to learn confirmed everybody's expectations by not learning.

This colonial pedagogy is now discredited, but it has been replaced with an equally malicious idea: All children, regardless of backgrounds, have equal capacities to achieve at high levels. If they don't, it must be because teachers' and schools' standards are too low.

The notion that children in LAUSD—87% minority, 28% from homes in poverty, 13% who don't speak English—should, if only schools did their job, achieve at the same level as children from more advantaged communities is a conceit with unfortunate appeal across the political spectrum. But expecting all children to meet a similar standard defies everything we know about education.

For 30 years, experts have acknowledged that the most important determinants of student achievement are family and community characteristics. Children from literate homes with secure economic environments will always, on average, perform better academically than children without such advantages.

Can disadvantages of poverty, of less literate parents, of limited economic opportunity be overcome by dedicated and inspired schools and teachers? Somewhat. Some poor children enrolled in good schools will outperform most middle-class children, although most middle-class children will outperform most poor children. Some inner-city schools will have better academic programs, better teachers and higher test scores than typical suburban schools. Can this feat be duplicated in every inner-city school? No, because we are describing relative accomplishments. Unless we stop educating middle-class children, their average achievement will continue to surpass that of disadvantaged students, no matter how good a job our urban schools do.

Almost all data on student achievement is "norm referenced." This month, LAUSD students are taking standardized exams. The "norm" (students' score at the 50th percentile) has been established by administering the tests to a representative national sample of students, then determining the average score for each grade and subject area.

We all know what the results will be: A few L.A. schools and children will score above the national average, but most will not. This doesn't mean L.A. schools are failing. Indeed, it could be consistent with success. We don't know, because in the rush to denounce urban schools for their relative nonperformance, we have not bothered to develop absolute standards for what it is reasonable to expect urban children, with their socioeconomic handicaps, to learn.

In the absence of meaningful standards, cliches and anecdotes abound. We like to say, for example, that early in this century, immigrant children learned English without special programs and used education to assimilate to the middle class. What's forgotten is that this achievement took three generations and that few immigrant children graduated from grade school 70 years ago, much less high school or college.

Because there are no good standards by which to judge schools, a predisposition to see failure filters most anecdotal impressions. Tales about high school graduates not being able to make change are plentiful. But when a Hollywood film ("Stand and Deliver") depicts L.A. immigrant children passing advanced-placement calculus, people assume this was an exception. It's not. Last year, more than 5,000 College Board advanced-placement tests were given to Latino students in LAUSD; about half the scores were high enough for college credit.

Most are convinced that LAUSD's bureaucratic bungling makes education impossible, but they don't wonder how, in that case, the El Camino Real High School academic decathlon team made it to the national finals last month. El Camino Real's students, unlike most LAUSD youngsters, are comfortably middle class. While their accomplishments should be applauded, it should also be recognized that teachers in inner-city high schools who guide their students to the 30th percentile on national achievement tests may bring as much "value added" instruction to education as teachers in more comfortable communities, where students coast to the 70th percentile.

LAUSD's role, like that of many urban school systems, is to give disadvantaged children a hand up the ladder of integration into middle-class America. From 1980 to 1995, Latino enrollment in the University of California increased by 220%; African American enrollment increased by 43%, despite a 29% drop in the number of African American adolescents in California's population. These are not results