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TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 08/03/91

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EDUCATION AND A REQUEST TO BRIEF DR. BROMLEY AND
STAFF ON THE REPORT AT A CONVENIENT TIME.

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3306

CARNEGIE COMMISSION
ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

TASK FORCE ON K-12 SCIENCE AND MATHEMATICS EDUCATION

John F. Kennedy School of Government, 79 John F. Kennedy Street, Cambridge, MA 02138, Phone: (617) 496-8691, Fax: (617) 495-5776

RECEIVED

91 AUG 6 P 1: 48 August 3, 1991

Hon. D. Allan Bromley
Assistant to the President, Science and Technology
Old Executive Office Building
Washington DC, 20506

OFFICE OF THE
DIRECTOR

COMMISSION

William T. Golden
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Helene L. Kaplan
Donald Kennedy
Charles McC. Mathias, Jr.
William J. Perry
Robert M. Solow
H. Guyford Stever
Sheila E. Widnall
Jerome B. Wiesner

Dear Allan,

I enclose a copy of the final report of the Task Force on Education of the Carnegie Commission on Science, Technology and Government. This report has been substantially changed since the last draft I gave Tom Ratchford, and is now completed. It was reviewed and has been approved by the Carnegie Commission for publication and public release.

Prior to final publication, which we expect to accomplish in September, I would be very pleased to brief the report to you and others you may designate and to benefit from your views on our recommendations. When might this be convenient?

TASK FORCE

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Rollin B. Johnson
Project Director
Bill G. Aldridge
Richard C. Atkinson
Hon. Garrey Carruthers
Eugene H. Cota-Robles
Shirley M. Hufstедler
David T. Kearns
Leon M. Lederman
Shirley M. McBay
Lauren B. Resnick
F. James Rutherford
Roland W. Schmitt
Maxine F. Singer
Sheila E. Widnall

Our assignment was to address the federal role in K-12 grade mathematics and science education, and to make constructive suggestions on organization and decision-making processes that might enhance the effectiveness of federal participation in the national effort at educational improvement. Policy and management issues cannot be addressed, of course, without identifying some of the the priority programmatic issues. We have highlighted these issues both to call attention to them and to provide the logical justification for organizational recommendations.

The members of the Task Force, its Advisory Committee, and the Carnegie Commission, are very highly motivated, as you are, to see the nation move with speed, imagination, and determination to remedy what many see as the most serious threat to the long-term well-being of the American people: the weaknesses in our system of universal education. We see your leadership as offering an extraordinary opportunity for a sea-change in government leadership and public support for educational progress.

I am also sharing this pre-publication copy and offering personal briefings to Lamar Alexander, Jim Watkins, and Walter Massey.

Sincerely,

cc: David Hamburg
David Robinson ✓

Lewis M. Branscomb

In the National Interest:
The Federal Government
in the Reform of
K-12 Science and Math Education

August 5, 1991



THE WHITE HOUSE

August 15th 41

Dear hero:

Do you get the value for the copy of your
final report. As yet I have only
had a chance to skim it but it
is already obvious that it will be
extremely useful and influential.

Respectfully
Merrill

logged out 10/15/91

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DAB and I met w/ Branscomb + D. Robinson 11:30 a.m. Sept. 30, 1991 to discuss report
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3306

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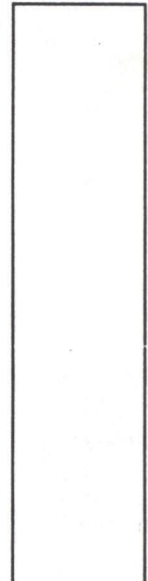
Lewis M. Branscomb

for Tom Ratchford

In the National Interest:

The Federal Government
in the Reform of
K-12 Science and Math Education

August 5, 1991





ACKNOWLEDGEMENTS

This report of the Carnegie Commission on Science, Technology, and Government was prepared by its Task Force on K-12 Science and Mathematics Education and adopted by the Commission at its meeting on June 26, 1991. The members of the Task Force were:

Lewis Branscomb, *Chair*
Bill Aldridge
Richard Atkinson
Garrey Carruthers
Eugene Cota-Robles
Shirley Hufstедler
David Kearns (*through May 20, 1991*)^a
Leon Lederman
Shirley M. McBay
Lauren B. Resnick
F. James Rutherford
Roland W. Schmitt
Maxine Singer
Sheila Widnall

The Task Force established an Advisory Council whose members were generous with their criticism and advice and contributed many important ideas based on their broad range of expertise.^b The members of this group and their affiliations are listed in Appendix A, along with the affiliations of the members of the Task Force. The members of the Carnegie Commission on Science, Technology, and Government and its Advisory Council are also listed in Appendix A.

The Task Force benefitted from discussions with a number of government officials; among them are Tom Ratchford, Associate Director of the Office of Science and Technology Policy; Walter Massey, Director, National Science Foundation; Ted Sanders and Chris Cross, then Deputy Secretary of the

^a David Kearns resigned from the Task Force when he was confirmed as Deputy Secretary of Education.

^b However, the findings of this report are the responsibility of the Carnegie Commission and its Task Force.

Department of Education and Assistant Secretary for Educational Research and Improvement, respectively; Luther Williams, Assistant Director, Education and Human Resources, National Science Foundation; and Peggy Dufour of the Department of Energy, Executive Director, Committee on Education and Human Resources, Federal Coordinating Council for Science, Engineering, and Technology.

The Commission is grateful to Dr. Branscomb for his leadership, to the members of the Task Force and its advisors, to Rollin B. Johnson, the project director, and to David Z. Robinson, who served as principal liaison to the Commission and its staff.

Joshua Lederberg, *Co-Chair*
William T. Golden, *Co-Chair*

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EXECUTIVE SUMMARY

A large number -- probably a majority -- of American public schools are failing to prepare their graduates adequately for the jobs of the future, for life in a diverse culture, or for the civic responsibilities so essential to democracy. The President and Governors are committed to educational reform aimed at improving overly-regimented schools with dispirited teachers and unmotivated students. These efforts are meant to produce fully-functional institutions with properly trained, motivated teachers who use modern materials and teaching methods in creative environments and develop strong incentives for student progress.

Unfortunately, that may not be enough for disadvantaged students from poor communities. In the year 2000, when the national goals agreed by the President and Governors call for American students to be best in the world in math and science, one American child in four will be poor; one child in three will be a minority group member; and one child in ten will not be sufficiently proficient in English to learn without special assistance. School reform alone will not suffice to address these sources of deprivation. Yet the Task Force is convinced that education is the best hope for all children, and that math and science skills are especially critical for good jobs, for further education, and for effective participation in an increasingly technological world. We also believe rapid progress is possible, despite the aspects of disadvantage that beset many schools, students, and families.

The charge given the Task Force by the Carnegie Commission was to examine how the federal government is organized to make decisions and implement change in the reform of science and math education, and to identify changes in organizational structure and decision-making processes that will help the federal government to be an effective partner in education reform. Why focus on math and science education, when the schools are beset with systemic problems not specific to any subject and teaching problems in every subject area? There are at least two reasons why the federal government should pay special attention to math and science education: the increasing demand for numeracy and problem-solving ability in tomorrow's world, and the federal government's special responsibility for assuring the nation's technical capability to address national goals for the economy, environment, health, and security.

The Task Force shares with most Americans a sense of urgency for bold initiatives that will provide real help to schools and will renew public confidence that dramatic progress can be made in the nation's schools. There is no shortage

of motivated Americans with good ideas about how to serve our children better. In short supply, however, is the institutional capacity to aggregate enough resources, build a national consensus for action, and -- most important -- to persist with a specific program of reform for at least decade or two.

The federal government should, therefore, identify the most promising initiatives in the country and build a constituency for launching them on a large enough scale to make a substantial difference in every school in America. The Task Force recommendations are intended to help the federal government more capably identify the best responses to those challenges and then to support them more swiftly, wholeheartedly, and intelligently.

KEY ELEMENTS OF FEDERAL REFORM STRATEGY

The Task Force developed specific recommendations in each of these areas:

- Make math and science education reform a federal priority, consistent with the primacy of national interest in this area. (The FCCSET report indicated, however, that only 4 percent of federal K-12 education dollars are spent specifically for math and science.)
- Engage all federal science agencies in the math and science reform effort; do not give it to the Department of Education (DoEd) alone. The National Science Foundation (NSF) has major responsibilities. The National Institutes of Health, NASA, the Departments of Energy, Interior, Defense, Agriculture, and others should play increasing roles.
- Move toward building a discretionary component of the DoEd K-12 funding dedicated to math and science improvement initiatives. A fraction of 10% would, with NSF's budget, provide over \$1 billion in federal funds for reform.
- Select the best ideas in all areas of reform by competitive evaluation. Increase the receptivity of federal agencies to initiatives outside government.

- Create an effective system for supporting diffusion and adoption of best practice to make sure the best ideas reach all the schools and all the students. Do not be satisfied with successful demonstrations.
- Train math and science teachers as professionals from a diversity of backgrounds and provide them for every school by (a) enhancing the knowledge, skills, and motivation of current science and math teachers, (b) ensuring professional training for math and science teachers, and (c) recruiting math and science teachers from under-represented groups.
- Invest in innovative curriculum and educational materials and provide stronger incentives for the private sector to do so: curricula, textbooks, software for new educational technology. Empower federal science agencies to encourage efforts in their areas of expertise.
- Decide what students need to know and know how to do -- by establishing requirements for the jobs of the future, and engage the Department of Labor, the business community, scientists, and citizens in this effort. Develop methods of assessment appropriate to this goal.
- Enhance student motivation. Create strong role models and meaningful incentives for students to take their educational opportunities seriously, especially in mathematics and science. Fully engage science centers and museums, educational television, and other sources of "informal" education, with support from all the science agencies.

WHO DOES WHAT: ORGANIZATION, MISSIONS, AND MANAGEMENT

We urge the President to use the full prestige of his office to mobilize all Americans for a sustained, national, bi-partisan reform effort. By Executive Order the President should instruct every technical agency to invest proportionately in the ability of the nation's schools to create the needed skills on which the agency's mission depends. 11

Both the Department of Education (DoEd) and the National Science Foundation (NSF) must lead K-12 math and science education reform, with each having distinct but interdependent roles. The two agencies should develop

management mechanisms to facilitate closer collaboration in over-all strategy and planning and in the management of projects undertaken jointly.

- The National Science Foundation should take the lead in those areas where access to the nation's universities and science professionals is most vital: revitalizing science and math teacher education, curriculum, materials and technology; supporting cognitive and applied learning research; and stimulating science education in unconventional settings. NSF should broaden its staff experience beyond education research.
- The Department of Education should take the lead role for systemic change, for educational systems analysis to inform the reform strategy, for assessment of progress, and for the diffusion of successful innovations. The Office of Educational Research and Improvement (OERI) of the DoEd should help the nation develop a "cerebral cortex" of education reform, and should acquire the capability to manage the kind of competitive, innovative programs required to make rapid progress in math and science reform.
- The Department of Labor should become a more significant participant, particularly with regard to defining goals for educational content in relation to changing work skills requirements.
- The Department of Energy should continue its leadership of the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) and through that mechanism insure that all the research-and-development-intensive agencies coordinate their contributions to math and science educational progress.
- The Department of Health and Human Services, especially the National Institutes of Health and the National Institute for Mental Health, should assess the impact of deficiencies in K-12 math and science education on the nation's health and the supply of health professionals; then design an appropriate long range program, coordinated with NSF and DoEd, of math and science education reform.
- The Department of Defense should consider creating model federal schools in which to demonstrate its capabilities in educational technology, processes, and programs, to transfer them to the private sector, and to facilitate the entry of demobilized personnel with science and math training skills into public school teaching.

Because the science and math reform effort requires urgency, vision, and dynamism, all technical agencies should look to their administrative and decision-making processes with a view to developing a more streamlined and responsive infrastructure.

NEW INSTITUTIONS

DoEd and NSF should create a mechanism for collaboration such as a Joint Office for Math and Science Improvement. It would report directly and jointly to the Secretary of Education and the NSF Director. We recommend that there be a mechanism for shared input from outside advisors to facilitate close collaboration.

To support the national reform effort, DoEd should set up, with NSF participation, a National Center for Educational Systems Analysis that can serve as "systems engineer" for new efforts at a national system for accumulating research knowledge to guide reform, evaluate the effectiveness of reform initiatives, and diffusing best educational practice. A federally funded research and development center (FFRDC) might be the appropriate institutional form for the Center.

A non-governmental National Center for Educational Content and Assessment should be created, perhaps under the National Goals Panel, to build consensus on what American students should know and know how to do, and to assess progress toward that end.

The National Education Goals Panel should be supplemented by a Council of education reform leaders from outside government together with senior officials from the Executive branch, the Congress, and the states (such as the Directors of the Office of Science and Technology Policy (OSTP) and of NSF, Chairmen or staff directors of key education committees of the Congress, governors and chief state and city school officers). This Council would support the work of the Goals Panel and would convene a biennial National Conference on Educational Improvement sponsored by either the Goals Panel or by OERI to review the national strategy on math and science reform, and the progress toward national math and science goals.

MECHANISMS FOR COORDINATION AND MANAGEMENT

Two channels of White House oversight (in addition to the Office of Management and Budget) are important: (a) the Domestic Policy Council, with the Secretary of Education as chair of its Education subcommittee, coordinates overall education policy, and should give math and science a high priority in the strategy; (b) the President's Assistant for Science and Technology uses the Committee on Education and Human Resources (CEHR) of FCCSET as an

extension of the OSTP staff to encourage and coordinate activities of the Department of Education and the 15 agencies with science and math content in their missions.

CEHR should become a standing committee of FCCSET, with a full time staff devoted to the coordination of agency activities and the review of agency strategies for K-12 math and science improvement in the quest for an integrated federal strategy. The current pattern of having two vice-chairs of CEHR drawn from senior executives at the DoEd and the NSF should be continued. The Director of OSTP should assign to an Associate Director substantially full time responsibility for math and science education issues.

MECHANISM FOR CONGRESSIONAL REVIEW

The many Congressional committees with jurisdiction over DoEd, NSF, and other engaged agencies should cooperatively review the activities the Executive Branch may propose that agencies undertake to accelerate K-12 math and science education reform, and determine the priority that math and science issues are to enjoy in the intensified program of federal action. A temporary Select Committee on Math and Science Education might be a useful instrument for this purpose. If these activities take any agency beyond its statutory authority, the committee with legislative jurisdiction over the agency will need to consider extensions of authority.

PART I

INTRODUCTION^a

"All who have meditated on the art of governing Mankind have been convinced that the fate of empires depends on the education of their youth."

-- Aristotle

This report is about the serious shortcomings in U.S. science and math education, and what the federal government can and should do to prepare itself for a much more effective role in the national effort to remedy those shortcomings.

Inadequacies in pre-college math and science education are a chronic and serious threat to our nation's future. The national interest is strongly bound up in the ability of Americans to compete technologically. This requires not only an adequate supply of scientific and technical professionals but a workforce able to solve problems and use the tools of a knowledge-intensive economy. All young people, including the non-college bound, the disadvantaged, and young women, must be given the opportunity to become competent in mathematics and science.

A large number -- probably a majority -- of American public schools are failing to prepare their graduates adequately for the jobs of the future, for life in a diverse culture, or for the civic responsibilities so essential to democracy. This conclusion is supported by both expert and political assessment,[1] even though some public schools provide an excellent education for college-bound children in middle and working-class families. Most families, in fact, think their local schools are fine -- not realizing how inadequate their children's education may be in light of tomorrow's higher demands for skills and judgement.[2] Most efforts at school reform, including those to which the President and Governors are committed, are aimed at improving overly-regimented schools with dispirited teachers and unmotivated students. These efforts are meant to produce fully-functional institutions with properly trained, motivated teachers who use modern materials and teaching methods in creative environments and develop strong incentives for student progress. The current division of federal and state

^a Footnotes are designated by letters and appear at the bottom of each page; endnotes are designated by bracketed numbers and appear at the end of the report.

accountability, even with today's per pupil expenditures, may be able to achieve this transformation in many of America's public schools. Unfortunately, that may not be enough for disadvantaged students from poor communities.

For the most rapidly growing segment of the children in our land -- the poor and other disadvantaged children -- public schools and the other social institutions on which they depend are failing to reverse a downward spiral that threatens to relegate the majority of these children to a lifetime of second-class citizenship. In the year 2000, when the national goals agreed by the President and Governors call for American students to be best in the world in math and science, one American child in four will be poor; one child in three will be a member of a minority group; and one child in ten will not be sufficiently proficient in English to learn without special assistance.* The state of American public education is therefore a reflection -- indeed, a victim -- of the nation's social condition. With many children in impoverished urban communities facing inadequate educational stimulation at home, and even inadequate nutrition, the current financial, political, and institutional arrangements are not equal to the task of effecting the escape from the spiral of despair. School reform alone will not suffice.

Yet the Task Force is convinced that education is the best hope for all children, and that math and science skills are especially critical for good jobs, for further education, and for effective participation in an increasingly technological world. We also believe rapid progress is possible, despite the aspects of disadvantage that beset many schools, students, and families. This report is directed to the federal government's opportunity to contribute to that progress much more effectively than it does today.

The charge given the Task Force by the Carnegie Commission was to examine how the federal government is organized to make decisions and implement change in the reform of science and math education, and to identify changes in organizational structure and decision-making processes that will help the federal government to be an effective partner in education reform. The many Americans who are driving education reform efforts around the country may feel that few ideas for improvement originate in federal agencies. From their perspective, it is more important for the federal government to identify the most promising initiatives in the country and to build a constituency for launching them on a large enough scale to make a substantial difference in every school in America. Members of the Task Force share this sense of urgency. A passion for

* *New Voices*, p. 43; *Immigrant Students in U.S. Public Schools*; *Current Population Reports*.

bold and dramatic initiatives that will provide real help to schools may also renew public confidence that dramatic progress can be made in the nation's public schools.

It has been noted before that radical reforms are sometimes more likely to be adopted than evolutionary steps.* But the education problem is not a shortage of motivated Americans with good ideas about how to serve our children better; it is a failure to create the necessary institutional capacity, to aggregate enough resources, and -- most important -- to persist with a specific program of reform for at least a decade or two. Can the government at federal, state, and local levels create those institutions, find those resources, and provide continuity of effort through bad times as well as good? If not, how else can our democracy assemble the capacity to act in its own national interest? Thus, while this report does identify a number of challenges requiring dramatic national action, its focus is on helping the federal government more capably identify the best responses to those challenges and then to support them swiftly, wholeheartedly, and intelligently. We discuss the most needed improvements in the way the federal government encourages, evaluates, and supports reform. We have made a serious attempt to help the President, his cabinet, the Congress, and the states and communities make better use of their resources by recommending ways to increase the institutional capability to attack the nation's educational problems -- specifically in mathematics and science -- with all the skill, judgment, and organized effort of which this nation is uniquely capable.

* See Carnegie Task Force on Teaching as a Profession, *A Nation Prepared: Teachers for the 21st Century*, Carnegie Corporation of New York, 1986.



PART II

INADEQUACIES IN PRE-COLLEGE MATH AND SCIENCE EDUCATION: A CHRONIC AND SERIOUS THREAT TO THE NATION'S FUTURE

A long series of reports[3] citing poor student achievement, vicious cycles of poverty and crime, illiterate and innumerate job applicants, remedial education investments by businesses and by the military, inequitable educational opportunity, and shortages of American scientists, engineers, and technicians are vivid and convincing testimony that **our public school system is failing to prepare all of our young people for the future, and that this failing is particularly serious -- in both degree and consequence -- in mathematics and science.**

There is, indeed, a serious problem with U.S. math and science education. When 47% of our nation's 17 year-olds cannot convert 9 parts out of 100 to a percentage,[4] we know that math education is not working. When 63% of American adults think that lasers work by focusing sound waves,[5] we know that science education in this country is not working. According to the Department of Education, only 7% of high school seniors are prepared for college level science courses.[6] A school system whose graduates are ignorant about science, repelled by mathematics, and confused by technology is a system that is not working well.[7] Many refer to this state of affairs as a "crisis." If so, it is a crisis become chronic.

The crisis in math and science education was first recognized 34 years ago when the Soviet Sputnik could be seen crossing American skies every 96 minutes, reminding us not to take our technical excellence for granted. At that time government was primarily concerned about the adequacy of the number and quality of professional scientists, engineers, and mathematicians needed to assure our freedom from a Soviet threat. The National Defense Education Act (the source of the only major pre-college math-science program remaining in the Department of Education) began the first of several waves of education reform.

In the past 10 years, the United States has experienced two more major waves of educational reform, this time recognizing that a secure and competitive nation must have a better informed citizenry, and a better trained workforce prepared for life-long learning. The alarm of the early '80s[8] brought stricter standards, but no substantive change in how schools are staffed and run, and little positive result beyond an increasingly aroused public.

The middle and late '80s brought designs for systemic change widely adopted by the governors[9], but there was marked reluctance on the part of the federal government to address the problem with the urgency it deserved.[10] The states undertook many isolated innovations,[11] and many governors gave priority attention to reform. But too often the effort faded with the end of a governor's term, the onset of hard times, or the absence of an effective strategy drawing on all the resources that were needed, public and private, state and federal. The sustained effort to address all the critical, interdependent elements of K-12 schooling was not there.

In September 1989, the President and Governors made a number of dramatic commitments at an "education summit" in Charlottesville, Virginia. Among them: **By the year 2000, U.S. students will be first in the world in science and mathematics achievement.** Now, Governors, Congressional leaders, and Administration officials[12] are working together through the National Education Goals Panel and independently through proposed legislation, to reach that goal.

What does "first in the world in science and mathematics" mean? In terms that are relevant to American needs and expectations, it means a level of math and science attainment in a society in rapid demographic transition[13] that will best prepare all Americans for the kind of jobs that keep our economy competitive and growing, keep our citizenry informed and capable of self-government, and ensure that U.S. scientists and engineers are as creative and productive as those of any other nation.[14]

Math and science education should receive priority attention as a specific focus area in federal pre-college education reform initiatives. However, math and science educational improvement must be undertaken in the context of systemic reform of K-12 education as a whole: teacher capability and diversity, school structure and management, and student motivation. Federal programs in math and science education improvement and in general school reform should be concurrent, coordinated efforts.

PART III

ASSUMPTIONS TO GUIDE

FEDERAL STRATEGY AND ORGANIZATION

American schools have been subjected to pressures for reform since at least the 1920's. "A central paradox of education... is that schools, possibly more than any institution in our society, are constantly changing in response to external pressures; yet they never seem to change in ways that satisfy reformers."^a Throughout this history there runs a contrast between the urgency, enthusiasm, energy, creativity, and serious effort that reformers brought to the task, and the slow, ineffective, short-lived efforts to diffuse local successes to other schools.

Each reform effort was rapidly supplanted by the next "new" idea. Reforms have been based on simplistic rather than sophisticated understanding of teaching and learning; they have rarely had the benefit of an overall strategy. Systemic change has been preempted by clever but fleeting and relatively superficial change, to which the education system is highly resistant. Progress has more often faded away than endured.

But the urgent, serious efforts of teachers, administrators, parents, and citizens are more vital than ever to a new reform agenda. The challenge is to engage all elements of communities in the effort and give their commitment a better chance to be effective that it has ever had before. The federal government can, if properly staffed, organized, and "missioned," make a decisive contribution to that end.

The following assumptions underlie our recommendations on how the federal government should decide its strategy for math and science education improvement, how it should organize itself to carry out that strategy, and how agency missions should be allocated.

- **There is no time to waste.** If, as many experts find, the pre-school environment affects a child's ability to learn, none of the children benefiting from pre-school intervention today will have graduated from high school by year 2000. Children now entering elementary school will encounter many teachers with weak educational backgrounds in math and science. The National Science Teachers

^a Richard F. Elmore, "Innovation in Education Policy," Conference on Fundamental Questions of Innovation, Governors Center, Duke University, May 3-5, 1991.

Association estimates that only about 35,000 of the 1 million elementary school teachers are specifically trained for science and math teaching. According to leading professional associations in math and science education, 67% of elementary science teachers have inadequate course preparation in science and 82% are deficient in math.[15] Every school day students in these grades come to school naturally curious about the world and go home having learned to hate math and science a little more.

The graduates of the class of 2000 have already finished third grade. How can these graduates expect to be best in the world in science if, when they reach middle school, they find 86% of the math teachers and 69% of the science teachers fall short of standards for course work preparation set by professional associations of math and science educators? When they reach high school, will they still find that 71% of the biology teachers, 69% of the chemistry teachers, and 88% of math teachers have substandard preparation in their subjects, as is the case today?

Considering the magnitude of the problem, it is clear that extraordinary efforts, both short and long term, will be required to help children in every grade during this decade. With adequate remediation, current students in all grades can make up for lost ground, but it will take perhaps another decade before each child benefits fully from improvement at all levels, pre-school to 12th grade, and remediation becomes much less necessary.

■ **Deep and effective change in the K-12 education system is needed if the goal is ever to be met.** There is widespread agreement that most American schools have limited control over how they teach, are encrusted with bureaucracy, and are frequently staffed with inadequately prepared and motivated teachers who teach outdated curricula and use strategies driven by inappropriate testing. This agreement has created a receptive climate for some radical institutional experimentation. However, reform will be very difficult to accomplish within the resources now available, since most state education budgets are in crisis, and federal contributions to K-12 education are modest by comparison (discussed in Part III, below). The most immediate opportunity is to gain much greater leverage for all the funds available. Change is also needed in the capabilities of the federal agencies and the policies that guide them if the federal government is to be a fully effective partner with the states, the private sector, and concerned citizens in achieving the goals. Growing evidence that the business community is becoming deeply committed to education reform makes it particularly important

that federal agencies are able to take advantage of their experience at identifying weaknesses and creating structural change and effective management.*

■ **Student performance will not improve nationally until the teacher force is improved nationally.** Who will teach science and math to the graduates of 2000? Will they be fully prepared? Over 60% of junior high school principals report difficulty in hiring physics, chemistry, and computer science teachers.[16] Currently, 30% of U.S. high schools offer no physics courses, 17% offer no chemistry courses, and 70% offer no earth or space science courses. Less than 50% of high school graduates of the class of 1987 took chemistry, and only about 20% took physics. Only 7% of high school graduates evaluated in a national study by the DoEd had the preparation needed to take college level courses in science.

These dismal statistics paint a picture of students whose educational opportunities are far below what the nation requires. This is not surprising when one considers that their teachers have come from the same schools and that students who enroll in college level teacher training generally come from the weaker levels of high school academic performance. A high priority must be accorded helping the teachers we have and attracting the best to teaching.

■ **Reform strategies must be informed by the best available understanding of the education system and of teaching and learning strategies.** That understanding must rest on a sound base of education research and evaluation of what works, what does not, and why. Recent advances in education research have potential for greatly improving mathematics and science education. Basic research in cognitive science is revealing how people learn mathematics and science, how the learning context affects learning, and what barriers may block understanding. The potential for a breakthrough in learning effectiveness is there. But too little effort has been devoted to applied research: bringing these ideas into realistic school settings and curricula, testing them in the field, and implementing those that work. Even under the best of circumstances, translation of major research insights into practice takes a long time.

* For example, a number of Chief Executive Officers of large corporations affiliated with The Business Roundtable have teamed up with the Governors to institute essential elements of reform in state policy. See The Business Roundtable, *Essential Components of a Successful Education System: The Business Roundtable Education Public Policy Agenda*, New York, 1990.

■ **Effective educational innovations must be available to all schools.** A conspicuous shortcoming of reform efforts to date is the absence of effective incentives and facilities for the diffusion of better teaching methods, content goals and curriculum materials designed for them, and support services for teachers. Past experience shows that many innovations are quite successful, but their rate of adoption by other districts is painfully slow. To reach the national goals, or even to come close, a greatly accelerated rate of diffusion of best practice is required. Two approaches are available: national incentives to adopt standard content goals combined with more appropriate assessment of progress, and network-based distribution of quality-assured materials, methods, and services.

Targeted efforts to improve rural and urban schools -- arguably the greatest challenge to reform, are vitally necessary. Access to information and assistance in adopting best practices and materials in these schools should be the first priority. Parental involvement must be encouraged through all possible means to keep education high on the family agenda even when kids are not at school. Mechanisms for aiding parental involvement, and providing special help particularly for single-parent families and families in poverty, must be instituted.

■ **Specific change must also address what goes on inside the classroom, especially with regard to math and science.** Changes in structure and organization, important as they are, will not be enough. Education reform must be top-down, bottom-up, inside-out and outside-in.^a "Reformed" schools^b will have the same parents, the same students, and much the same educational process, until those schools adopt content standards for what students should know, and that content is embodied in new curriculum taught by better trained teachers and measured by better assessment methods. This is particularly important in math and science, which pose special problems different from other subjects taught in the schools (see Appendix C).

Enhancing the human relationships among teachers, and between teachers and students, will greatly enhance the performance of both. Teachers with strong collegial relationships and students who are not anonymous occupants of a

^a James Rutherford, "Reflections on the Federal Role in the Reform of Science Education," Feb. 9, 1990, p. 6: prepared for the Carnegie Commission on Science, Technology, and Government; unpublished. "Top-down" refers to statewide or national policies applicable to many schools; "bottoms-up" to changes originating at the local level. "Inside-out" changes are created by teachers and others in the schools; "outside-in" changes originate outside the education system.

^b "New American Schools" are envisioned in *America: 2000*. These schools, initially one in each Congressional district, are designed by each community with one-time federal review and startup support, to adopt and reach the National Education Goals.

classroom will be more motivated. Parents and the home environment are equally critical to learning outcomes, especially to motivate students to apply themselves wholeheartedly to the most rewarding, if often most challenging, courses of study.[17]

Children come to school naturally curious about the world, always experimenting and learning how it affects them and how they can change it. The public schools, parents, and communities should do everything possible to nurture, encourage, and develop that curiosity and that natural tendency to experiment. Children should be guided in how to ask big and little questions about the world as they explore and test. Their learning should be placed in the context of the larger world and the how science and technology can help them answer more and more sophisticated and important questions. The ways science and technology have helped people and transformed the world should be stressed. The idea of pushing the limits of technology or at least the excitement of using the latest technology should be transferred. The impression that children can participate in that future, use that technology, and solve problems with it for the good of others should be reinforced. The idea that the future can be better and that science and technology can help make it so should be the greatest motivator of children to pursue math and science with real zeal in the classroom.

■ **All young people, including the non-college bound, can and should be competent in math and science; in particular, efforts should be made to draw in women and minority men.** The crippling fallacy that math and science ability is innate, and that many or most young people cannot learn mathematics and science, though disproved by sound research,[18] persists in the minds of both parents and educators. This perverse idea becomes self-fulfilling when poor academic performance is blamed on the children instead of their parents, their school, and their community. The result is the exclusion of a large proportion of children from the math/science talent pool. As Harvey Brooks put it, "It is remarkable and paradoxical to me that the country in the world that is most dedicated to the proposition that everyone is equal is the first to accept the notion of differences in learning ability -- something which is much less accepted in Europe and Japan than in the U.S."[19]

Today's system of education discourages most young women and young minority men from success in math and science, creates the expectation of failure, and promotes the fallacy that women and minorities will not be in the front ranks of technical achievement. This discourages the fastest-growing segment of the school population, unfairly deprives these young people of the skills needed to

hold jobs with a future, and cheats the nation of a substantial source of needed technical talent.

We must also dispel the fallacy that students disadvantaged by poverty, race, or language in urban and rural schools are not needed to support the technical base in this country. Students in poverty comprise nearly 25% of our student base and thus 25% of our potential technical expertise. Because their school systems cannot attract the best teachers or supply the latest teaching materials and environments, poor urban and rural students are shortchanged in their education. The benefits to our society of lifting these students out of poverty can be immense.*

Another excuse for accepting student failure to master work in math and science is the fallacy that these subjects are only important for the immediately college-bound. The Secretary's Commission on Achieving Necessary Skills (SCANS) in the Department of Labor is addressing what high school graduates need to know and know how to do in the jobs of tomorrow. SCANS is analyzing the need for both foundation skills, e.g. literacy and numeracy, and functional skills, which are heavily technical and include complex problem analysis, understanding production systems, etc. A strong focus on preparing students for real jobs and facilitating the school-to-work transition should drive K-12 education goals and is critically needed for the revitalization of the U.S. economy.

NATIONAL WILL AND NATIONAL SCOPE

The U.S. can succeed at educating and preparing our citizens when there is the national will and the leadership to do so. In an age when national security is defined by economic strength and environmental protection as much as by military readiness, a well-educated and well-trained workforce is more essential than ever. Therefore America must mount a national offensive in education with the same bold leadership, commitment, and professionalism the nation accords to national defense. However, the task of educational reform will be much more difficult to achieve than a quick and decisive military victory, even if substantial new resources were available. The goals of education are more diffuse, the problems are systemic, and the education structure is highly decentralized and adapted to local needs and local visions. Hence, **the reform**

* The results of Head Start and other programs have already shown this to be true. From a purely economic perspective, education can shift a growing fraction of the population from a sink for public expenditure to a source of national wealth.

of the '90s must be national in scope, well-coordinated, long-term in vision, persistent in execution, and committed to the expectation of success in math and science by every child in every American school room.

The nature of the federal government's responsibility for public education has a long history. Jefferson, Madison, and Hamilton had clear ideas about the connection between education and the national interest, but left the means for carrying out this responsibility undefined in the Constitution. **The principle that underlies the view of the federal role embodied in this report is that there are national interests in educational quality and equity that go beyond state interests, but the primary responsibility for both educational policy and administration lies with the states, cities, and communities contained therein. Thus the federal government should dedicate its efforts to helping the states and communities reform and improve the system, leveraging state efforts rather than displacing them.*** New institutional arrangements to enhance the collaboration of federal, state, and private reform activities are required.

ELEMENTS OF A FEDERAL STRATEGY

These assumptions led the Task Force to four elements of a federal strategy for math and science education reform:

1. Committing to change both how schools are organized and run and what goes on inside the classroom. This requires the action of two lead agencies, the Department of Education and the National Science Foundation, working together through new mechanisms for collaboration with each other and with other agencies.
2. Deploying the resources of the technology-based agencies of the federal government to improve science and math education and expanding the supply of professionally-trained scientists and mathematicians to serve the nation as teachers and technical professionals.
3. Leveraging state and private initiatives and supporting effective change through greater emphasis on flexible, competitively-evaluated funding mechanisms

* For an excellent discussion of this issue, see Richard F. Elmore and Susan Fuhrman. "The National Interest and the Federal Role in Education," *Publius: The Journal of Federalism*, vol. 20, No. 3, pp. 149-162, 1990.



informed by the best available understanding of the education system and of teaching and learning strategies.

4. Building an informed, broadly participatory, and productive collaboration among leaders of states and communities, federal agencies and the Congress, private institutions and the technical community, using a variety of new institutional mechanisms to ensure that federal activities are both effective and supportive.

The goal is a federal structure for math and science education that will endure changes in political climate and enable government to be a more effective partner in this national endeavor than it has been in the past.

PART IV

FEDERAL ACTIVITIES IN MATH AND SCIENCE EDUCATION

This section describes what the federal government is doing in science and math education and what more it could be doing, through which agencies, and with what resources.

CURRENT STRATEGIES

The administration has put forward two strategic plans for its role in education reform. *By the Year 2000: First in the World*,^a prepared by the Committee on Education and Human Resources (CEHR) of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), describes a sixteen-agency effort to support science and math education at all levels. At the pre-college level, the report emphasizes teacher preparation, curriculum and materials development, organizational reform, and student opportunities.

The report is particularly important in view of the absence of close collaboration among many of these agencies in the past, and particularly between the National Science Foundation (NSF) and the Department of Education (DoEd), which together control 86% of the federal investment in pre-college math and science improvement.

America 2000: An Education Strategy^b is a report recently released by the White House calling for systemic change in pre-college education. Much of the reform strategy described in *America: 2000* is based on empirical trials of new school concepts and ways to expand parental choice. Dealing with K-12 schools as a whole, it does not focus specifically on math and science; the FCCSET report, which was released two months earlier, is not mentioned. The strategy is bottom-up (i.e., decentralized, originating locally) and outside-in (i.e., initiated

^a *By the Year 2000: First in the World*, was released in February as an official part of the President's budget. It requests an increase of \$146 million for pre-college education activities.

^b *America 2000: An Education Strategy* released by the White House in May, 1991, promises the Administration will "reward progress and spur change." A \$690 million increment in the Department of Education FY 1992 budget is requested to fund its initiation.

by non-school organizations). By contrast, the *By the Year 2000* strategy is top-down (created at the state or national level) and inside-out (created by teachers, students, administrators, or parents). Whatever the comprehensive program eventually agreed upon by Congress and the Administration, we believe that all four elements of strategy[20] must be used in concert if the nation is to reform its schools successfully.

THE MAJOR FEDERAL PLAYERS IN MATH AND SCIENCE EDUCATION

Two agencies of the federal government share primary responsibility for programs in K-12 education: the National Science Foundation (NSF) and the Department of Education (DoEd). The NSF is the agency most specifically concerned with improving K-12 math and science education, and best prepared today to mobilize the nation's best talent in this endeavor. The DoEd is responsible for K-12 education across all disciplines, is experienced in the conflicts and complexities of educational politics, and in addressing systemic problems that afflict all elements of schooling, and it has the networks in place for more effective diffusion of innovations.

Background: The National Science Foundation

The NSF's primary mission is the support of the nation's professional scientific and technological capabilities, through support for basic research. Out of the NSF's \$2.4 billion budget request for FY 1991, \$1.95 billion is for scientific research, mostly at universities. But the Congress also assigned to the NSF responsibility for improving mathematics, science, and engineering education at all levels. For this activity, conducted in the Directorate for Education and Human Services, \$0.251 billion was requested in FY 1991, of which \$0.165 billion was for K-12 education. Today, the pre-college program is receiving increasing attention as concerns about the impact of poor schooling on the nation's technical excellence grow.[21]

The NSF accesses the best research capabilities in the nation, including cognitive science and learning research which should inform strategies for educational improvement. It is experienced in running competitive programs to support the best ideas arising outside the government, and has an excellent reputation for integrity, technical sophistication, and the use of peer judgement in program selection. The research universities, which have the most to offer to future science teachers, are NSF's constituency. The NSF has abilities to develop and test educational materials, methods, and tools for assessment, and to create institutional innovations. However, because of its modest budget and its competing science research mission, the NSF alone cannot carry the federal role in math/science education reform.

Background: The Department of Education

The Department of Education has a long history. In 1867 a non-cabinet-level education department (soon called an Office of Education) was formed, and was associated with a variety of federal agencies. Beginning in the 1960's, the federal education responsibility was sited in the Office of Education in the Department of Health, Education, and Welfare (HEW, now called Health and Human Services (HHS)). This office was given Department status by Congress in 1979. The DoEd strongly emphasizes providing equitable educational opportunity for all, including the poor, the handicapped, and the learning-impaired. Serving disadvantaged students more effectively calls for reform and innovations which are not necessarily the same initiatives needed to engage science and math educational issues. The major spending programs of the Department of Education were devised primarily to reduce the within-district inequities of state and local spending on schools and students, and to help specific groups of students with special needs that are poorly met by the schools. These include programs of the Office of Elementary and Secondary Education (\$ 7.8 billion in FY 1991 outlays), Special Ed and Rehabilitation Services (\$ 4.4 billion), Bilingual Education (\$ 193 million). The major programs in these offices are Chapter I programs for disadvantaged schools and students; the Education for All Handicapped Children Act (P.L. 94-142); and bilingual education.[22] Few of the DoEd's programs are subject-specific, and its statutes place some constraints on its role in curriculum development and other activities pivotal to education improvement.

The DoEd's active participation in math and science education reform is essential, because progress in math and science will only be made by literate, numerate students in fully functioning schools throughout the nation. Even if the nation's need for professional scientists and engineers were to be fully met by those schools of superior quality and by the immigration of foreign scientists, both equality of opportunity and the quest for the best talent demand that special attention be given to young women and minorities and the poor. The scale of the equity effort required is far beyond the NSF's capability, and must be joined by the DoEd through its efforts to leverage state action. But the DoEd will need the

collaboration of the NSF, particularly for those activities that must draw on the talents of science, math, and engineering professionals, such as research-based development of innovative curriculum, materials, and teacher preparation in math and science.

The NSF and the DoEd each has statutory responsibility for federal efforts supporting the reform of math and science education. Redundancy is not a problem; these are very different agencies and their responsibilities are complementary. The resources, skills, and cultures of both agencies are required if rapid progress is to be made toward the national goals for math and science.

Some 15 other agencies, of which the Departments of Health and Human Services (HHS), Labor (DoL), Energy (DoE), Defense (DoD), and the National Aeronautics and Space Administration (NASA) are particularly important, are in a position to make important contributions to these goals. The Secretary of Energy also has a key role as chairman of the CEHR which coordinates the efforts of the many agencies involved.

However, in terms of dollar investments, the NSF and the DoEd are the major players in pre-college math and science education (with DoEd having much larger opportunities for leverage, given the total scope of its activities.) These 15 other agencies together account for only 14% of the total federal investment on activities directly related to K-12 math and science education.[23]

MONEY MATTERS: FEDERAL SPENDING FOR REFORM AND IMPROVEMENT IN K-12 MATH AND SCIENCE EDUCATION

The NSF and the DoEd have the primary federal mission responsibility and the budget authorization for science and math education (see boxes for details).

Federal Expenditures for K-12 Math and Science Education

According to the recent inventory by the FCCSET Committee on Education and Human Resources, only \$524 million, spent by all federal agencies, was designated for pre-college science and math education in 1991, \$406 million of that being directed at formal, or in-classroom activity.[24]

The DoEd's total FY 1991 budget outlays are estimated at \$24.8 billion, with \$7.8 billion (31%) going to K-12 education. The corresponding outlays of the NSF are \$2.4 billion with \$222 million (9%) going to K-12 education. The great majority of the DoEd's K-12 budget is devoted to categorical programs that allocate funds to states and school districts on the basis of fixed formulae.

The DoEd invests only \$228 million, or less than 1% of its total budget and less than 4% of its K-12 budget, on precollege math and science education.[25] Most of this is Eisenhower Program funds. This investment is only slightly more than NSF's, even though NSF's budget is a tenth of the DoEd budget. The rest of the agencies combined devote far fewer dollars -- only \$74 million -- to pre-college math and science education than either the NSF or the DoEd.

Why is it that the federal government targets only \$524 million, or only 4 percent of its total K-12 public school expenditures^a, for the one area of schooling -- science and math -- singled by the President and the Governors for becoming the "first in the world"?

^a Calculated from percent of federal share of education revenues to public schools (6.2% in 1989) from *The Condition of Education 1991*, p.86; and the total federal education revenues for 1990 (\$213.3 billion), p.88.

There is a strong case for priority attention and funding by the federal government for math and science education specifically:

- Quantitative problem solving, reasoning, and basic scientific understanding, are, along with literacy, the essential skills for protecting the U.S. comparative advantage in the increasingly information-intensive world economy. From a trade perspective, this is a legitimate and major federal concern.
- Federal agencies finance almost half of the nation's research and development (\$64 billion out of \$145.5 billion in 1990), and federal investments in science and engineering make critical contributions to industrial competitiveness and hence to economic well being. Shortcomings in K-12 math and science education may put federal missions, the economy, and other national interests dependent on science, mathematics and engineering professionals at risk.
- Support for pre-college math, science, and engineering education has been a statutory federal responsibility (of the National Science Foundation) since 1950.
- Federal agencies, especially NSF, have excellent access to university resources that are essential not only for educational research but for educating young people for both teaching and research.
- Successful teaching of math and science is specifically dependent on subject matter competence, and an unacceptably large fraction of teachers in the schools do not possess the requisite background (see Part II).
- The nineteen federal agencies in FCCSET (which operate or finance over 750 laboratories with over a hundred thousand scientists and engineers) have that subject matter competence, have been encouraged to include education in their responsibilities, and have the capability to make a much bigger contribution than they do today.
- There is less political controversy over the content of science and math curricula than in other areas, such as ethnocentric and multilingual teaching, and therefore less ideological objection to federal participation

in reform in mathematics and science than in other areas. Mathematics and the physical and life sciences have been largely free of such ideological strife, with the lingering controversy about evolution vs. creationism an important exception.

- The President indicated his priorities in giving math and science education priority attention in the FY 1992 budget request (a 28 percent increase). Thus, federal, state, and local roles and motivations are in alignment in science and math education reform.

One can only conclude that 4 percent of the total federal pre-college educational investment, itself only 6 percent of public school revenues, is an inadequate reflection of the priority accorded to math and science education in the national goals.

But would increasing expenditures in the current programs of the Department of Education solve the math and science education problem? There is no question that substantial expenditures are necessary to redress the crippling societal problems that impede or prevent the schools from being more effective, such as poverty, crime, and parental neglect. Although education will not eliminate these conditions, it is a critical tool for helping young people escape them. Therefore it is especially urgent that educational opportunities in low income areas be rapidly improved.

More funding could speed the reform effort in the entire curriculum, including math and science. The FY 1992 budget requests an additional \$690 million to support the America 2000 strategy, over and above existing funds in the Department of Education and other agencies. For math and science in particular, the FCCSET CEHR budget requests an additional \$146 million above last year's \$514 million, for a total of \$660 million. Together, these increases amount to \$836 million in new funding for school reform.^a

Many believe that far more should be appropriated for improving the schools. Most immediately important, however, is how funding (at any level) will be used, and how well the agencies are prepared to use it. The right question, then, is: Does the federal government have, or can it acquire, a unique and effective capability, working with the states, to achieve the national educational goals on time? This question can be answered by examining the way the agencies do their jobs and use their budgets.

^a With the additional \$150-200 million requested from the business community for the *America 2000* project, this amounts to about \$1 billion in new funding for federal initiatives in education reform.

Federal K-12 Education Expenditures.

Pre-college education is the only education most Americans will experience and is the only formal education common to all. It is universally accepted as the shared responsibility of governments, including federal, state, and local.^a Since 1920, the financial contribution of the federal government to total pre-college education revenues has been small, compared to state and local expenditures. In 1980 the federal share of total public school education revenues stood at 10%. Since then it has declined gradually and today it stands at about 6%.^b The bulk is funded by state (50%) and local (44%) contributions. With state and local governments contributing over \$200 billion to K-12 public school revenues, even a doubling of the federal investment would leave the federal share at 12 per cent.^c

Thus, the federal government is not the financial heavyweight in the K-12 education arena. As combined state and local expenditures on education have grown, the federal share has actually been declining. With federal contributions unlikely to increase dramatically under present fiscal conditions, the federal government's role in reform should be to leverage state and private investments and produce change in the system, not to sustain it as it is. But real change, brought to every state and every community, cannot be achieved either by subsidies for the existing system, or by exhortation. It requires bold responses to original ideas from inside and outside the educational community, managed to provide incentives to take risks, assessed for effectiveness, and institutionalized throughout the country when they are

^a Even those favoring privatization advocate a system of publicly funded vouchers to pay for the educational service.

^b Office of Educational Research and Improvement, U.S. Department of Education, *The Condition of Education, 1990*, Vol. I, Elementary and Secondary Education, p. 168.

^c U.S. Department of Education, *Projection of Education Statistics to 2001*, Table 37, p. 62, December, 1990. Figure used is in current dollars.

successful. The role for the federal government, then, is not a passive one, but is both empowering and responsive to ideas from within schools and from outside the educational system on how schools and the condition of children ill prepared to come to school, can be improved.

A substantial reorientation of education funding toward educational reform is needed quickly. The states are occasionally able to assemble moneys to finance a program to upgrade the public schools or improve instruction. When they are, the amounts are generally tiny in relation to school operating costs. Inevitably when the local economy turns down, fixed costs consume whatever latitude has been assembled. If only ten percent of the DoEd's \$7.8 billion annual K-12 expenditure were appropriated for funding incentives for improvement in all aspects of the education system, this, added to NSF funding, would produce over a billion dollars for reform. Funds at this level, even when spread across much of the country, represent a unique resource for planning and leveraging change at the level of a state, city, or community.

How much flexibility in funding for reform is currently available to the federal agencies? It is difficult to pull out which parts of the billions spent by the federal government on K-12 education are for change, but we believe the fraction is much too small. The FCCSET survey suggests that resource allocation priorities are not oriented toward the systemic planning and implementation of change. The FCCSET agencies are investing only 11% of the federal spending in pre-college science and math education on systemic change, evaluation and assessment, and diffusion of innovations.[25] Thus the flexible funds available to for these vital functions, which are not supported by state and local funding, are less than 1% of the annual federal K-12 budget. The government should consider that, because they draw upon the trained math and science personnel of the nation, the agencies should earmark some percentage of their research and development funding to science and math education. This would significantly improve the directed funding for enhancing the science and math pipeline. If the percentage were set at ten percent of R&D funding, for example, another \$4.8 billion would be generated for science and math education.^a

^a American Association for the Advancement of Science, *AAAS Report IV: Research and Development FY 1992*, Washington, 1991; Table II-1, p.135. Total 1991 R&D funding (not including spending on facilities) for all agencies was estimated at \$65 billion. 10% of this is \$6.5 billion; Committee on Education and Human Resources, *By the Year 2000*, Federal Coordinating Commission on Science, Engineering, and Technology, 1991; p.313. Total agency spending on science and math education at all levels in 1991 is estimated at \$1.7 billion. The increment from such a program would be about \$4.8 billion.

RESOURCES FOR SCIENCE AND MATH IMPROVEMENT

How might a federal strategy aimed at rapid improvement in math and science education be strengthened? The most immediate step forward would be for the Administration and the Congress to convert all of the funding for the Eisenhower grants program in the DoEd to a competitive, peer-reviewed program. Today these grants, as described below (see box), are primarily allocated by a population-based formula with limited oversight and accountability, and thus may not be serving their intended purpose of in-service teacher training as efficiently as they might.

The Eisenhower Program for Math and Science

In math and science education, the largest single federal program is the Eisenhower program administered by the DoEd as part of the National Defense Education Act. About \$202 million is distributed to the states by formula through the Eisenhower State Mathematics and Science Education Program, which is managed by the Office of Elementary and Secondary Education. Three quarters of the funds received by the state are then distributed by formula grants to counties or school districts. These grants are intended to improve math and science teaching through in-service training of teachers, but because there is no competition for grants or follow up on outcomes by the DoEd, many feel that this program has much less leverage than it could have. The other portion of the Eisenhower program, representing only about 5% of the overall Eisenhower funds, is a competitive grants program called the Eisenhower National Mathematics and Science Program, administered by the Office of Educational Research and Improvement (OERI). This smaller portion has better mechanisms for review and accountability and a better record of attention to reform.^a

^a For example, the Eisenhower National Program has contributed funding to the National Science Teachers Association's Scope, Sequence and Coordination program and to Project 2061 of the American Association for the Advancement of Science (in both cases sharing costs with NSF).

Thus, we recommend that the **\$202 million component of the Eisenhower State Mathematics and Science Education Program, should be made fully competitive and devoted to change and improvement in math and science education.** This program, now managed by Elementary and Secondary Education, would be combined with OERI's \$12 million competitive National Program and both administered by the OERI. Together with existing competitive programs at the NSF, this would almost double the funding available for enhancing the performance of K-12 math and science teaching.

A longer term goal is to have a designated fraction (perhaps 10 percent) of DoEd's program funding allocated for discretionary activities aimed at more effective achievement of program goals. These activities would be devoted to change-oriented, competitive, professionally-reviewed programs that provide incentives for reform to states and communities. As this flexibility would allow the DoEd programs to be more effective in serving the intended groups of students, learning in science and math would be enhanced along with all other parts of the curriculum. These activities would be designed in collaboration with states and communities to support constructive change in ways that serve the same population to which each categorical program is directed. Over time, the returns on better use of the formula-allocated funds would result in an overall benefit to cost improvement.

A first priority is to strengthen the DoEd in order to persuade the Congress and the Governors that the DoEd has the capability to manage such programs with the need professionalism. The Office of Educational Research and Improvement is a likely one for the management of these programs. Such programs would be competitive, managed against clear objectives with measured outcomes, and targeted to the pursuit of the national interests in education and achievement of the national goals.

The federal agencies concerned with science and technology should devote some percentage of their research and development funds to science and math education. While many of the agencies support efforts in post-secondary education, the immediate need is for additional funding to be directed toward K-12 science and math education. These funds, too, could be administered through a competitive grants process, which would encourage the best innovators and the best ideas.

PART V

PRIORITY ROLES FOR THE PRESIDENT AND THE FEDERAL AGENCIES IN MATH AND SCIENCE EDUCATION

Earlier in this report, we concluded that the federal role is not to subsidize the basic operating costs of schools,^a but to induce constructive change and assist the states with the diffusion of new policies, structures, tools, and innovations to all the schools. Federal officials and agencies possess unique capabilities to help that process of constructive change.

ROLE FOR THE PRESIDENT

Foremost among federal responsibilities is the leadership role of the President himself. The President has acknowledged his personal responsibility to provide that leadership in his America: 2000 report: "The President, the Department of Education, and the entire Cabinet will help keep the focus on this [reform] strategy, will spotlight areas of trouble as well as areas of excellence, will reward progress and spur change." The most difficult requirement for rapid educational progress is the necessity of building a national coalition for change. Parents and other citizens, school boards, principals and teachers, chief state school officers, business leaders, teacher educators, state legislators, the Congress, and many others must collaborate if the national goals are to be reached. The most difficult group to reach may well be the public, particularly some older voters whose children are no longer in school and who take a cynical attitude toward the likelihood of real improvement in the schools. **The Task Force urges the President to use the full prestige and influence of his office to mobilize the citizens for a sustained, national, bi-partisan reform effort.**

^a An important exception is the need for federal funding to support equity programs: expanding rapidly the number of disadvantaged students pursuing science and math, enhancing the quality of their science and math teachers, and creating incentives for their professional education for teaching or research careers. However, even these DoEd "Chapter I" investments might be used more effectively to leverage state investments and to influence state policies on equitable allocation of funding for schools.

ROLES FOR THE AGENCIES

The NSF and the DoEd are the only federal agencies having a legislative mandate for broad-based educational improvement and change. Their contributions make up 86 percent of the total federal formal education support for pre-college math and science education, as determined by the FCCSET CEHR. For this reason, the following discussion focuses primarily on the NSF and the DoEd. The roles of the other federal agencies are also addressed.

SPECIFIC RECOMMENDATIONS FOR FEDERAL AGENCY ACTION: EIGHT KEY INSTITUTIONAL AND PROGRAM INNOVATIONS

The Task Force has identified eight goals of areas for action at the federal level that deserve high priority. Most of these require institutional innovations or modifications. For each area, we suggest how responsibility could be allocated among the NSF, the DoEd, and other agencies.

- **Provide fully qualified math and science teachers for every school, by (a) enhancing the knowledge, skills, and motivation of current science and math teachers, (b) ensuring fully professional training for math and science teachers from diverse backgrounds, and (c) recruiting math and science teachers for schools that do not have them.**

Enhancing teacher skills and knowledge: With a small investment compared to the current level of federal expenditures, the nation could retrain 50,000 teachers per year over the next decade to empower a half million science and math teachers to transmit the excitement of learning to a major fraction of our minority population and our children in poverty.* Teacher summer institutes have been NSF's most popular programs for K-12 science and math education in the past. They gave teachers self-confidence by bringing teachers up-to-date in science, but by most accounts, teacher's experiences were not well-linked to what they faced on return to their classrooms. This teacher training model should be re-thought to include training in how to teach the basics of science, in new methods arising from cognitive science, and in the transfer and use of the best educational materials and technology. As noted above, special attention should

* According to Leon Lederman, the Chicago Academy project and others show that quality retraining costs about \$10,000 for the initial training and \$2,000 for follow-up per teacher. The per year expense for training 50,000 teachers is thus about \$600 million.

be given to measures to help teachers adopt what they learn in institutes, for example by bringing teams (rather than individuals) from the same school to support the pursuit of improvement objectives they have defined and to overcome institutional resistance to change.

Encouraging the establishment of voluntary professional board accreditation for superior teachers would do much to enhance the quality of teachers. The National Board for Professional Teaching Standards^a will set standards for professional board certification for superior teaching ability. The Congress has authorized the DoEd to match private contributions to finance the development of the necessary assessments of how teachers meet those standards.

Ensuring fully professional teacher training: the single professional path to teaching or practice in math and science. Colleges and universities with strong science and math faculties should provide an undergraduate major in math or science leading to a bachelors degree with electives that qualify a student for a teaching certificate or entry to graduate study, or both.^b The National Science Foundation should encourage this integration of undergraduate preparation of future science teachers and researchers. This approach offers the NSF a means to align the interests of both its research and education constituencies and allows federal investment in higher education in science and math to be leveraged to produce more well-qualified teachers. Specific incentives should be created to attract minorities into the profession, such that in ten years there would be enough fully qualified science and math teachers and researchers to more nearly match the demography of the student body, and thus providing role models for all students.

Colleges and universities, along with science centers and museums, are among the institutions appropriate for encouraging young people, especially minorities and women, to pursue professional education in math and science. Professional societies and other not-for-profit institutions,[26] together with national laboratories (e.g., in DoE and NIH) and other laboratories, can also make substantial contributions to in-service teacher training and classroom enhancement.

^a Creation of this board was a principal recommendation of the Carnegie Commission task force on teaching as a profession, described earlier. It is a private professional body, whose board of directors has a majority of active classroom teachers, devoted to setting standards and providing teacher assessments for professional board qualifications in teaching.

^b For example, Vanderbilt University, with the cooperation of the State of Tennessee education authorities encourages all its undergraduates to pursue this option, which can be fulfilled with the proper choice of electives without any sacrifice of the requirements for the science major. This approach was recommended in the Carnegie Corporation's study *A Nation Prepared: Teachers for the 21st Century*, loc. cit.

Recruiting qualified math/science teachers for every school. There are many urban and rural schools without qualified and adequately trained math and science teachers. One way of addressing this problem is through a teacher corps program whereby needy schools could apply for teachers to be assigned for a fixed period of time, providing the school district commits to picking up the full costs of those teachers over time. Alternative paths to teaching certification will be needed to meet this goal. Another approach to addressing this need is through competitive grants for teacher training programs targeted to the inner city and rural areas.

Although there is debate about the degree of mismatch between supply and demand for all teachers, there are serious concerns about the falling supply of math and science graduates for both school teaching and professional practice, and the quality of preparation of the teacher workforce. As Nobel laureate physicist Sheldon Glashow put it, "What I hope for by the year 2001 is that middle and high school teachers know more about science than their students are expected to learn".

■ **Establish a national center for educational content and assessment.**

A federally-funded but independent center should be created to reach a consensus and advise the nation on what students need to know and what competencies they require to be productive in the workplace of today and tomorrow. This work would have a critical influence on curriculum, teaching materials, and teacher training. Math and science should have high priority in this work, and might form the focus of its initial work.

That such an institution can be very important is demonstrated by the National Assessment Governing Board (NAGB), a Congressionally-established, OERI funded, independent body that recently completed an assessment of 8th grade mathematics performance in U.S. schools. The NAGB is introducing open-ended questions that test students' reasoning ability. This kind of work has important implications for how any national assessment is done.

Research to develop better testing methods, defined in relation to the descriptions of educational content, should be devised by such an independent institution. Once the assessment methods have been worked out, the assessments must be competently administered by an independent organization. The same institution could serve this purpose.

Such a center might well be established under the guidance of the National Goals Panel, which would ensure that the states, the Congress, and professional

organizations are full partners in this work. The Department of Labor should have a significant role in it. The consensus it seeks should embrace not only the diverse parts of the education community but also parents, employers, and citizens generally.

- **Strengthen educational systems research and analysis to support the reform strategy. Establish broad-based support for basic cognitive and applied learning research and field testing of innovations resulting from this research.**

Inadequate attention is being given by federal agencies to research and analysis of the K-12 educational system to ensure that public policy alternatives are based on solid evidence and strong basic and applied research. Without a strong capability to pull together the best data and analysis in this area, federal officials will have great difficulty resolving conflicting views about what the national strategy should be, and what the federal role is in it. The Task Force suggests that serious consideration be given to establishing a Center (organized as a Federally Funded Research and Development Center), charged with assembling the best analytical understanding of the K-12 education system, and providing "systems engineering" support for educational diffusion programs. This center should promote the closest possible relationship between university researchers and users of research results in the schools, such that practice informs research even as researchers inform practice. The center should be established by DoEd, most likely by OERI, but with NSF participation. A prerequisite to its effectiveness is to strengthen the OERI staff that will have the responsibility for establishing the Center and to ensure its competence and usefulness.

The last two decades have seen important advances in understanding, much of it specific to math and science learning. Unfortunately, the number of experienced researchers is small, and the field has suffered from lack of stable funding. In addition, there has been serious under-investment in the applied research on translating new learning theories into classroom practice, with field experiments to validate it.[27] The NSF estimates that it devotes only a \$7 million education research effort to that objective[28]; the DoEd Research and Development Centers make additional investments of a similar magnitude. While educational research has lacked consistent support and attention to quality in the past, rapid progress in cognitive science and applied learning research is possible, if the research is funded competitively in response to the best proposals from university and other experts. In addition to the DoEd and NSF, the FCCSET

CEHR should encourage other agencies to be an active source of support for peer reviewed research from diverse sources of research talent.

- **Ensure diffusion of successful innovations: provide access by all schools and all students to tested educational improvements and support their successful adoption.**

It has been characteristic of educational research that many innovations have been shown to be very effective when tested in one or a few schools, yet few have been widely adopted. Neither the federal agencies nor the education networks within states have been effective in promoting widespread adoption of promising programs. There must be much greater emphasis on diffusion and adoption of the best education products and initiatives the nation can devise. As noted earlier, the FCCSET study reveals that of the \$524 million devoted to math and science education by federal agencies in 1991, only \$5 million, or 1%, is devoted to the diffusion of promising innovations. This is wholly inadequate.

If diffusion and adoption are not facilitated, the other expenditures on school reform, education research, etc., activity that the states cannot hope to fund individually, will have been wasted. DoEd's current efforts at diffusion, through the National Diffusion Network and the Educational Resource Information Center, are underfunded, have a poor reputation for turn-around time, and lack the collaborative relationships required for successful technology transfer. A major upgrading of this capability is required.

Successful diffusion of new ideas, materials, and methods requires active collaboration between schools and those who have successfully practiced the innovation. The Michigan Partnership, with associated educational extension services, represents an important effort to provide such services.

The private sector should be encouraged to participate in diffusion activities. The textbook and computer software industries make considerable investments in the development of integrated curriculum materials, and are important intermediaries in the dissemination of curriculum innovation in math and science as well as other fields. K-12 schools should have access to sources of support, materials, in-service training, and other services from both public and private sources.

This could be facilitated inexpensively by access to an electronic information network such as the proposed National Research and Education Network (NREN). NSF has been the leader in the development of NREN's predecessor, the INTERNET, and plays a major role in the Federal Networking

Council which will determine how NREN is to be created and managed. If teachers and principals could have inexpensive access to sources of materials and expert guidance on their use, costs could be minimized. But distributing ideas and information to guide the adoption of successful ideas is not sufficient; some form of extension service, presumably state operated, is needed in addition to information distribution.^a

One means of facilitating diffusion and adoption might be a two-stage funding incentive to outside organizations, which could receive a grant for initial demonstration of an innovation, to be followed, if promising, by a larger grant to finance wider scale implementation.[29]

- **Empower all federal science agencies to take a leadership role in systemic reform of K-12 math and science education.**

Major innovative projects undertaken by communities, cities, and states to improve math and science education should be able to come to the federal government for guidance, evaluation, and an opportunity to compete for funding. The President's *America 2000* report promises to "unleash America's creative genius to invent and establish a New Generation of American Schools, one by one, community by community." [30] The goal is to create over 535 such schools (at least one in each Congressional district) by 1996. While this directive could win political support, targeting urban and rural schools would address the major problem areas and be a more dramatic test of reform strategy. Indeed, 250 out of the 16,000 school districts in the country educate 30% of school children.[31] The DoEd, with its involvement in the school network in every state, is the obvious federal leader in this effort, though the NSF may have important input as to how schools might be organized to access the scientific expertise of the community, national labs, and universities and research institutions receiving government funding.

Improvements in math/science instruction require reform of the school environment, and this reform requires the cooperation of chief state school officers, local school officials, teacher organizations, universities, the private sector, and citizens groups. Agencies can encourage and stimulate such cooperation. For example, the NSF has initiated the Statewide Systemic Initiatives Program for math and science, placing states in competition for grants to create detailed reform plans. This program has promise, since the states,

^a Extension services of the Department of Agriculture (which have been highly successful) provides a model, but the extension agent model is expensive; half of the USDA R&D budget is devoted to extension services.

including some that did not receive grants, have made substantial progress toward building consensus for reform. If such programs are to reach all the states, the NSF will be hard-pressed to finance them. NSF's S.S.I. program might be considered the model for an expanded effort of this kind by the DoEd once OERI has demonstrated the capacity to manage the program.*

Every science agency of the government should have an explicit education charter defining its responsibilities to address precollege issues -- materials, elements of curriculum, teacher skills and knowledge upgrading, outreach of scientists and engineers to the schools, encouragement of university/school linkages -- that lie within the agency's special technical expertise and human resource requirements.

- **Encourage private sector development of educational materials, curriculum, textbooks, and software for new educational technology.**

The NSF, with its excellent relationship to university scientists, professional societies, and the science academies, has historically played a leading role in science and math curriculum development, and continues to do so.[32]

However, NSF has given insufficient attention to collaboration with educational innovators in the private sector: textbook publishers, educational software firms, and video producers, who not only make significant educational investments but have the capability of diffusing innovations throughout the country. NSF should go beyond the support of research and invest in prototype development, with primary reliance on private firms for commercialization.

- **Encourage science centers and museums, educational television, and other sources of "informal" education.**

Ample evidence of the power of non-traditional education to interest students in the study of math and science and to explode negative stereotypes of science and scientists -- for example through science centers and museums, television, and science fairs -- suggests that this should be a significant component of the federal strategy. Many of the best science centers -- San Francisco's Exploratorium and Chicago's Museum of Science and Industry, for example, go far beyond the vital role of motivating young people to be interested in science,

* There is concern that the DoEd does not have sufficient staff or experience with objective peer-review standards to take responsibility for the SSI program. The Task Force recommendations on staffing and funding address those shortcomings.

and create vitally needed educational materials. The Lawrence Hall of Science, for example, produces science teaching materials used by 100,000 teachers and 5,000,000 students.* This is another area in which the private sector can be more involved, both through their foundations and through opening laboratories and personnel to the K-12 classroom. Some kind of coordinated encouragement could be managed through a DoEd/NSF matching grants program.

The FCCSET report notes that \$100 million, nearly 20%, of the \$524 million invested by federal agencies in pre-college math/science education, is devoted to non-traditional educational environments. Since these activities touch the spirit and excitement of science common to all of the technical agencies in the CEHR, the NSF and the other science agencies should be the main contributors.

- **Provide an information and referral service to document innovations and help innovators locate programs, services, information, and support concerning K-12 math and science activities.**

Individuals outside the federal agencies have difficulty locating the correct agency through which to gain access to program materials, services, and information -- a particularly severe problem, given the large number of participating agencies. A central office is needed in which requests for possible federal sponsorship of non-federal activities are screened and referred to the appropriate agency.

It would also be valuable to develop a comprehensive picture of who is doing what, by collecting information on innovations originating outside the federal government. This would most appropriately be housed in the DoEd, as such an office would probably not be discipline-specific. Large programs, or those appropriate for multi-agency support would be identified and referred to CEHR to identify and assemble cooperative resources. Much of the function described here is analogous to the very successful National Library of Medicine, and like that Library's MEDLARS service, should be integrated with the networks providing education diffusion services.

The complexity of these efforts for change and the links between the responsibilities assigned to the DoEd and the NSF demonstrate how essential it is for the two agencies to develop a very close working relationship. This does not imply that other agencies of the government should be excluded from any of these activities. Lead responsibility for each endeavor, however, should be

* Interview with Glenn Seaborg, Chairman, Lawrence Hall of Science; June 6, 1991.

assigned to one or the other of these two players. The Task Force recognizes that some time must elapse before the DoEd has all the needed professional capabilities and the NSF has developed the relationships with officials in states, cities, and communities necessary for full effectiveness of their efforts.

WHO SHOULD DO WHAT FOR MATH AND SCIENCE EDUCATION?

In summary, the several elements of reform and innovation recommended above can be distributed between the DoEd and the NSF as follows:

Primary missions for the NSF:

- New math and science teacher recruitment.
- Math and science teacher education revitalization.
- Science and math teacher enhancement.
- Innovative curricula and educational materials.
- Cognitive and applied learning research; field testing innovations.
- Non-traditional, motivational education activities.

Primary missions for DoEd:

- Education research, field testing and education systems analysis to inform the reform strategy.
- Research on assessments of educational progress and their national application.
- Incentives for state reform initiatives.
- Rapid diffusion and adoption of successful innovations.
- Innovative means of operating schools.
- Clearinghouse and referral service for guiding new efforts.

PART VI

STRENGTHENING THE KEY FEDERAL AGENCIES: DoEd and NSF

In order to take the lead on the initiatives above, DoEd and NSF need to be strengthened. The Department of Education, and especially the Office of Educational Research and Improvement (OERI), should give priority attention to the competence, experience, and management policies necessary to operate the kind of competitive, targeted programs required to make rapid progress in math and science and other disciplines. The OERI needs to augment its staff with experienced and respected scientists and mathematicians familiar with managing innovations that are devised outside the government. To ensure the continued infusion of talent, the DoEd should ask Congress to authorize the appointment of a limited number of "rotators" as NSF does. The DoEd should then be given greater latitude in the use of its funds in pursuit of the national goals.

Until recently, the NSF Education and Human Resource Directorate followed the practices of the research directorates in NSF in responding to unsolicited research proposals primarily from university faculty. It now practices a more directed style, making program announcements in pursuit of an agency strategy, and working directly with states and schools in many of its K-12 activities. To be even more effective, the NSF needs to gain additional staff with field experience in K-12 education, strengthen its relationships with all elements of the educational system, and build a better balance between permanent professional staff and rotators who are essential for increasing effectiveness and maintaining access to new ideas. Arrangements for close and effective collaboration with the DoEd are of critical importance.

MISSIONS FOR OTHER FEDERAL AGENCIES

By taking initiative on behalf of a government-wide effort to upgrade math and science education throughout the nation, the Secretary of Energy demonstrated the power of agencies with vast technical resources to take a long-term view of their missions and act accordingly. The Department of Energy should continue its leadership of the CEHR and through that mechanism ensure that all R&D-intensive agencies coordinate their contributions to math and science educational progress. The FCCSET report By The Year 2000 summarizes for the first time the great variety of other agency activities touching on K-12 math and

science education, from programs of direct support of school-based activity and informal education to the voluntary activities of federal laboratory personnel. In some agencies, the activities derive from an agency-specific charter (e.g., the Department of Interior's Youth Conservation Corp, programs for Native American youth, and others totalling \$22 million; the Agriculture Department's 4-H Youth Development School Enrichment Program, costing \$42.5 million; and the Department of Labor's efforts to enhance the competence of our technical workforce). In other agencies, the mission is implicit because of their dependence on a continuing source of quality scientists and engineers.

If orchestrated into a more coherent strategy for educational improvement, the benefits of these programs might be leveraged substantially. In addition, certain agencies having an abundance of technical talent, have specific opportunities to make a contribution which the Administration and Congress might seize and put into effect. Examples for such efforts by three agencies are given below. If, however, these and other agencies are to make more substantial contributions to pre-college math and science education, they will need clearer statutory authorization to do so than they have now. In a later section, we will recommend steps to be taken by the President and the Congress to address this issue.

National Institutes of Health

The National Institutes of Health (NIH) and the National Institute for Mental Health have research mandates similar to that for the NSF, but are directly oriented toward basic and applied health research. Their involvement in education is heavily oriented toward post-graduate and professional medical education. In 1991, NIH's pre-college science and math education investment was \$22 million, or about 0.2% of its budget, its participation in undergraduate education was \$61 million, or 0.6% of its total budget; and its graduate investment was \$414 million, or about 4% of total budget.

As the shortcomings in K-12 math and science education begin to affect the health professions in the same way they are affecting physical sciences and engineering, NIH will need to play a major role and invest more heavily in early intervention to attract students and to help prepare them in math and science.

The Task Force recommends that NIH study the future impact of deficiencies in K-12 math and science education on the nation's health-related research and professional human resources, assess the extent of its responsibility to address the human resource pipeline on which the nation's

health and health industry depend, and design a long range program, coordinated with NSF and DoEd, based on the findings.

Department of Defense

The investment of the DoD in science and math education is even more skewed toward higher education than is the case in the NIH. However, DoD has great experience with efficient skills training, and has unique capabilities and resources at hand that may be very useful in the current reform efforts in the pre-college area. DoD has been very aggressive in educational technologies; has success in training of students at all levels of ability and socioeconomic background; and has proficiency at teacher training. As part of the President's interest in "a new generation of American schools," DoD might undertake to demonstrate its capabilities in model schools serving defense-impacted communities.

The Task Force recommends that the DoD, recognizing the increasingly sophisticated technical skills required of the military voluntary forces, consider creating model federal schools in which to demonstrate DoD capabilities in educational technology and processes, and transfer these capabilities to the civil sector..

Department of Labor

The Department of Labor (DoL) may be the sleeping giant of the national science and math education reform effort. With its command of resources, outreach, and direct links to American competitiveness, it has the potential to become a partner in math and science education on the scale of NSF and DoEd. Until very recently, most people have separated the world of work from the world of school. This is the crux of the mammoth problem of the school-to-work transition in the United States (which is much more successfully dealt with in a number of other countries, notably Germany and Sweden).

In the future, the DoL will have a profound influence on school curricula through its specification of the knowledge base and skills base needed to move from school to the workplace. Its analysis of technical competencies will have a profound affect in the areas of math and science. The Department of Labor should support and encourage high school apprenticeships and other programs to facilitate school-to-work transitions and other meaningful ways of integrating school and career paths.

The Task Force believes that science and math education would benefit from increased interaction between the NSF, the Department of Education, and the Department of Labor; a mechanism for this interaction, perhaps through the FCCSET (CEHR) structure, should be devised.

Other Departments

Other Departments with strong technical capabilities have much to offer the public schools in math and science. Some, like Energy and NASA, have national laboratories of great strength and depth, and can not only contribute to schools in their communities but can motivate teachers and provide innovative ideas to developers of curriculum and teaching materials. Still others like the Departments of Agriculture and Interior and the Environmental Protection Agency have a widely distributed federal professional presence and through programs like the 4-H clubs can reach very large numbers of young people. Still others, such as Commerce, can help enlist businesses and other institutions in the reform effort. Specialized agencies, such as the Smithsonian Institution, have unique resources not available elsewhere. These opportunities have been extensively surveyed by the FCCSET and, if properly supported and coordinated, can make a big contribution.

The coordination and accountability for science and math education activities of all the technically-based government agencies should be firmly and permanently supported through the FCCSET structure.

PART VII

DECIDING ADMINISTRATION POLICY AND AGENCY ROLES

The questions to be addressed in this section are:

- Where in the federal government structure should decisions on policy, strategy, and agency mission assignments for K-12 education be located?
- Where in the federal government structure should decisions on operational responsibility for K-12 math and science education reform activities be located?

ADMINISTRATION POLICY AND OVERSIGHT

Ultimately, of course, the President decides both questions. But the parallel and seemingly independent origins of the FCCSET and the *America 2000* strategies, mentioned above, point to the need to clarify responsibilities within the Executive Office. Further, the dispersion of responsibility across the Administration, the Congress, the states, and the private sector points to the need for a continuing mechanism for interlacing their strategies.

The President has made education a highly visible part of his domestic policy. The Assistant to the President for Economic and Domestic Policy has been a focal point in the White House staff for promulgating the strategy expressed in *America 2000*. However, overall education policy clearly falls within the province of the Domestic Policy Council,^{*} and the responsibility for defending and developing the education reform strategy falls primarily to the Secretary of Education, who has also assumed the chairmanship of the Education Policy subcommittee of the Council.

For questions of math and science education specifically, the primary staff responsibility in the White House falls to Dr. Allan Bromley, the President's Science and Technology Advisor, who also serves as Director of the OSTP. Dr. Bromley sits on the Domestic Policy Council and also chairs the FCCSET and

^{*} There is a largely moribund organization on the books called the Federal Interagency Committee on Education, but it has apparently been superseded by FCCSET and other offices in the Executive Office of the President.

uses its CEHR to help coordinate the work of the 17 agencies most involved with scientific and technical matters.

The Task Force concludes that two existing channels of White House oversight of math and science education activities, in addition to OMB, are both required: (a) the DPC for overall education policy (largely through the DoEd), and (b) the OSTP, through FCCSET and its Committee on Education and Human Resources, overseeing NSF, DoEd, and 15 other agencies.

This form of organization (see Figure 1) is not as clean as a single channel of authority with unique assignment of staff oversight responsibility, but it reflects the reality that, while math and science education is a vitally important matter in its own right, it is imbedded in the overall K-12 education system which is the focus of a highly visible set of domestic policy issues going far beyond math and science.

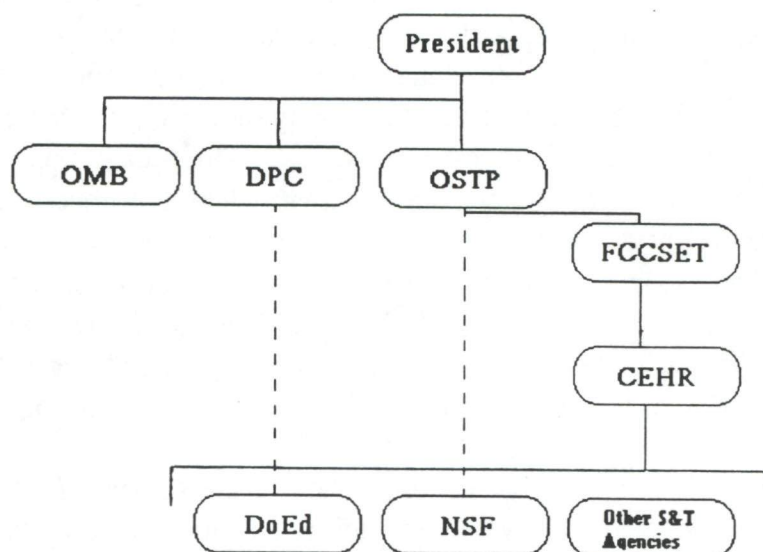
The CEHR has proved a very useful instrument at a time when many agencies depend heavily on the human resources produced by the math and science education process, and when the NSF and the DoEd, the two agencies with primary missions in this area, have had little experience in collaboration. The facts that CEHR is chaired by an influential member of the FCCSET from an agency other than the NSF or the DoEd,^a and that OMB is well represented, have made possible the process of developing a comprehensive federal agency strategy on math and science education. This mechanism may not be as badly needed in five or ten years, by which time the joint development of NSF and DoEd activities may have matured and developed active relationships with the other agencies involved.

The Task Force recommends that for a transitional period of perhaps five years, the OSTP appropriation be expanded to provide funding for the operation of CEHR as a standing committee of FCCSET, with a full time staff devoted to the coordination of agency activities and the review of agency strategies for K-12 math/science improvement in the quest for an integrated federal strategy. The current pattern of two vice-chairmen of CEHR drawn from senior executives at the DoEd and the NSF should be continued.

Within OSTP, the Associate Director for Policy and International Affairs has ably managed K-12 math and science education issues, helping Dr. Bromley provide oversight for CEHR. If CEHR is to have a continuing role in the review and coordination of K-12 math and science education, the demand on the time of OSTP staff will be a substantial burden to the office. We recommend that the

^a Admiral James Watkins, Secretary of Energy, is chair of CEHR.

Figure 1. Organizational Chart of management and oversight for federal K-12 science and math education activity.



This chart depicts the major channels of White House oversight discussed above:

- 1) *The Executive Office of the President interacts with the DoEd through the Domestic Policy Council (DPC). The DPC and the DoEd have the strongest role in defining overall education policy, but in math and science, OSTP and CEHR have the stronger role.*
- 2) *The natural policy channel of supervision of the NSF is through the OSTP.*
- 3) *The math and science education activities of the NSF, the DoEd, and all the other agencies are reviewed and coordinated by FCCSET's CEHR, reporting through OSTP to the President.*

Director of OSTP assign to one of the Associate Directors full-time responsibility for math and science education. This Associate Director could also cover higher education issues and basic research, to which K-12 issues are closely linked. Alternatively, the K-12 science education issue could be the sole responsibility of an Assistant Director.

The FCCSET report observes that the "vast network of Federal scientific laboratories, technical facilities, and expert personnel, and the science- and mathematics-related information and materials they produce...have a previously unrecognized and under-utilized potential for rapidly improving the basic science knowledge of American teachers and students."^a FCCSET makes an excellent case that all of these efforts will be more effective if they are orchestrated into an integrated federal response.^b Although the report advances a multi-agency strategy to this end, it does not address explicitly the statutory basis for the pre-college activities of these agencies (other than the NSF and the DoEd). While advocating more emphasis on pre-college activities (relative to graduate and post-graduate programs), the report may not constitute a sufficiently strong mandate to produce the desired agency response.

The nation faced a similar situation in the immediate post-WWII period, when wartime research activities were being terminated and the government was searching for policies to replace war work with peace-time investments in research in fulfillment of federal missions, both civil and military. A particular concern, reflected in Vannevar Bush's 1945 report to President Truman,^c was that the nation would under-invest in that component of research of greatest value over the long term: basic research carried out in university laboratories. The practical interpretation of Bush's recommendations came in 1947 in what is known as the Steelman report.^d The Steelman Report set goals for federal R&D funding (1 percent of GNP) and for public and private R&D (3 percent of GNP); it also proposed a rate of progress toward these goals (15 percent/year). A few years later President Eisenhower made an Executive order establishing the principle that every agency making substantial use of science and technology

^a FCCSET Committee on Education and Human Resources, *By the Year 2000: First in the World*, Washington DC: Exec. Office of the President, 1991, page 2.

^b *By the Year 2000* loc. cit. p. 16.

^c Vannevar Bush, *Science the Endless Frontier*, submitted to President Truman, July 5, 1945, republished by the National Science Foundation, May 1980.

^d President's Scientific Research Board, *Science and Public Policy: Administration for Research*, 3 vols. Washington DC: Government Printing Office, vol. 1, p. 26, 1947.

resources should proportionately re-invest in the source of that knowledge -- basic science.

Today Americans find themselves in a similar situation. But this time it is the skill base, in addition to the knowledge base, which is in danger of frustrating the attainment of national goals. The FCCSET report shows that agency heads are making conscientious efforts to use their resources to help out in public education reform, especially in math and science. But their mandate to do so is sometimes limited, sometimes unclear.

The Task Force is concerned that, despite the President's encouragement to the agencies to make a contribution to K-12 math and science education and the broad support in the Congress for educational progress, the budget process will impede the "integrated federal response" called for in the FCCSET report. Agency officials defending their budgets before skeptical appropriations subcommittees may find it difficult to defend long term commitments in science education without clear mandates from the President and Congress.

Accordingly, the Task Force recommends that every agency dependent for its mission on a strengthened system of math and science education invest in improving the education pipeline that creates the needed skills. This policy instruction should be put forward in an Executive Order, with implementation guidance to be provided by OSTP, OMB, and FCCSET. OMB should review the statutory flexibility of each of the agencies to see if amendment of enabling statutes is needed.

ASSIGNMENT OF OPERATIONAL RESPONSIBILITIES TO THE FEDERAL AGENCIES

There are various alternatives for assigning lead responsibility for planning and directing activities in K-12 math and science education. These alternatives are (a) lead responsibility to an office in the Executive Office of the President, presumably OSTP, (b) assign the full responsibility to the DoEd, with NSF and other agencies in support, (c) give NSF lead responsibility for math and science education, relieving DoEd of this area of education, and (d) merge DoEd and NSF into a single Department of Education and Science. (These options are discussed in Appendix B.)

Our conclusion is that sharing overall responsibility between NSF and DoEd, with each assigned specific responsibilities, is the best and the only realistic choice. Timely achievement of national goals for K-12 math and science education reform demands capabilities and legislative authority unique to DoEd

and to NSF, both agencies must play important, distinct, and interdependent roles. In this partnership, the DoEd will play a lead role in systemic change; the NSF will play a lead role in research-intensive activities and teacher training specific to math and science, drawing on the professional talent in the nation's universities and laboratories.

A DOED/NSF JOINT OFFICE FOR K-12 MATH AND SCIENCE IMPROVEMENT

As Walter Massey, the new Director of the NSF, put it, "Separating science from science education is wrong, but separating science education from education is wrong, too."^a As noted in Parts V and VI, science and math education should not be the sole province of either the NSF or of the DoEd. The NSF and the DoEd are far and away the major federal players financially and programmatically in formal science and math education, and they require a special joint structure or collaborative device (apart from the FCCSET structure^b) to take advantage of their complementary strengths, coordinate similar efforts, maintain communications, ensure common policies in dealing with the states, and maximize agency accountability. This structure should also allow the two agencies to approach congressional committees jointly on math and science education matters.

The Task Force recommends that the DoEd and the NSF create a mechanism for collaboration such as a Joint Office for Math and Science Improvement. It would report directly and jointly to the Secretary of Education and the NSF Director.[33]

The mission of the Joint Office would be to insure coordination and communication between the two agencies. In addition, the Joint Office could act as a clearing house for science and mathematics education program assessments of all the other concerned agencies and compile these in a biannual report (perhaps to FCCSET) that would assess progress. The Joint Office would also be charged with suggesting new programs and new procedures for federal intervention to help fine tune the federal effort as the science education situation begins to respond. Such a centralized entity could serve as the repository of

^a Presentation to the Task Force on K-12 Science and Math Education of the Carnegie Commission on Science, Technology, and Government, March 25, 1991.

^b The current FCCSET Committee on Education and Human Resources is not a substitute for this function. It is a device for reporting to the President through his science advisor, and it is concerned with missions and resource allocation, not with operations. Further, it covers the activities of too many agencies in addition to NSF and DoEd.

educational data in math and science, as a commentator on the efficacy of federal intervention, and as a cerebral cortex, collecting and evaluating new ideas and disseminating them to the federal agencies. To do these things, it needs a small, highly professional staff that will make use of existing agency facilities and experiences. The opportunity to significantly influence policy would assist in attracting an outstanding Executive Director.

Because of the very large number of interested parties and sources of expertise in any program involving federal, state, and private partnerships, it is important that the two agencies in such a Joint Office have access to the same sources of outside advice. One way of accomplishing this is an Advisory Panel for math and science, reporting to the Joint Office. This Panel should be comprised of both educators and scientists.

Figure 2. Chart showing a recommended collaborative office between the NSF and the DoEd.



The DoEd and the NSF collaborate in managing interdependent responsibilities through a mechanism such as a Joint Math and Science Improvement Office between the DoEd's Office of Education Research and Improvement (OERI) and NSF's Directorate for Education and Human Resources (EHR).

ROLE OF CONGRESS

Role of Congressional Committees

The education committees of the Congress, in the House and Senate, are structurally divided much like the executive agencies. The House Science, Space and Technology Committee writes legislation and provides budget authority for the NSF's research and education activities (as well as those of NASA and other independent agencies.) The House Committee on Education and Labor has similar legislative jurisdiction over the DoEd (as well as the Department of Labor and others). The situation is similar in the Senate. The support of both sets of committees will be necessary if a tightly coordinated federal program of math and science education reform is to be successful.

The Task Force recommends that the education and the science committees, particularly those with jurisdiction over DoEd and NSF, cooperatively review the arrangements the Executive Branch may propose to facilitate the coordination of K-12 math and science education activities, and to determine the priority that math and science issues are to enjoy in the intensified program of federal action. One possibility might be the creation of a temporary Select Committee on K-12 Science and Math Education to bring together the appropriate committees in the House and Senate.

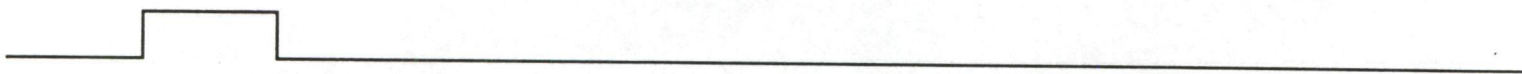
Mechanism for Funding Reform

The Task Force believes that, once the Administration and the Congress are convinced that significant increases in budgets for K-12 math and science education reform will be successful in achieving significant results, additional resources will be made available. Whether such increases become a reality now or later, the present federal funding must also be spent more effectively. As the federal government funds comprise only 6% of school budgets, its expenditures must be leveraged properly, and some mechanism must ensure that more is spent on the incremental cost of reform.

To this end, Congress should give the DoEd new legislative authority to guide the spending of an increasing proportion of that 6%, i.e. to make the grants more competitive, to coordinate and evaluate them, and to terminate the funding if it is not spent for meaningful reform or does not redress inequities in the present system. In science and math education reform, the Office of Education Research and Improvement or the proposed Joint Office

should be the site of most of this activity. Congress should also give DoEd the additional flexibility required for effective collaboration and joint funding of projects with NSF and other agencies under CEHR guidelines. In the past, because of statutory restrictions on DoEd activities in curriculum development, DoEd has experienced some difficulties in co-sponsoring large projects, such as Project 2061, with NSF.

The Task Force recommends that Congress remove any statutory restrictions that might impede the close collaboration between the NSF and the DoEd math and science projects.



PART VII

BUILDING A NATIONAL STRATEGY FOR MATH/SCIENCE EDUCATION IMPROVEMENT

How might the federal government and the states improve their capability to accommodate and execute their education reform strategies, addressing the complex relationships among federal agencies, the states, private groups, and the Congress?

In Part I we called attention to the National Education Goals Panel within which key Governors, the Congressional leadership, and senior figures in the Administration assess progress toward the national goals for the year 2000. The level of representation of these key parties is essential to sustain the commitment to the goals. The Panel has assembled working groups of experts to guide the requirements for data needed from the states and agencies by which to recommend standards and measure progress.

The Task Force suggests that the National Education Goals Panel be supplemented by a council comprised of senior education and science officials from the Executive, the Congress, and the states (such as the Directors of OSTP and of NSF, Chairmen or staff directors of key education committees of the Congress, and leaders of education reform representing state governors) to provide a stronger capability for implementation of consensus strategies.

To form those strategies the government's views (federal, state, and congressional) of reform strategy and priorities should be periodically brought together with the views of the business community, teacher organizations, school boards, educational research experts, parents' groups, and many other groups deeply committed to the national reform effort. Therefore, the Task Force further recommends the convening of a biennial National Conference on Educational Improvement sponsored by either the Goals Panel or by OERI and organized by the council to review the national strategy on math and science reform, and progress toward the national math and science goals. The outcome of the biennial conference would be a public assessment of the pace of progress and the identification of needed changes in strategy.



CLOSING STATEMENT

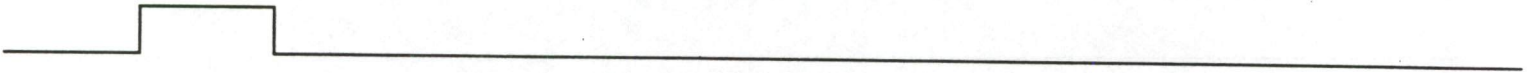
This report suggests ways the federal government can accelerate educational progress in math and science in our schools. Precisely because the federal government has no operational responsibility for local schools, it is free to focus its investments on encouraging systemic change and providing new ideas, materials, teacher training and other resources that the states have great difficulty providing for themselves, with special attention to disadvantaged students.

To these ends, it is essential to rebuild the competence of the DoEd, so that it earns the confidence of the Congress and the public and gains more freedom to innovate. Equally important, the science-intensive federal agencies - have access to the nation's scientific and engineering capabilities and the nation's universities, which are today the best in the world. These talents can and must be mobilized by these agencies if that leadership is to be preserved and joined by world leadership in pre-college math and science achievement.

Is there reason to be optimistic about lifting the capabilities of American students to "best in the world" in the next decade? The current situation has more possibilities for dramatic progress than has been seen for many years. On the other hand, few areas of social development have more often seen hopes crushed and cynicism prevail.

The most likely path to failure, and ultimately destruction of the American dream, is not what happens in the DoEd, the NSF, or even the statehouses and school board offices. It is the complacency of too many American parents who are unaware that their children's future is at risk, the myopia of retired Americans who do not understand that poor schools threaten their social security, and social conditions that result in children entering school unprepared. Most unfortunate is the tragic message our current system sends to young women, minorities, and the poor, that they haven't the talent to master mathematics and science, leading them to erroneously conclude that they shouldn't even try.

The one best hope for success is impassioned, persistent, non-partisan leadership by every American able to make a contribution -- but most importantly by the President of the United States. His crusade in the cause of education, if taken up by Governors, Congressional and other leaders, and the Presidents who follow, can turn this situation around. We can once again be proud of our schools and confident that future generations of young Americans are equipped to lead the nation to new levels of greatness.



ENDNOTES

1. See, for example: U.S. Department of Education, *A Nation at Risk*, Washington, D.C., 1983; Commission on the Skills of the American Workforce, *America's Choice: High Skills or Low Wages*, National Center on Education and the Economy, 1990; Committee on Education and Human Resources, *By the Year 2000: First in the World*, Federal Coordinating Council on Science, Engineering, and Technology.
2. A recent survey by the National Association of Independent Schools reports that three out of every four parents are satisfied with the public schools their children attend, and 45% say they would continue to send their children to public schools even if cost were not a concern; *USA Today*; Wednesday, July 24, 1991; p. 2D. See also Arthur Powell, Eleanor Farrar and David Cohen, *Shopping Mall High School*, Boston: Houghton Mifflin, 1985.
3. A selection of such studies includes: 1) The National Science Board Commission on PreCollege Education in Mathematics, Science, and Technology, *Educating Americans for the 21st Century*, National Science Foundation, 1983; 2) U.S. Department of Education, *A Nation at Risk*, Washington, D.C., 1983; 3) Task Force on Teaching as a Profession, *A Nation Prepared: Teachers for the 21st Century*, Carnegie Forum on Education and the Economy, 1986; 4) U.S. Congress Office of Technology Assessment, *Elementary and Secondary Education for Science and Engineering*, Washington, D.C., 1988; 5) Corporate Task Force on Education, *Undereducated Uncompetitive USA*, Union Carbide Corporation, 1989; 6) Quality Education for Minorities Project, *Education That Works: An Action Plan for the Education of Minorities*, Cambridge, 1990; 7) Commission on the Skills of the American Workforce, *America's Choice: High Skills or Low Wages*, National Center on Education and the Economy, 1990.
4. Dossey, J.A., Mullis, I.V.S., Lindquist, M.M., and Chambers, D.L. *The Mathematics Report Card: Are We Measuring Up?* Princeton: Educational Testing Service, 1988.
5. Robert Langreth, *Science*, Vol. 251, 1991, p.1024.
6. Federal Coordinating Council on Science, Engineering, and Technology, Committee on Education and Human Resources, *By the Year 2000*, 1991, p. 40.
7. F. James Rutherford, *Reflections on the Federal Role in the Reform of Science Education*, Feb. 9, 1990, p. 1: an unpublished paper prepared for the Carnegie Commission on Science, Technology, and Government.
8. U.S. Department of Education, *A Nation at Risk*, Washington DC, 1983.
9. Task Force on Teaching as A Profession, *A Nation Prepared: Teachers for the 21st Century*, Carnegie Forum on Education and the Economy, New York, May, 1986. This reform strategy emphasizing increased qualifications, responsibility, and accountability for teachers was adopted without dissent by the governors at the National Governor's Association meeting of August 1986.

10. In 1981, upon assuming office, the President announced his intention to terminate the recently formed Department of Education, and the budget for the NSF's Science Education Directorate was eliminated. Although the NSF Education Directorate was abolished, it was re-established a few years later, and the Department of Education suffered budget reductions but continued to exist.

11. Examples include systemic reform initiated by a number of governors, private reform initiatives in collaboration with cities, as in Chicago, creation of dozens of magnet and other special schools for math and science, "school adoption" initiatives by private industry, peer mentoring programs for disadvantaged students, and the expansion of computer firms and not-for-profit institutions into new educational technologies.

12. The membership of the National Education Goals Panel includes -- from the Administration: the White House Chief of Staff, the Director of the Office of Management and Budget, the Assistant to the President for Economic and Domestic Policy, and the Secretary of Education; from the Congress: the Majority and Minority Leaders of the House and Senate; from the states: the Governors of Colorado, Missouri, Indiana, Iowa, South Carolina, and Washington.

13. The ethnic mix in the country for children under 18 changed between 1980 and 1987 from 51.0 million white, 9.3 million black, and 1.7 million Hispanic students to 50.4 million, 9.5 million, and 2.6 million, respectively (Source: Department of Education, *The Condition of Education 1990*, Table 1:18-1). Minority populations have grown dramatically since 1987; by the year 2000, some states will have "majority minority" populations.

14. The task force suggests that, in addition to a dramatic reduction in school dropouts, especially among disadvantaged students, (also one of the national goals) an attainable minimum goal can be expressed as follows:

"Ensure that the mathematics and science education preparation of all high school graduates will allow them to be successful in entry level technical positions in the workforce or to pursue successfully a quantitatively-based field of study in college without the need for remedial assistance. Math and science preparation will enable graduates to fulfill their civic responsibilities with an understanding of the scientific dimensions of policies and decisions that affect our citizens and the world."

15. Federal Coordinating Council on Science, Engineering, and Technology, *loc. cit.*, p.6.

16. *Ibid.*, p.26.

17. Robert Langreth, "School Science Surveyed," *Science* Vol. 251, p. 102, March, 1991.

18. There is ample evidence that difference in learning ability are related to the speed of learning rather than what can ultimately be learned. A given level of learning requires more effort on the part of some, but the capacity for learning is nowhere near saturated for even the least gifted in our society. See Herbert Walberg, "Educational Effectiveness: Psychological Problems and Possibilities," in *Issues in Science Education: Science Competence in a Social and Ecological Context*. Thorsten Husen and John Keeves (eds.), Pergamon Press, 1991.

19. For elaboration of this idea see Harvey Brooks, "Educating and Training the US Workforce for the Twenty-first Century," in Dorothy Zinberg (ed.), *The Changing University*, NATO, 1991.

20. To review, "top-down" refers to state-wide or national policies; "bottom-up" changes originate locally, on a decentralized basis. When created by teachers, students, administrators or parents, they may be called "inside-out;" when initiated by non-school institutions (businesses, national laboratories, etc.) they are "outside-in."

21. American Association for the Advancement of Science, Research and Development FY 1991, Washington DC, 1990, p. 78.

22. These programs were authorized to fund initiatives in virtually all school districts, to assure that services for special groups served them directly, and to fund and motivate local educators to deliver those services. Many of the largest programs also required evaluation at local, state, and federal levels; grants to enhance the abilities of state education agencies; and support for R&D programs to improve teaching, curricula, and materials for disadvantaged students. Paul Hill, *The Federal Role in Education: A Strategy for the 1990's*, National Center on Education and the Economy, Rochester, NY, 1989.

23. Sources: Office of Management and Budget, *Budget of the U.S. Government FY 1992*, p. IV-78; Federal Coordinating Council for Science, Engineering, and Technology, Committee on Education and Human Resources, *By the Year 2000: First in the World*, February, p. 313.

24. The other \$118 million goes to "informal education," or off-school-site education: museums, libraries, educational video and computer programs, etc.; FCCSET CEHR report, *By the Year 2000: First in the World*, February, 1991.

25. Since significant parts of the Chapter I, II, and III programs in DoEd do benefit math and science education (along with other disciplines) a more generous accounting might reach a little over \$1 billion, but CEHR made the judgement that it was more appropriate to base the accounting on efforts specifically targeted to math and science education.

25. For science and math specifically, the \$524 million 1991 budget for formal precollege education, as determined by the FCCSET CEHR, includes \$312 million (61%) for teacher preparation programs and \$86 million (17%) for curriculum and materials development, and \$42 million (8%) for student incentives and opportunities. However, this budget includes only \$40 million (8%) for comprehensive reform programs and organizational and systemic change; \$10 million (2%) for applications of technology to education; \$9 million (2%) for program evaluation and assessment; and \$5 million (1%) for diffusion of information and technical assistance. These categories are presented with the caution that they are the result of post hoc efforts of an interagency committee to categorize very different programs. The categories under which each program was created within each agency may have been different from those chosen here; similarly, each program may have the characteristics of more than one category applied by the interagency committee, or may not fall into any particular category.

26. The National Geographic Society, for example, has established a Geographic Education Foundation which trains substantial numbers of teachers of geography, and supports geography education through television and other programs. The "Kidnet" interactive computer network program, funded by NSF, brings hands on scientific skills to middle school students across the country.

27. The categories into which the CEHR allocated the federal agencies' current math and science education activities do not include an explicit category for research. The agencies do engage in relatively modest amounts of applied educational research, which in the CEHR expenditure compilation is assigned to the most appropriate area of application. For example, where the research is associated with development, of curriculum, the associated research is included with development under the heading "pre-college curriculum materials". See FCCSET CEHR report, pp. 120, 283.

28. Estimate by Assistant Director for Education and Human Resources Luther Williams, May 25, 1991.

29. This concept is similar to the two-stage grants for research awarded by federal agencies under the Small Business Innovative Research program. After an initial support for research, and a subsequent showing of potential for commercialization, the grantee may receive a five-fold larger grant to take the work to the next stage of application.

30. *America 2000*, loc. cit., p. 15.

31. Shirley Malcom, testimony to Senate Committee on Labor and Human Resources, 19 April 1990, p.19.

32. Project 2061, a collaboration of NSF with the American Association for the Advancement of Science, the Carnegie Corporation, and others, represents a comprehensive effort to define an integrated and contemporary view of what adults should know about science, with the development of appropriate materials for use in K-12 schools. The NSF is also funding the Scope, Sequence, and Coordination project of the National Science Teachers Association, which is designed to teach a range of science courses every year starting in middle school, as opposed to the traditional "layer cake" approach, with one course per year starting in high school.

33. Since it is only through the joint decision of the two agency heads that a stable balance can be struck between collaboration in shared responsibilities and coordinated but separate activities, it is essential that the Director of the Joint Office have direct access to the two principals in the event there are disagreements within the two agencies. However, the Director must operate collegially with the key officials of each agency: the Assistant Director of NSF for Education and Human Resources and, presumably, the Assistant Secretary responsible for the OERI of the Department of Education. A management device to ensure their active involvement in the work of the Joint Office will have to be created by the two principals.

APPENDIX A:

THE TASK FORCE ON K-12 SCIENCE AND MATHEMATICS EDUCATION

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Former Governor of North Carolina

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Directorate for Education and Human
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James B. Reston
Alice M. Rivlin
Oscar M. Ruebhausen
Jonas Salk
Maxine F. Singer
Hon. Dick Thornburgh
Adm. James D. Watkins (Ret.)*
Herbert F. York
Charles A. Zraket

*Through January 20, 1989

APPENDIX B:

ALTERNATIVE ASSIGNMENTS OF MANAGEMENT RESPONSIBILITY FOR FEDERAL K-12 MATH AND SCIENCE EDUCATION

The Task Force has recommended that both NSF and DoEd have essential and distinct responsibilities for K-12 math and science education. However, these responsibilities are strongly interdependent: neither agency will be successful in making the pace and depth of progress required to meet the national goals without the cooperation of the other. Thus, we have discussed how the agencies might organize to work cooperatively, for example by establishing a Joint Math Science Education Office. Further we call attention to the importance of oversight by the OSTP and OMB, and note the usefulness of the FCCSET and its Committee on Education and Human Resources to this end.

What are the alternative organizational arrangements for achieving the same end, and why were they not recommended? There are merits as well as disadvantages, in our view, in each of four other alternatives:

1. Assign lead responsibility for federal K-12 math and science education activities to OSTP or to a senior executive on FCCSET:

We have recommended that OSTP, operating through FCCSET's Committee on Education and Human Resources, coordinate the federal agencies and review their strategies. In theory the chair of this committee could also be given lead responsibility, working through the committee to engage the maximum number of federal agencies in the task, to spread the cost and engage their talents. Given that two agencies (NSF and DoEd) almost equally divide the math and science responsibility today, there is a case to be made for giving the balancing role to a third party. The Secretary of Energy has shown himself to be an articulate and committed advocate for federal effectiveness in K-12 math and science education.

The primary responsibility should be on the shoulders of one or both of the principal operating agencies. Giving the FCCSET responsibility for managing the math/science education strategy risks separating responsibility from accountability. Although CEHR has proven itself effective, it is a staff body, and its effectiveness depends too heavily on the leadership of the head of an agency for which education is not the primary mission.

2. Assign lead responsibility to DoEd:

The "cleanest" solution from a management perspective is to give the DoEd the role of "lead agency," with the NSF expected to accommodate its math and science education activities to the strategies of the DoEd, or in the more extreme form of this option to transfer NSF K-12 education activities to DoEd, as favored by one member of the task force.

During the past decade, few experts in education reform would have advocated this approach, for the DoEd was widely regarded as ineffective and lacking in sufficient competence. Until recently, the DoEd was generally unresponsive to initiatives taken by the NSF to open up channels of cooperation. Few in the university educational research community would have preferred this choice, and today many state education officials prefer dealing with the NSF rather than with the DoEd.

Recent events support optimism that the DoEd is to be rejuvenated. Its total budget swamps that of the NSF; the DoEd has much higher political visibility and leverage. Virtually every member of Congress cares about public schools; only a few have taken a deep interest in science.

However, organizational decisions today should reflect today's reality. The DoEd, whose mission has been a matter of controversy almost from its inception,^a has never had the opportunity to develop its capabilities. It has little capacity in math and science education beyond some experienced senior staff in the Office of Educational Improvement and Research and one or two other offices. The Congress has not yet indicated its willingness to unleash the DoEd as the agent for structural change in pre-college education, nor has the DoEd shown how its internal capability is to be upgraded.

The Task Force hopes that the DoEd will acquire the sophistication to take a leadership position in educational innovation and diffusion in math and science as well as in other fields. However, the importance of integrating the national strategy for math/science teaching into the strategy for national leadership in math/science research is so great that the NSF will always be needed to play a major role.

^a Within 18 months of the DoEd's establishment, President Reagan came into office and recommended that the agency be abolished. While this was not done, there were deep differences of view between the Reagan Administration and the Congress over the mission and budget of this agency for the next eight years.

3. Assign lead responsibility to the NSF:

Another possibility is that the NSF be given the lead agency responsibility for math and science education improvement, with DoEd expected to accommodate its programs to NSF's strategy as they relate to math and science. This assignment draws most directly on the statutory assignments of mission, and reflects the much greater strength of the NSF staff in math and science than is found today in the DoEd. One might argue that science and math education should be dealt with separately from education in other disciplines for all the reasons outlined in sections II.b and III. Thus, recruitment of students and teachers, teacher training and retraining, curriculum development, and education research in mathematics and science would all be developed by the NSF. The NSF's launching of the Systemic Statewide Initiative indicates that NSF can indeed address systemic issues, and work with leaders in the states. The DoEd would be a secondary player employed primarily for its diffusion capability.

Such an arrangement would require a major expansion of the NSF K-12 education budget, something that may not be acceptable to its research constituency, and implies that the DoEd, a much bigger agency with far higher political visibility, would in fact follow the NSF's lead. Neither seems realistic. In any case, the larger job of systemic school reform clearly requires efforts outside math and science, and should provide the context for the NSF's focused effort on math and science.

4. Create a Department of Education and Science

There is a fourth alternative, although favored by almost no one in the U.S. scientific community. Many other industrialized democracies have Ministries of Education and Science, combining the functions that in the U.S. are assigned to NSF and Department of Education. We do not recommend it for this country. The diversity of state-supported public and private and private universities is a major asset in the U.S., as is the competitive research support system from multiple federal sources. The independence of universities from federal control also facilitates institutional innovation, including cooperative relationships between university science and industry. There are also powerful reasons to believe this would not be in the best interests of U.S. excellence in scientific research, a very important concern going beyond the scope of this report.

APPENDIX C:

SPECIAL PROBLEMS OF SCIENCE AND MATH EDUCATION

There is not much dispute about a number of outstanding problems specific to math and science education that remain to be addressed:

- Rote learning in math and science, aggravated by the emphasis on standardized testing, leaves students without the capacity to think quantitatively and solve problems for themselves.
- Even in schools that offer science courses, the sequential nature of courses in different science subjects deprives students of the opportunity for integrated learning.
- The rapid obsolescence of scientific knowledge necessitates a different approach to teacher training from the traditional one.
- Declining minority representation among teachers and other professionals in technical fields (in relation to the mix of students) is a particularly serious problem for math and science education.

GLOSSARY OF ACRONYMS

AAAS	American Association for the Advancement of Science
CEHR	Committee on Education and Human Resources, FCCSET
DoC	Department of Commerce
DoD	Department of Defense
DoE	Department of Energy
DoEd	Department of Education
DoI	Department of the Interior
DoL	Department of Labor
DPC	Domestic Policy Council
EHR	Directorate for Education and Human Resources, NSF
EOP	Executive Office of the President
EPA	Environmental Protection Agency
FICE	Federal Interagency Committee on Education (defunct), EOP
FCCSET	Federal Coordinating Council for Science, Technology, and Engineering
FFRDC	Federally Funded Research and Development Center
HEW	Department of Health, Education, and Welfare, now HHS
HHS	Department of Health and Human Services
NAGB	National Assessment Governing Board
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Association
NIH	National Institutes of Health
NIMH	National Institute of Mental Health
NREN	National Research and Education Network
NSF	National Science Foundation
NSTA	National Science Teachers Association
OERI	Office of Educational Research and Improvement, DoEd
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy, EOP
SCANS	Secretary's Commission on Achieving Necessary Skills, DoL
SSC	Scope, Sequence, and Coordination program, NSTA
SSI	Statewide Systemic Initiative program, NSF
USDA	US Department of Agriculture

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9123308

ORIGINATOR: 02

STATUS I

DIRECTORATE STATUS

FROM: KENNEDY, Donald: STANFORD UNIVERSTIY

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 08/01/91

SUBJECT: RE: HIS DECISION TO STEP DOWN AS PRESIDENT OF
STANFORD AND A COPY OF HIS LETTER TO THE BOARD OF
TRUSTEES.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
INTERNATIONAL/POLICY
LIFE SCIENCES

WHITE HOUSE TRACKING #: CONTACT PERSON:
REMARKS: PHONE: EXT:

CLOSED

OSTP RECEIVED: 08/06/91 FILE: P-DAB-PERSONAL*EDUCATION
DEPT RECEIVED:



STANFORD UNIVERSITY
OFFICE OF THE PRESIDENT

DONALD KENNEDY
PRESIDENT

August 1, 1991

3306
RECEIVED
91 AUG 6 PM 1:17

OFFICE OF THE
DIRECTOR
BUILDING 10
STANFORD, CA 94305-2060
(415) 723-2489
FAX (415) 725-6847

Dr. Allan Bromley
Assistant to the President for Science
and Technology
Old Executive Office Building, 360
17th Street & Pennsylvania Ave, NW
Washington, DC 20506

Dear Allan:

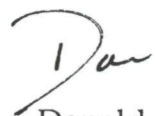
Although you may have already learned of my decision to step down as President of Stanford at the end of the next academic year, I wanted to write you about it directly. The enclosed copy of my letter to the Board of Trustees explains the reasons for this announcement now.

Above all else, I wanted to remove any ambiguity about my personal plans so that my colleagues and I can have a vigorous and productive year tackling the problems we face. Of course, continuing to resolve the indirect cost issues will be a major effort, and the reform package which I sent you earlier does, I think, put that set of problems on the path toward solution.

During this coming year, I want to contribute as much as possible to the development of wise public policies regarding higher education and research -- and as always, I'll be asking your help. Above all, I want you to know how much I have valued your personal advice and support during the past year.

I hope to see you in Washington soon.

Sincerely,


Donald Kennedy

Enclosure



STANFORD UNIVERSITY
OFFICE OF THE PRESIDENT

DONALD KENNEDY
PRESIDENT

BUILDING 10
STANFORD, CA 94305-2060
(415) 723-2489
FAX (415) 725-6847

July 28, 1991

To the Board of Trustees
Stanford University

Dear Friends:

Our meeting tomorrow finds Stanford at an important historical moment. We face many problems, some of which — like earthquake repair and administrative organization — were recognized a year ago. We knew that the solutions to these would take time and concentrated effort. And entirely new difficulties have burst upon us suddenly, with unexpected ferocity and potentially severe consequences.

As a result, we face formidable challenges: to reshape the institution and rebalance its budget, to restore the faith of its several publics, and to replace confusion and doubt inside the Stanford family with the usual confident energy. As you know, we have been working very hard at these challenges — and as you also know, much remains to be done.

The announcement last week of our reform program on the indirect cost issue will move us inexorably forward to resolve our problems with the government on Stanford's accountability for Federal funds. The resolution of these problems will be neither swift nor easy, but I believe it will be sure.

As we have engaged these problems during the recent months, I have been acutely conscious of how distressing and difficult it is for my colleagues to labor constructively in an environment that is so uncertain and so permeated by critical outside attention. I have also been fully aware of the pain and uncertainty felt by

members of this Board, and by so many others to whom this institution is so important. The Stanford family is an inclusive and nurturing congregation, and during the past months it has suffered. You must know that I have shared this pain in a very personal way.

At this critical moment, it will not be surprising to you that I have been asking myself hard questions about the institution's leadership. What actions on my part are most likely to relieve ambiguity about our direction, to heal internal differences, and thus add to the momentum for change and improvement?

I have used the time since our Commencement meeting to gather views on this subject. I have sought the advice of many thoughtful people, including especially some of my wisest colleagues on the Stanford faculty and members of this Board. I am deeply grateful both for the loyalty and the candor that have characterized these conversations. The warmth of the expressions of support and the astringent frankness of the criticism have both helped to form my views.

Over the past six weeks, as I reflected on this advice, my own thinking shifted. With great reluctance at first, but with growing confidence, I reached the conclusion that I share with you now: I intend to step down as President of Stanford University at the end of the academic year 1991-1992.

I believe in change — and the refreshing excitement that follows the recognition that change is coming. At present we are talking too much about our problems and too little about our opportunities. And, to be quite frank about it, there is entirely too much speculation about my future at Stanford. It is very difficult, I have concluded, for a person identified with a problem to be the spokesman for its solution.

We need to banish ambiguity and to look to the future as we resolve the problems of the past. The prospect of new leadership for our new direction will help lift our gaze and renew our spirit. And, knowing the lead-time that it takes to select new leadership and make an orderly transition, I think we should begin that process at once.

In the meantime, there is much work to do. I want this to be a productive year, one that engages with the difficult work of repair and finishes it, leaving a clear track for my successor. I do not intend it to be a lame-duck assignment; I am going to make it a labor of love, and I ask your enthusiastic support in ensuring that it produces the results we all expect.

When that is done, I plan to begin another venture about which I am very excited. You probably know that in my career as a biologist, in government, and in my few *pro bono* commitments outside Stanford, environmental concerns have loomed large. I want to help make Stanford *the* university for academic and policy studies in this arena — a realistic prospect given the extraordinary human resources already represented on this faculty and the enthusiastic interest of its student body. It is a great opportunity.

I look forward to realizing that that ambition — after I have done my best to help form a new Stanford, trimmed and reconfigured for its second century, imbued with new optimism, and faithful to its traditions of excellence, of innovation, and of community.

Sincerely yours,

A handwritten signature in dark ink, appearing to be 'Don', written in a cursive style.

Donald Kennedy

"CORRESPONDENCE TRACKING"

TYPE: ACTION

DOCUMENT NUMBER: 9122066

ORIGINATOR: 02

STATUS I

DIRECTORATE STATUS

FROM: STANLEY, Julian C.: SMPY AT JHU

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/09/91

SUBJECT: REQUEST AS TO WHETHER DR. BROMLEY HAS HEARD ABOUT
THE UNIQUE MODEL EXEMPLIFIED BY THE TEXAS ACADEMY OF
MATHEMATICS & SCIENCE (TAMS).

DIRECTORATE STAFF
ASSIGNED: INTERNATIONAL/POLICY ASSIGNED:

ACTION
REQUIRED: FOR DAB'S SIGNATURE ✓ STAFF
ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: 07/26/91 STAFF DUE DATE 8/12/91
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:
REMARKS:

CLOSED

OSTP RECEIVED: 07/12/91

FILE: P-EDUCATION

DEPT RECEIVED: 7/26/91: was sent erroneously to
Marian Nida for action.

THE WHITE HOUSE
WASHINGTON

July 31, 1991

Dear Dr. Stanley:

This is to let you know how much I appreciated your letter and copies of the articles on successful state-supported programs for mathematically talented high-school age students. Your analysis of the accomplishments of the State of Texas in its support for the Texas Academy of Mathematics and Science is very interesting.

I am sure you will be able to have a more extended discussion about programs such as the ones you cite in your articles during the meeting of the PCAST Education and Human Resources Panel next month here in Washington. My staff and I look forward to this meeting and to the ideas that you and your colleagues will share with us.

Sincerely,

A handwritten signature in dark ink, appearing to read "D. Allan Bromley". The signature is fluid and cursive, with the first name "D. Allan" and last name "Bromley" clearly distinguishable.

D. Allan Bromley
The Assistant to the President
for
Science and Technology

Dr. Julian C. Stanley
Study of Mathematically Precocious
Youth at Johns Hopkins University
430 Gilman Hall
Johns Hopkins University
Baltimore, Maryland 21218



SMPY at JHU

2066

STUDY OF MATHEMATICALLY PRECOCIOUS YOUTH at JOHNS HOPKINS UNIVERSITY

RECEIVED

430 Gilman Hall • Johns Hopkins University • Baltimore, MD 21218 • (301) 338-7087
Bitnet: P31Z1974@JHUVIM Fax: (301) 338-5200, Ext. 7087

91 JUL 12 AM 11:39

Dr. Julian C. Stanley
Director of SMPY
Professor of Psychology
(301) 338-7087 or -6179

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Associate Director
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Postdoctoral Fellow
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Administrative Assistant
(301) 338-7087

9 July 1991

OFFICE OF THE
DIRECTOR

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
The White House
Washington, DC 20500

Dear Dr. Bromley:

On page 14 of the June 1991 issue of the Newsletter of the North Carolina Association for the Gifted and Talented your congratulatory letter of February 1990 to the North Carolina School of Science and Mathematics is reproduced. Having known about this school since its inception, when I was a consultant to the planners, I agree with you that NCSSM is rendering a most valuable service to North Carolina and the nation.

Have you heard, however, about the unique model exemplified by the Texas Academy of Mathematics and Science (TAMS), which began in 1988? It has some points of similarity with NCSSM, but the differences are fundamental. TAMS students take only a largely required set of actual college courses. In two years, as eleventh and twelfth graders socially but college students academically, they graduate with college-junior-year standing.

The TAMS model is far less expensive and susceptible to political pressures than the NCSSM one. I believe that it is preferable for quite able, reasonably mature, highly motivated youths who have completed the tenth grade.

Sincerely,


Julian C. Stanley

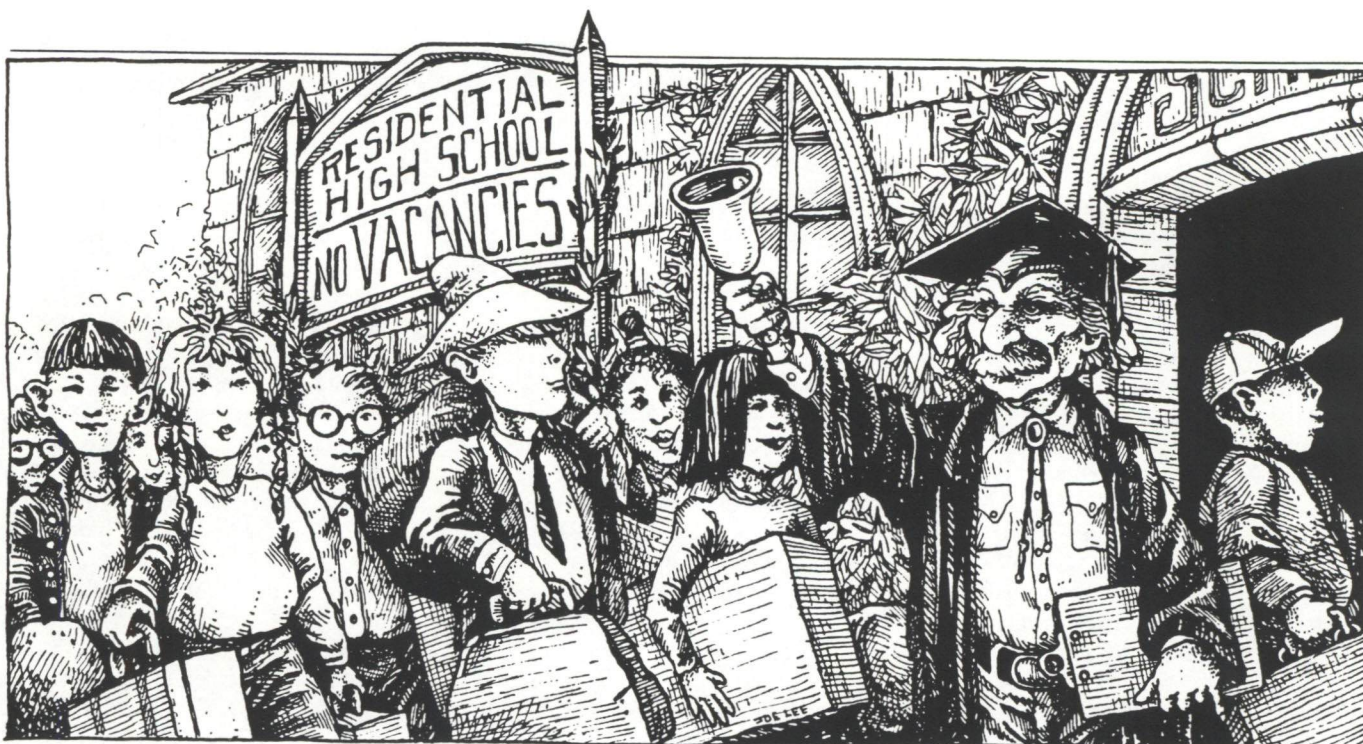
JCS/lrs

Encls.: A set of items about TAMS, The Clarkson School, and "free-standing," sub-college state residential high schools

SMPY at ISU:
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University of North Texas
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(817) 565-3621

A Better Model for Residential High Schools For Talented Youths



Mr. Stanley describes for readers an academically sounder, less politically vulnerable, and more cost-effective version of the state-financed residential high school for young people who are talented in science and mathematics.

BY JULIAN C. STANLEY

IT IS generally acknowledged that there is a crying need for effective training in science and mathematics in the United States. In an earlier *Kappan* article, I gave a qualified endorsement to the establishment of state-financed residential high schools for

JULIAN C. STANLEY is director of the Study of Mathematically Precocious Youth and a professor of psychology at Johns Hopkins University, Baltimore.

youths who are talented in mathematics and science.¹ Since then I have been deeply involved in the development of what seems to me an academically sounder, less politically vulnerable, and more cost-effective version of that idea. I am referring to the Texas Academy of Mathematics and Science (TAMS), located on the campus of the hundred-year-old University of North Texas in Denton, a city north of the Dallas/Fort Worth area.

TAMS is similar in a number of ways to other major state residential high schools, such as the North Carolina School of Science and Mathematics (NCSSM) in Durham and the Illinois Mathematics and Science Academy (IMSA) in Aurora. All of them enroll students who have not yet finished high school: 11th-graders at TAMS and NCSSM, 10th-graders at IMSA. These students are among the academically ablest young men and women in their states. Nearly all of them are college-bound, and quite a few — a much larger percentage than in almost any other type of high school — become National Merit semifinalists (at TAMS in 1988, 20 of the 67 students enrolled).

These high schools are also residential. Students live together away from home and interact with their "true intellectual

peers" every day for two or three years. But only the level of the subject matter they study is unusual. There is no accelerated placement, either by age or by grade. This arrangement helps to avoid the social and emotional problems that can sometimes occur when students skip grades and then must compete and socialize with older classmates. In other words, at IMSA, NCSSM, TAMS, and similar schools in Indiana, Louisiana, and other states, the students have relatively "normal" social and emotional experiences with their agemates, while benefiting from the increased academic challenge.

However, there are ways in which TAMS differs from other state-supported residential high schools. Students at TAMS, who come as 11th-graders, take only regular college courses taught by university faculty members. They have no high school courses. Moreover, nearly all their courses are required: two semesters each of biology, calculus, chemistry, and physics, plus 24 semester hours of well-integrated English, humanities, and social science (the "classic learning core" of the University of North Texas). Beyond these required courses, students may elect whatever additional courses they wish to take and can handle. But they must pass at least 57 semester hours of college work, most of it prescribed, in order to be awarded a high school diploma from TAMS.

Thus all students who graduate from TAMS have completed the last two years of high school *and* the first two years of college in just two academic years. They have had the social and emotional benefits and responsibilities of living with their agemates on a college campus. Of course, they are protected as much as possible from the hazards that 16- and 17-year-olds might encounter on a college campus, and they are carefully supervised and guided by counselors. For example, TAMS students are not allowed to join fraternities or sororities, nor may they date anyone other than a TAMS student without their parents' permission.

A BETTER MODEL?

It seems to me that TAMS is a considerably better model than the more familiar state residential high schools for several reasons. TAMS provides highly

Students at TAMS take only regular college courses taught by university faculty members. Moreover, nearly all their courses are required.

challenging courses, all at the college level and for official college credit. It requires breadth of study in the sciences, humanities, and social sciences. No one is permitted to avoid biology, calculus, chemistry, physics, or the university's classic learning core. Extremely few college students anywhere choose such broad coverage; indeed, most avoid some sciences or some nonsciences during the freshman and sophomore years.

There is also a great political advantage in requiring a rigorous curriculum of all students. For one thing, such a requirement makes infeasible the implied quotas often urged by legislators who represent special constituencies, because most underqualified students could not succeed. Moreover, the *minimum* criteria for 10th-graders applying to TAMS are 550 on the mathematics part of the Scholastic Aptitude Test (SAT) — a higher score than that posted by 63% of college-bound male high school seniors — and a composite SAT score on the math and verbal sections of 1,000, which is higher than the composite score of 61% of college-bound male high school seniors.²

The average SAT math score of entering 11th-graders in the first TAMS class in the fall of 1988 was 652. The class of 1990 averaged 660. The average composite score for 1988 was 1,195 and, for the 190 students entering in 1990, 1,205. These high scores help ensure that TAMS students are capable of doing excellent

college work even with a few gaps in their high school background, such as not yet having taken physics. In addition, because all TAMS students have the ability to succeed in the required courses, it is not necessary to offer several levels of a subject like biology to accommodate a heterogeneous student body.

The experience of being college students academically and living in a special section of a college dormitory for two years tends to encourage TAMS students to mature socially and emotionally, especially in their relationships with one another. They are permitted to go home only one weekend per month, so on most weekends, when almost all the "regular" college students have departed, TAMS students must rely on one another for companionship. TAMS students also have full access to all cultural activities on campus as well as to those in nearby Dallas and Fort Worth.

TAMS is a highly cost-effective model, far less expensive than "free-standing" state residential high schools. Regular university facilities are used. No high school buildings, complete with expensive science laboratories, need to be built or adapted. Moreover, the University of North Texas receives the state high school allowance of \$1,260 per school year for each TAMS student.

No high school faculty members need to be recruited, accredited, trained, or supervised. Members of the university faculty, specially selected for their ability to work well with TAMS students, do all the teaching. The composition of the faculty means that TAMS can be directed by a distinguished scientist and full professor rather than by a school administrator, a feature that gives the program a more collegiate ambience.

TAMS students who maintain reasonably good grades in their college courses may remain as juniors at the University of North Texas or transfer with full credit (and often with a scholarship) to other state schools, such as the University of Texas at Austin or Texas A&M University. Having excellent grades makes transferring to selective colleges and universities outside the state possible, as well. For example, two of the first graduates entered Johns Hopkins University with full junior-year status, the male majoring in bio-psychology and the female in mechanical engineering.

A CLOSE COUSIN OF TAMS

As a two-year public high school program offering only college instruction, TAMS is unique. However, there is a similar one-year program, called the Clarkson School, at private Clarkson University in Potsdam, New York. Selected students from a number of states spend their senior year at the Clarkson School and earn a diploma, usually from the high school they formerly attended.

Clarkson School students, who are in the same grade and of approximately the same age, also tend to form a close-knit group. Of course, the yearly expenses of the Clarkson School program are considerably higher than those at the state-supported University of North Texas.

LIMITATIONS OF THE TAMS MODEL

Academically, the TAMS model is more demanding than almost any high school could be because of the level of the subject matter and the number and breadth of the required courses. For most students, it is a real challenge to go straight from the 10th grade to a college course in chemistry, sometimes without any high school background in the subject. One special feature of TAMS is that beginning students whose mathematics background is weak may enroll initially in a special course in precalculus, but those who do so must still go on to complete two semesters of calculus.

Many students handle the transition to TAMS well. For example, 43 of the 90 students who entered the program in the fall of 1989 made the dean's list in their first semester (i.e., maintained a grade-point average of at least 3.5). Eight earned a perfect 4.0 grade-point average.

Even with the best possible selection procedures, a certain amount of attrition must be expected — perhaps 10% over the course of two years. Of the 90 students who entered TAMS in the fall of 1989, one soon chose to go back to his former high school, and two others were dismissed for scholastic reasons because they could not adapt to the sharply increased academic demands. Those who leave have not necessarily wasted their time, however. Most will have learned something important about their motivation and study habits, and they will have been exposed to more new subject mat-

ter than they would have been exposed to had they spent the time in a regular high school.

The social and emotional demands of TAMS are probably somewhat similar to those at IMSA and NCSSM or at such private residential high schools as Phillips Academy in Andover, Massachusetts, or Phillips Exeter Academy in Exeter, New Hampshire. Living on a college campus for two years will make TAMS graduates feel more comfortable wherever they continue their education beyond high school.

ADAPTING THE TAMS MODEL

Based on my considerable experience with state-supported residential high schools — from the NCSSM in the 1970s to the TAMS program today — I offer a number of cautions, as well as possible modifications of the TAMS model for those who may be interested in adapting it to meet their local circumstances.

- Situate the academy at a low-cost state university, as TAMS is.

- Start small; have no set number of students the school "must" enroll during its first few years; work out the "kinks" carefully.

- Do not restrict enrollment to one state; consider admitting highly qualified students from neighboring states, thereby creating a regional academy.

- Charge each enrollee whatever fees the regular in-state or out-of-state student at the university pays; find financial aid, within the university and privately, for families that need it.

- Ask the state legislature for as little money as possible, preferably none.

One final adaptation of the TAMS

model seems worthy of special mention. I believe that the U.S. needs a centrally located, *national* academy of mathematics and science, designed along the lines of TAMS. Such an academy would enroll some of the nation's ablest youths.

Starting a successful academy of mathematics and science will require a hard-working "prime mover." But the academic and social directors of the Clarkson School and of TAMS have a great deal of experience and know-how to share. Interested readers are invited to send inquiries to: William T. Brady, Regents Professor of Chemistry and Director, Texas Academy of Mathematics and Science, P.O. Box 5307, Denton, TX 76203; or to Gary F. Kelly, Headmaster, Clarkson School, Clarkson University, Potsdam, NY 13676. I am a member of the TAMS Advisory Board and have been involved with TAMS almost since the original idea for the program was conceived by James Miller, dean of the College of Education at the University of North Texas. Readers may write to me as well.

Clearly, many academically able young people could benefit from schooling based on the TAMS model. Along with the current "free-standing" residential state high schools, such academies can help provide the trained scientific and technical personnel that our country needs. The costs are relatively small, and the benefits to students and society are huge.

1. Julian C. Stanley, "State Residential High Schools for Mathematically Talented Youth," *Phi Delta Kappan*, June 1987, pp. 770-73.

2. *National Percentiles, College-Bound Seniors* (New York: College Entrance Examination Board, 1989). [K]



SMFY at JHU

STUDY OF MATHEMATICALLY PRECOCIOUS YOUTH at JOHNS HOPKINS UNIVERSITY

30 Shriver Hall • Johns Hopkins University • Baltimore, MD 21218 • (301) 338-7087

Dr. Julian C. Stanley
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Professor of
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19 February 1988

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Professor Rogers Redding, Director
Texas Academy of Mathematics and Science (TAMS)
P.O. Box 5307
North Texas State University
Denton, Texas 76203

Dear Dr. Redding:

The longer I study the TAMS model for a residential state high school, the more I am amazed and intrigued by its promise. You and your associates have come up with a brilliantly unique plan that seems to me vastly superior in principle to the free-standing residential state high schools already underway in North Carolina, Illinois, and Louisiana and being planned or considered in several other states (e.g., Indiana, Maryland, Mississippi, and New York). As I see it, the following are some of the great advantages of your model over the other state efforts:

- 1) It is far more cost-effective. Students will live in college dormitories, so construction costs will be zero or low. Faculty members, laboratories, dining facilities, athletic and social facilities, etc. are already largely in place.
- 2) Students will compress four years of schooling into two, thereby effecting further economies.
- 3) The curriculum for every student will be rigorous, because each will take a full load of honors courses* along with the regular college students enrolled in such classes. This will mean that underqualified applicants must not be admitted, because even with the best efforts of the Academy they would have great difficulty academically. That should take care of most of the wholesale efforts toward establishing quotas that politicians and educators in the states having free-standing residential high schools inevitably make and thereby severely lower the academic level of the student body.
- 4) Every TAMS graduate will have had two years of excellent college education in his or her own state. Many will then choose to complete the rest of the baccalaureate within the state, either at the University of North Texas or at another state or private institution. This makes unnecessary the vigorous recruiting of graduates of residential state high schools to become undergraduates within the state, even though their best interests at the college level might be served better elsewhere. Every TAMS entrant has explicitly chosen the in-state route for at least two years.

SMFY at ISU:

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(OVER)

*Not all are honors-level courses,
I learned later. JCS

5) By taking only honors-level college courses, the TAMS students will mature both academically and socially earlier than the usual student in the free-standing high school. Academically, they will think of themselves as college students. Thus, they can have the best of two worlds, that of the college and concurrently of the Academy. (I'm glad you did not call your novel brain child a "high school.")

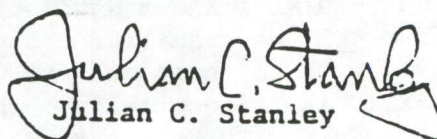
6) The TAMS model requires only two years, versus the three years that would seem needed for an effective free-standing high school. (The Illinois school starts at the tenth grade, and Maryland plans to begin its school at that grade level.) TAMS enables the student to stay in his or her home community through the tenth grade, thereby becoming a year older and more mature before leaving home. Also, of course, by having two grades rather than three it automatically saves about one-third of the cost of a residential high school.

7) I am glad you named the school TAMS rather than TASM, because excellent mathematical reasoning ability undergrids success in the sciences.

Several other advantages could be noted, but perhaps the above seven help explain my great enthusiasm for the TAMS model. I am convinced that it should be considered carefully by any state thinking of starting a residential high school of science and mathematics. The political and financial problems of the free-standing school are too great for most states to solve. So far as I am aware, only North Carolina has done this successfully yet, and for only a two-year school. TAMS could cost its students moderate amounts, although even enough (if necessary) to make annual fiscal dependence on the state legislature slight. Students and parents would be paying for college education, which most of them anticipate having to do, anyway.

It is going to be fascinating to see how, in practice, this appealing model works. I'm quite optimistic that, under your leadership, it will produce academic and social results never before obtained for a substantial body of students of high mathematical and scientific promise.

Sincerely,


Julian C. Stanley

JCS/lrs



SMPY at JHU

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12 September 1988

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SUBJECT: Likelihood that students at the Texas Academy of Mathematics and Science (TAMS) who make excellent grades will be able to transfer after two years to an outstanding university or college throughout the United States

FROM: Dr. Julian C. Stanley, Professor of Psychology and Director of the Study of Mathematically Precocious Youth (SMPY), both at the Johns Hopkins University in Baltimore, Maryland

1. In general, the prospects for such students are excellent. Undoubtedly, many highly selective schools such as Johns Hopkins would welcome the highest-achieving graduates of TAMS as transfer students with junior-year standing. The key problem anywhere will be the number of slots the school has for persons wanting to transfer in as juniors. In most institutions the number will be adequate.

2. The problem may be worst at Harvard, which has few vacancies for transfer students and probably allots most of them to the children of alumni. The situation may also be tight at Princeton, Yale, MIT, Stanford, and perhaps Brown. Prospects should be fairly good at Columbia, Cornell, Duke, the University of Chicago, Johns Hopkins, the University of California at Berkeley, and the California Institute of Technology, the last-named of which is small but probably has quite a few students who leave because the curriculum is extremely difficult.

3. Best chances may be at prestigious, large state universities such as Berkeley (mentioned above), Michigan at Ann Arbor, Wisconsin at Madison, Illinois at Champaign-Urbana, Virginia at Charlottesville, and North Carolina at Chapel Hill.

4. Other outstanding universities that would probably be interested: Rice at Houston, Washington at St. Louis, Emory at Atlanta, Texas at Austin (of course!), Washington at Seattle, and Oregon at Eugene.

5. Some of the nation's top colleges may be ideal for students not wishing to specialize heavily in a certain technical subject such as physics while still undergraduates. Examples are Amherst in Amherst, Massachusetts; Wesleyan in Middletown, Connecticut; Williams in Williamstown, Massachusetts; Dartmouth in Hanover, New Hampshire; Swarthmore and Haverford, near Philadelphia; Oberlin in Oberlin, Ohio; Carleton in Northfield, Minnesota; Grinnell in Grinnell, Iowa; Earlham in Richmond, Indiana; Reed in Portland, Oregon; Pomona and Harvey Mudd in

SMPY at ISU:

Dr. Camilla P. Benbow
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Claremont, California; and the famous "Seven Sisters" (Barnard, Bryn Mawr, Mt. Holyoke, Radcliffe, Smith, Vassar, and Wellesley).

6. Of course, if a student really feels that he or she MUST graduate from one of the most selective schools in the country, such as Harvard, Princeton, Yale, Caltech, or Stanford, it is possible to apply to become an entering freshman with advanced placement in certain courses, but not course credits, and spend four years there. By doing so, one might be able to take two (or even more) majors, rather than the usual one, and/or earn a master's degree along with the bachelor's. The student won't have lost any time along the educational road, nor spent a huge amount of money for the two "forfeited" years, and should be superbly equipped to star academically.

7. Some admission officers are virtually certain to get confused by the dual nature of TAMS, because it is a truly unique blend (amalgam? mixture?) of high school and college. A careful statement by TAMS, plus the college transcript of courses and grades, should convince all but the most stubborn of them that the TAMS graduates' course credits are truly honors college ones.

8. I'd be glad to help Dr. Rogers Redding do a systematic survey of many colleges and universities to alert them to applications from you that may be coming in the fall of 1989 (that quickly!) and to inquire about the usual number of vacancies for transferring into their institutions as juniors.

9. When I'm on the UNT campus Wednesday, September 21, Dr. Redding may arrange for persons especially interested in transferring outside Texas to talk with me.

10. For the present, dig into those textbooks and make excellent grades. Without at least a 3.5 grade point average on a scale where A is 4.00, your chances of transferring into a highly selective college or university upon graduation from TAMS may not be great.

11. I'll have a conference with Mr. Jerome D. Schnydmann, the Director of Undergraduate Admissions at small Johns Hopkins, and tell him all about TAMS so that he and his staff will be favorably disposed toward the applications of any of you who choose to apply here. Johns Hopkins is excellent in many fields, especially history, English, and the history of art, and is probably the top premedical college in the country. Last fall, seven graduates of the North Carolina School of Science and Mathematics entered here, the largest contingent of that year's NCSSM graduating class to attend college outside North Carolina. They're doing well.

Sincerely,

Julian C. Stanley
Julian C. Stanley

JCS/lis

Dear Rogers: By taking relevant Advanced Placement Program examinations each May, students may be

Student life. In dealing with younger students, we have considered it imperative to maintain a small-group atmosphere in living arrangements and to maintain somewhat closer supervision than is typical in college dormitories. The students now live in four houses in a residential neighborhood adjacent to the campus and in one wing of a nearby university dormitory. Graduate students or college juniors and seniors serve as live-in house advisors. In addition, one member of the Clarkson School administrative staff lives in one of the houses. The students eat in a nearby college cafeteria, and one evening each week we hold a "family dinner" for all Clarkson School students and staff in a separate dining room.

To provide for a smooth transition to college life, there is a curfew during the first semester. This is liberalized as the year progresses, and by year's end it has ceased altogether. Visitors are prohibited from the houses after midnight, alcoholic beverages are not permitted, and Clarkson School students are not permitted to have automobiles.

Over the 10-year history of the program, we have come to believe that the residential setting is the most critical factor in students' adjustment to college — and thus in the program's success. The students enjoy the family atmosphere of the houses, and the only problem we have encountered has been setting up quiet hours and other conditions conducive to study in such close quarters.

Personal adjustment. Clarkson School students take part in an extensive five-day orientation prior to the beginning of classes. In addition to preparing students for the rigors of college-level work by providing sessions on study skills, the orientation offers structured opportunities, such as an all-day retreat, for getting acquainted and for building a sense of cohesiveness in the group. We circulate a questionnaire to gain information about personal interests, preferences, and habits that helps us match students with compatible roommates.

Since the academic pressure at Clarkson is great, we realized after the first two years of the Bridging Year Program that it was essential to encourage extracurricular involvement. In 1980 we instituted the Self-Development Program. Each student is required to establish goals and to earn self-development units in five general areas: human relationships and responsibility, physical fitness, cultural awareness, professionalism in society, and field trips. The program provides for a great deal of flexibility in the ways that these goals can be met, but it has succeeded in involving students in many aspects of campus and community life that they might otherwise have neglected.

Recruiting and college placement. The program has required more active recruiting than we originally envisioned. At first we feared that the

high schools would see the Clarkson School as a recruiting effort very low key. Before long, however, it became obvious that the idea of a head start on college for selected students was highly appealing to parents, guidance counselors, and the students themselves.

Our director of admissions has made students aware of the program by attending regional "college fairs" for high school students. We have also found mailings to sophomores who register high scores on the Preliminary Scholastic Aptitude Test (PSAT) to be a useful recruiting strategy. In addition, we have publicized our admissions criteria, which include being in the top 10% of one's high school class, having a score of 650 or higher on the quantitative section of the PSAT, and having demonstrated academic motivation. Most students who apply are well-qualified for the program, though we occasionally admit unique young people who do not quite meet all our criteria. On-campus interviews help us assess each student more accurately, and open-house events held in the fall and spring give high school students a chance to meet our students and to see our facilities.

Now that the program has been operating for 10 years, we receive about 90 applications for 55 openings. We anticipate gradual expansion.

About 50% of our students have elected to go on to other colleges and universities following the Bridging Year Program. They have received full credit for the college courses taken at Clarkson. We encourage all students to keep their educational options open by applying to at least one other institution. However, satisfactory completion of the program guarantees them a place in the sophomore class at Clarkson.

In 1980 and again in 1982, we distributed detailed questionnaires to all current and former students. We found that the Clarkson School graduates were generally achieving higher grade-point averages than their college classmates, regardless of the college they were attending. They felt that their academic and social preparation had been superior to that of their classmates, both in their home high schools and in college. The Clarkson School graduates also have remained in college at a higher rate (96.4%) than typical early admission students. Only eleven of 331 students have left the program — four were expelled for disciplinary reasons, and seven returned to high school because of weak academic preparation.

The Clarkson School is now gaining national recognition for its innovative program. When reports began to appear decrying dangerous weaknesses in science and mathematics at the secondary level, the Clarkson Bridging Year Program was one of the few existing model programs for high achievers.⁵ An extensive review of the program by a committee of Clark-

son deans and administrators in 1982 led to the decision to strengthen the programs' objectives.

High schools have begun to recognize the value of early college-level experience for selected students, and colleges have begun to realize the long-term benefits of creating such programs. The Carnegie Foundation for the Advancement of Teaching has recently cited a number of such projects across the U.S.⁶ As the findings of the various national commissions that have studied secondary education are digested, more options of this sort will be springing up. It is essential that these new programs learn from the experience of existing programs and establish living/learning environments that recognize the physical, emotional, and social needs of younger students.

1. Leon Botstein, "Educational Restructuring in Historical Perspective," in *Conference Proceedings, A Case for Educational Restructuring* (Great Barrington, Mass.: Simon's Rock of Bard College, 1981), pp. 47-55.
2. B.F. Blanchard, *A National Survey of Curriculum Articulation Between the College of Liberal Arts and the Secondary School* (Chicago: DePaul University Press, 1971).
3. Gene I. Maeroff, *Don't Blame the Kids* (New York: McGraw-Hill, 1982).
4. Franklin P. Wilbur, "High School-College Partnerships Can Work," *Educational Record* (Spring 1981): 38-44.
5. National Science Foundation and U.S. Department of Education, *Science and Engineering Education in the 1980s and Beyond: A Report to the President* (Washington, D.C.: U.S. Government Printing Office, 1980).
6. Gene I. Maeroff, *School and College: Partnerships in Education* (Lawrenceville, N.J.: Princeton University Press, 1983).

Update — When invited to update this article, Mr. Kelly chose to rewrite the original. Most of the changes are minor. Mr. Kelly reports that the Clarkson program appears to remain unique on the American educational scene. Many colleges and universities offer opportunities for early admission, but without much structure for students who so easily can flounder because of their younger age.

State Residential High Schools for Mathematically Talented Youth

FROM ACROSS the land we are hearing cries for stronger preparation of students in mathematics, so that they can meet the quantitative demands of a world increasingly dependent on scientific and technological sophistication. Harold Stevenson, Shin-Ying Lee, and James Stigler jolted many Americans into the realization that elementary school pupils in Minneapolis lag far behind their counterparts in the apparently comparable cities of Sendai, Japan, and Taipei, Taiwan.¹

Our very best high school students seem better qualified. For example, in the annual International Mathematical Olympiad, held in Warsaw in July 1986, the six-person U.S. team competed with the best that 36 other nations could offer and tied the Soviet Union for first place. For a dozen years U.S. teams have ranked well in that event. The U.S. teams have also performed well in the International Chemistry Olympiad and in the International Physics Olympiad — even though we have participated only three times in the former and once in the latter.

These world-class performers are, however, merely the tip of the tip of the educational iceberg. They emerged, presumably, because of fortunate combinations of basic ability and special educational opportunities, mainly through extracurricular competitions at the local, state, and national levels. Their

How can states promote the preparation of more highly qualified students in mathematics? One way, says Mr. Stanley, would be to establish residential high schools for the best and the brightest.

.....
BY JULIAN C. STANLEY

individual motivation was also quite strong. They reasoned extremely well mathematically and found fascinating those activities in which they could use their aptitude. They were highly motivated and alert to competitive opportunities.

Few mathematically and scientifically talented high school students are so fortunate. Most need an enhanced educational framework in which to learn mathematics and science far better than they could in nearly any school. In addition, they need systematic, prolonged interaction with large numbers of their true intellectual peers. As Harriet Zuckerman put it, the most outstanding scientists arise because of cumulative educational facilitation: at each stage, the potentially highest-achievers study under or associate with people who are already eminent scientists or are on the way to becoming so.²

SPECIAL SCHOOLS

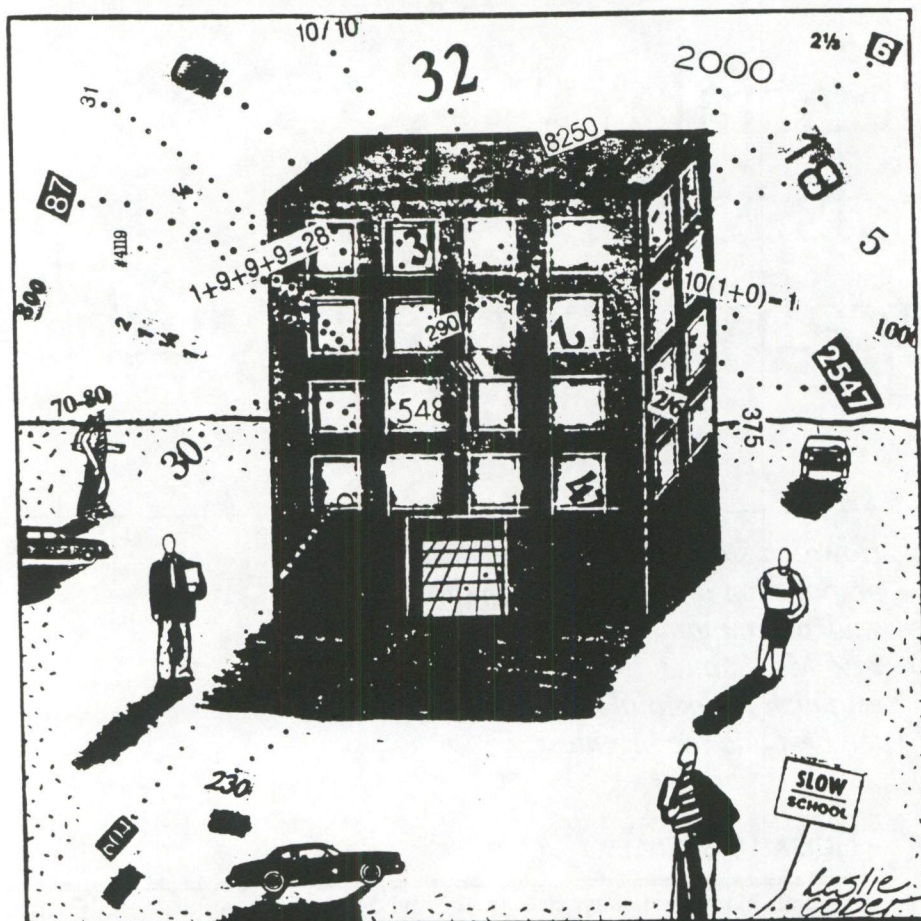
From the vast experience of the Johns Hopkins Study of Mathematically Precocious Youth (SMPY), which since 1971 has been identifying, helping, and following up on youths who reason exceptionally well mathematically,³ I venture to suggest that every state in the

union that has at least 300 National Merit semifinalists each year⁴ should consider establishing a residential high school for science and mathematics.

Students would enter such a school at age 14 or younger, after having completed the eighth grade or its equivalent. In three intensive years, they would finish the remaining four years of high school and earn some college credits. There would be no charges for tuition, books, or room and board. Part of these expenses would be met by allocating to the school the usual cost of the student's public education in his or her locality. Industry, service clubs, and individuals could be approached to bear some of the costs, and the rest would be appropriated by the state legislature. Long-term benefits to the community, state, and nation should make such a school a wise investment.

The method of funding is critical. For example, including the school as a line-item in the state budget can make it vulnerable to the year-by-year economics of the legislature. Having it in a university's budget, instead, may be better. But this will depend on how the fiscal systems of the state and the university operate. Those who would like to start such a school should ask the directors of the three schools now operating how ef-

JULIAN C. STANLEY is director of the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University, Baltimore. He wishes to thank Linda Brody, Susan Dauber, Ann Lupkowski, and Barbara Stanley for their editorial assistance. This article is based on a speech delivered in December 1986 at Ball State University, Muncie, Ind.



fective their method of financing is proving to be.⁵

THE STUDENTS

Much care must be taken in selecting for the school the best-qualified youths who can be found and recruited, because the intellectual and academic caliber of the school cannot exceed that of its students. How many students should such a school admit? The entering class each year should be large enough to accommodate the ablest mathematical reasoners in the state. Using the number of National Merit semifinalists in the most populous states, California and New York, as a starting point, the *upper* limit of class size would be about 450. (I have assumed that one-third of the 1,351 potential National Merit Scholars in California would both qualify and attend.) Thus in the three grades of the high school there would be, at most, about 1,300 students.

The lower limit each year would seem to be about 100 beginning students, the ablest one in 200 of the age group. This is about the level of National Merit semifinalists, most of whom are between 16 and 18 years old. The actual number would depend on the amount of talent for science and mathematics in a

particular state in a given year and on the attractiveness of the school to potential applicants.

How talented should a student be in order to be admitted? I strongly urge that a minimum ability level for an applicant in a particular state be established and that it not be subject to exception for any reason. Otherwise, political considerations and favoritism for special groups or individuals will probably be inevitable. Implicit or explicit quotas for females, members of minority groups, rural youths, and the like could seriously dilute the academic potential of the student body and adversely affect the curriculum. Of course, state legislators and others are likely to advocate exceptions, so setting an absolute minimum ability standard is crucial. If this cannot be done, then I question the wisdom of having the special school in the first place.

As an example of such a minimum criterion, I propose that each applicant's score on the mathematical part of the Scholastic Aptitude Test (SAT) be not less than the average score of male college-bound 12th-graders across the U.S. (at present, about 500) and that an applicant's combined mathematical plus verbal score be not less than the average combined SAT score of male college-

bound 12th-graders (at present, about 940). This is merely an example, however. The formula for the minimum standard might be based on a state rather than a national test or, for instance, on the American College Testing Program's four-test battery rather than the SAT. The important point is that an appropriate, inflexible standard — minimum but not low — should be set from the start.

It should always be kept in mind that the minimum standard is just that: a minimum, not a norm. The ablest students in the state will benefit most from attending the school. In addition, further testing of applicants is essential. Their nonverbal reasoning ability, mechanical comprehension, ability to handle spatial relationships, knowledge of mathematics, knowledge of science, knowledge of general information, and the like should also be assessed.

Because the school is being established to improve the education of future scientists and mathematicians, special attention should be paid to students' demonstrated interest in science and/or mathematics, including projects submitted to science fairs and competitions and recommendations from the applicant's science and mathematics teachers. Of course, no objective formula exists for combining the various evidence of an applicant's fitness for the school. The admissions committee should include, but not consist entirely of, outstanding scientists and mathematicians. It should also include a testing specialist who can interpret scores for the other committee members.

RECRUITING THE FACULTY

An institution of this kind must have the best principal and the most effective teachers available. There is no place for politics, patronage, preference for local teachers, or an "old boys" network. I recommend strongly that every instructor in the school be an experienced, successful teacher of the College Board's Advanced Placement (AP) Program curriculum in his or her subject. This will help insure an excellent grasp of the subject and a demonstrated ability to teach it to able youths.

The faculty should be recruited vigorously nationwide. Harlan Hanson, head of the AP Program since its inception in 1956, would undoubtedly be delighted to help identify prospective candidates.

Each teacher should have at least a master's degree or the equivalent in the subject taught, not just in graduate education courses. Some should have academic doctorates and experience in teaching able college freshmen.

The principal of the school should be an experienced, highly successful administrator of a school or college that places considerable emphasis on science and mathematics. Assistant principals of high schools whose students tend to score high in the Westinghouse Science Talent Search — such schools as the Bronx High School of Science and Stuyvesant High School in New York City — might be well-qualified and interested in such a position. On the other hand, a successful science-trained college administrator, such as an associate dean, might be sought.

The search for the best possible principal should be both wide and thorough. Of course, the salary and fringe benefits offered would have to match the caliber of the person selected.

THE CURRICULUM

Superb students, magnificent teachers, and the best principal possible, combined with excellent facilities and a carefully planned program of studies, should virtually guarantee that the school will be worth the effort and money spent on it. I urge that the courses in mathematics, physics, chemistry, computer science, and biology aim toward the Advanced Placement Program examinations in calculus (Level BC), physics (Level C, both parts), chemis-

try, computer science, and biology. The ideal would be for every graduate of the school to have earned a 5, the highest possible grade, on each of these AP exams.

I realize full well, however, that this is an example of reaching for the stars. No school could attain the ideal of having all its graduates begin college with five two-semester courses already completed with the equivalent of A+ grades. Nevertheless, the ideal will motivate some students to do so, and each student will strive for at least one 4 or 5 on one of the exams.

LOCATION OF THE SCHOOL

The school itself should be located close to a highly selective college or university, so that students can quickly walk to the campus to take the college courses that they need to supplement the high school offerings. Indeed, the school could be located on the campus itself. That would eliminate the necessity for AP courses in subjects other than the five already mentioned. It would also allow students who qualify to enroll in higher-level college courses in the five core mathematics and science subjects.

By a combination of AP exams and college courses, many graduates of the school could enter college with sophomore or junior standing. They would have saved at least two years of schooling, one in high school and another in college, and this should hasten their earning a doctorate and thus provide them more years of vigorous youth in which to do creative research. I urge would-be physicians among the students to work toward the combined M.D.-Ph.D. degrees and enter medical research. Those who decide to follow this path might be well-advised to complete the Ph.D. degree (or nearly complete it) first, in order to acquire a research orientation before the clinical orientation. Moreover, those who are very much younger than the typical college graduate could find age a barrier to direct admission to medical schools.

COMPETITIONS AND SPECIAL PROGRAMS

In 1986 one student from the North Carolina High School of Science and Mathematics ranked in the top 300 in the U.S. in the annual Science Talent

Search, sponsored by the Westinghouse Corporation.⁶ In 1987 none did. None from the Louisiana School for Mathematics, Sciences, and the Arts qualified either year. None of the top 40 contestants came from either school in either year.⁷

By contrast, the Bronx High School of Science placed 34 students among the top 300 in 1986 and 27 in 1987; Bronx Science placed three in 1986 and five in 1987 among the top 40. Stuyvesant High School had 22 and 37 students among the top 300 in 1986 and 1987, two and five among the top 40. The Research (formerly Rickover) Science Institute (RSI), held for six weeks in the summer, produced nine students among the top 300 in 1986 and two among the top 40; in 1987 RSI placed six students among the top 300 and two among the top 40. The 100 ablest high school seniors in the SMPY yielded one in the top 40 in 1986 and three in the top six in 1987. I firmly believe that a residential state high school of science and mathematics should follow the lead of these prestigious programs by preparing most of its students to compete in the Westinghouse Science Talent Search when they are seniors. To do less is to underdevelop the investigative scientific spirit of highly talented students.

Each summer the U.S. sends teams to three different international academic high school Olympiads: mathematics, physics, and chemistry. In my opinion, competing for a place on one of those teams should be a major co-curricular goal of the ablest students in a state high school for math and science. Even getting into the summer training session, from which team members are selected, is usually an inspiring experience.⁸

The school should also encourage and help its students to obtain valuable scientific or mathematical experience or training during summers. There are many such opportunities, but most students won't know about them. The Research Science Institute is one. Mathematics programs, such as Professor Arnold Ross' eight-week institute at Ohio State University or the various mathematics programs at such schools as Hampshire College, are others. Enriching apprenticeships, internships, and research assistantships can also be arranged.

I could discuss many other considerations for a state residential high school of science and mathematics, but I hope



"It's the last day of school. We have to clean out our desks."

I have already said enough to provoke much discussion. Suffice it to say that this kind of planning is far more than a pleasant diversion for a wet Sunday afternoon. It requires *several years* of a state's best efforts. Our scientifically promising young people deserve nothing less.

1. Harold W. Stevenson, Shin-Ying Lee, and James W. Stigler, "Mathematics Achievement of Chinese, Japanese, and American Children," *Science*, vol. 231, 1986, pp. 693-99.

2. Harriet Zuckerman, *Scientific Elite: Nobel Laureates in the United States* (New York: Free Press, 1977).

3. Camilla P. Benbow and Julian C. Stanley, eds., *Academic Precocity: Aspects of Its Development* (Baltimore: Johns Hopkins University Press, 1983); and Julian C. Stanley and Camilla P. Benbow, "Youths Who Reason Exceptionally Well Mathematically," in Robert J. Sternberg and Janet E. Davidson, eds., *Conceptions of Giftedness* (Cambridge: Cambridge University Press, 1986), pp. 361-87.

4. For example, in 1986 California had 1,351 National Merit semifinalists, New York 1,150, Illinois 752, North Carolina 390, Indiana 384, and Louisiana 270. "Semifinalists are designated on a state representational basis. Because each state's allocation is prorated according to its percentage of the nation's high school senior class, the scores required for semifinalist standing vary from state to state. In addition, a state's qualifying score may differ from one year to the next because of variations in the number of its students who participate and the level of their test performance." See National Merit Scholarship Corporation, *Semifinalists in the Thirty-Second Annual [1987] Merit Scholarship Competition* (Evanston, Ill.: NMSC, 1986).

5. Their addresses are as follows: Stephanie A. Marshall, Illinois Mathematics and Science Academy, 1500 W. Sullivan Rd., Aurora, IL 60506-1039, Ph. 312/801-6037; Richard G. Brown, Louisiana School for Mathematics, Science, and the Arts, Natchitoches, LA 71457, Ph. 318/357-0606; and Charles R. Eilber, North Carolina School of Science and Mathematics, West Club Blvd. and Broad St., Durham, NC 27705, Ph. 919/683-6656.

6. *The 45th Annual Science Talent Search* (Washington, D.C.: Science Service, 1986); and *The 46th Annual Science Talent Search* (Washington, D.C.: Science Service, 1987). For more information about the Westinghouse program, write to Science Service, 1719 N St. N.W., Washington, DC 20036.

7. The Illinois Mathematics and Science Academy began in the fall of 1986 with only 10th-graders, so it cannot yield contestants for the Westinghouse Science Talent Search until 1989.

8. U.S. addresses for the three Olympiads are as follows: International Chemistry Olympiad, American Chemical Society, 1155 16th St. N.W., Washington, DC 20036, Ph. 202/872-4380; International Mathematical Olympiad, Mathematical Association of America, 1529 18th St. N.W., Washington, DC 20036, Ph. 202/387-5200; and International Physics Olympiad, American Association of Physics Teachers, 5110 Roanoke Pl., Suite 101, College Park, MD 20740, Ph. 301/345-4200. 

The North Carolina School of Science And Mathematics

Years before A Nation at Risk, North Carolina was providing a special kind of education for students who demonstrated high ability and interest in science and math. Now, seven years later, what lessons can we glean from the work of the school?

BY CHARLES R. EILBER

GIVEN THE many changes that have taken place in U.S. education recently, a little-noticed event that took place in North Carolina 10 years ago does not seem very important. Yet it may turn out to be among the most significant events of recent years. Early in 1977, soon after assuming office, Gov. James Hunt established the North Carolina School of Science and Mathematics (NCSSM) — a public residential school for academically talented 11th- and 12th-graders.

Hunt's purposes were visionary. First, he recognized that the economic well-being of a state will increasingly depend on industries whose products and services have a technological base. To provide the leadership necessary for maintaining North Carolina's competitive position with these industries, Hunt advocated a renewed emphasis on the study of science and mathematics at the high school level.

The governor's second goal grew out of the first: to improve science and mathematics education for academically

talented high school students. Whether these students were currently attending schools with many or with few opportunities to develop their talents, the resources available at the new residential school would better enable them to reach their potential.

Third, Hunt sought to provide a source of new teaching methods, curriculum materials, and teacher training. What was learned in these areas at the residential school would eventually help to improve all schools in the state.

Gov. Hunt's determined efforts have given the nation a model for excellence in science and mathematics education. The North Carolina School of Science and Mathematics identifies students with the promise of becoming tomorrow's leaders and provides them with the broad educational experience they will need.

But in the beginning the school's detractors were many. Educators, legislators, and members of local school boards raised questions about cost, elitism, and the skimming off of the best students from local schools. They were skeptical of the residential requirement and fearful of political influence playing a part in the admission of students. Yet legislation was passed in 1978 establishing, under the governor's office, a state-

CHARLES R. EILBER (*University of North Carolina Chapter*) is director of the North Carolina School of Science and Mathematics, Durham.

wide residential school for students of high ability and interest in science and mathematics.

After that, events moved swiftly. A board of trustees was selected. A former hospital in Durham became the site of the school's 27-acre campus. The board appointed a director, and soon the recruitment of faculty, staff, and students began. The school opened in September 1980.

THE STUDENTS

The first entering class included 150 juniors. Since then, enrollment has grown steadily, reaching 475 juniors and seniors in 1986-87. That number will increase to 550 in 1989 and reach a maximum of 600 in 1991. This year, students come from 89 of North Carolina's 100 counties, from 114 of its 140 school districts, and from 220 high schools. The current student body is 53% male, 47% female. Because the students do not pay tuition or room and board, there is no need to assess parents' economic circumstances in the admissions process. Consequently, the school enrolls a mix of students from diverse socioeconomic backgrounds. Currently, 16% of the students are black, native American, or Hispanic; 8% are Asian.

Although there are no direct charges for attending the school, there are costs to the family for transportation, clothing, and spending money. In those cases in which even these expenses might cause hardship for a student's family, funds from private sources insure that no student will lack the necessary resources.

The school's commitment to serve all of North Carolina stems from the belief that academic talent is found in every segment of society, at every socioeconomic level, and in every community in the state. The admissions process assumes that the academic potential of many students, particularly those from educationally or culturally disadvantaged backgrounds, is not always revealed in standard measures of aptitude and achievement. Before the school opened, we decided on a multifaceted selection process and ruled out automatically excluding any student on the basis of a score on any single test or other instrument, such as the Scholastic Aptitude Test (SAT). We have reviewed and reaffirmed this policy and made only minor modifications. The

process has served us well for the selection of eight incoming classes of juniors.

Each prospective student has a selection portfolio, which includes the verbal and mathematical scores on the SAT taken during the 10th grade; a nonverbal test of critical thinking; the student's grades in mathematics and science from the ninth grade and the first semester of the 10th grade; a checklist prepared by a teacher or counselor that rates the student on characteristics attributed to academically talented students; an essay written by the student under controlled circumstances that seeks to measure both logical thinking and creative expression; letters of recommendation from teachers; and a statement from the student explaining his or her reasons for seeking admission to the school and suggesting the contributions he or she could make if selected.

From readings of the portfolios, the selection committee assigns each student a composite rating, based on its judgment of the student's potential to achieve under the rigorous expectations of the school. Then 400 of the nearly 800 applicants are selected for personal interviews. Finally, we select from those 400 the incoming class of 200 one year and 275 the next. Eventually, we expect to have enough dormitory space to accommodate an incoming class of 300.

No minimum scores have been set. Obviously, a low score on the SAT would be carefully reviewed by the

selection committee and considered in relation to all the other factors. Occasionally, however, reasons emerge to explain a low SAT score. For example, a student whose family had recently moved to North Carolina from Vietnam scored very low on the verbal SAT but very high on the mathematics portion. A minimum score on the SAT verbal or even a minimum combined score would probably have eliminated this student from consideration. But the flexibility of our admissions process allowed us to admit this student, and he was successful. Other less extreme examples of the virtues of flexible admissions criteria also exist.

The school operates under a guideline from the state legislature to enroll "insofar as possible without jeopardizing admissions standards" an equal number of students from each of the 11 congressional districts in the state. This guideline is intended to encourage equal representation of areas of equal population. Even though no fixed number has been set for these districts, the selection committee attempts to bring in the best-qualified students from each. If some districts have fewer successful applicants than others, the committee makes no attempt to increase that number by bringing in students who are unlikely to succeed in the program. When some districts have fewer students than others one year, we work to increase the pool of applicants in the following year by increasing the number of visits to local high schools in that district, by advertising more widely, by asking community leaders in the district for help, and by encouraging visits to the campus by the teachers, counselors, and families of interested students.

In the final stages of the selection process, when a limited number of spaces remain to be filled and the pool of qualified candidates outnumbers the available spaces, the committee will give some consideration, from among those with equal ratings, to regional representation, space available in male or female dormitories, and the breakdown of ethnic groups. However, no student is brought in who is rated lower than any student not admitted to the school.

The admissions process, though time-consuming and expensive, has provided a broadly representative student body from every part of the state and from every segment of the population.



"I want to welcome our honored guests, distinguished faculty, and the occasional passer-by."

THE INSTRUCTIONAL PROGRAM

Although the name of the school might suggest otherwise, the instructional program includes more than science and mathematics. The emphasis is on these subjects, but the NCSSM is a comprehensive high school. Students must complete at least two units of mathematics and three of science during their two years in residence. But they typically elect additional courses and

The admissions process assumes that the academic potential of many students is not revealed in standard measures of aptitude and achievement.

graduate having accumulated between six and seven units in mathematics and science during their two years.

The NCSSM offers 20 courses in mathematics and computer science, 16 in biology, eight in chemistry, and eight in physics. Students must select at least one course from each of the three main science areas. English, with an emphasis on writing, is required in both years. Foreign language is required, and students can choose French, Spanish, German, Russian, Latin, or Chinese. American history is required, and other classes in the social sciences, though elective, are well attended. A variety of electives in music and the visual arts are also available, and practically every student takes some coursework or participates in some activities in these areas. A number of interdisciplinary courses are offered, as well.

Most courses are taught at an advanced level and explore material and concepts that are usually found in college courses for freshmen and sopho-

mores. However, no attempt is made to offer specific college courses for the purpose of accelerating students' progress. The level of the courses is determined by the various departments in response to the goals of the school and the needs of this special population of students.

The curriculum is not directed toward the College Board's Advanced Placement (AP) Program. Most faculty members feel that teaching specifically for an AP test would be too limiting, especially in courses in laboratory science. A significant number of students do take the AP tests and earn college credit through them, but graduates report that, through a variety of other means, they are offered advanced placement and advanced credit when they enter various colleges and universities.

The instructional program, then, consists of a core of familiar courses and is conducted through familiar classroom organizations. But a great variety of other instructional activities are made possible by the purpose of the school; by the flexibility of a residential school in which classrooms, library, and computer facilities are available in the evenings and on weekends; and by the strength of a faculty willing to explore new ways of teaching and learning.

A mentor program permits many seniors to spend at least one afternoon per week working one-to-one with researchers in the universities and corporate laboratories of North Carolina's Research Triangle area. A number of these students have been mentioned in papers written on the projects in which they collaborated, and a few have been taken to national meetings to help present data from projects on which they have worked. Some students have continued working with their mentors in summer internships and then as undergraduates.

Independent study projects may be undertaken on campus throughout the year, if an individual or a small group of students and a teacher agree on the purposes of the project and devise some form of accountability for the outcomes. Every year, a Special Projects Week is devoted to independent projects. The normal schedule is completely set aside, and teachers, administrators, and staff members serve as mentors to small groups of students.

One other area of interest for many of our students, though it is secondary to

the academic program, is competing in statewide and national competitions. Various academic teams and individuals do very well in statewide competitions, though they do not always finish first.

In such national competitions as the Westinghouse Science Talent Search, the McGraw-Edison Competition, and the NASA Space Shuttle competitions, the record of the school might seem rather modest given the selective population of students. Students who have an individual project to enter in a competition or who are members of a team preparing for a competition are encouraged and helped in after-school hours. But the nature of the school and of its admissions procedures preclude our identifying students before the 11th grade, and so NCSSM cannot develop a "farm system" that would get students started on projects in earlier grades.

Nor is the NCSSM mentorship program a good source of projects for competitions. Although some national contests permit students to work with professional researchers (with appropriate acknowledgement of that assistance), students do not begin the mentorship program until they are seniors, and they and their mentors are matched on the basis of common interests and on the expectation of significant participation by the student in the mentor's research project. Occasionally, this results in a discrete piece of work by the student that might stand alone as an entry in an outside competition. But this is not usually the case with the projects that the students work on with their mentors. The long-range educational and career benefits to the student from taking part in a project at such institutions as the Duke University Medical Center or the North Carolina State University Chemical Engineering Laboratory or from conducting actuarial simulations at the North Carolina Mutual Life Insurance Company may have greater benefits than completing a project for the purpose of entering a national competition.

Competitions and other comparative measures of excellence are not ignored in assessing the impact of the school on students, and there have been notable achievements. For example, among the 208 members of the class of 1987, there are 63 National Merit semifinalists and 13 National Achievement Program semifinalists. A member of the class of 1986 was one of the three American

bronze medal winners in the International Physics Olympiad. At this writing, the Atlantic and Pacific Mathematics Competition has just completed five of its six rounds, and the NCSSM team is currently in first place nationally. An experiment by a former student has also been selected for inclusion in a space shuttle experimental flight when that program is resumed.

The NCSSM believes that these competitions at state and national levels can be important educational opportunities for students when they are in line with the educational needs and objectives of the student and of the school program. Academic competition within the school is not encouraged, however. There is no honor society and no honor roll, and there are no departmental awards. Peer tutoring and cooperation among students are encouraged.

Nor are our students ranked. Therefore, graduating classes do not have a valedictorian or salutatorian. Student participants in commencement exercises are chosen by a committee that evaluates essays that any senior may submit anonymously in order to be considered as a speaker.

THE RESIDENTIAL PROGRAM

At any residential school, some of the most important learning takes place in the residential setting. The students are away from home, probably for the first time, and they need to adapt to a community that is at once more structured and restrictive than most homes and yet more encouraging of independent decision making. How to manage time, what new friendships to initiate and develop, how to accommodate the needs of a roommate and the expectations of a dormitory community, and how to assume responsibility for some of the ordinary tasks of daily life that parents may have done for them previously are all important learning experiences for our students.

In renovating an old hospital to make an attractive and functional secondary school campus, the rooms that had formerly housed patients were grouped into halls, each of which accommodates about 35 students. Within each hall, an apartment was constructed for a resident advisor. Many of the activities of the residential program are organized around these hall units.

To begin with, the residents of the

hall are responsible for cleaning their own rooms and the common areas, including the corridors, study lounges, and rest rooms. Orientation at the beginning of the school year, social activities during the school year, and meetings on various issues for which student participation is necessary take place within the hall group. The resident advisor is also the disciplinarian who levies appropriate punishment for such transgressions as not observing quiet hours, staying out beyond curfew, and so on. More serious disciplinary situations are reported to the dean of students.

Along with the responsibility for maintaining the common areas in his or her hall, every student has a campuswide work-service responsibility of three hours per week. Juniors must take a turn at the "chores" of kitchen and dining room duty or grounds duty. Seniors have their choice of such other roles as library assistant, laboratory aide, clerical assistant, computer tutor, bus driver, student activity assistant, media production assistant, and so on. Students are not paid for this work. It is their contribution to the operation of the school and their way of recognizing the resources provided to them by the taxpayers of the state.

To further impress on students the responsibility to share their talents with the larger community, during the summer juniors are required to provide 60 hours of service in their home communities or in Durham. Satisfactory completion of both work service and community service is a graduation requirement.

Students are not permitted to have automobiles at school. This restriction is intended to allow them to concentrate better on both academic and personal growth. Nor are students allowed to have television sets in their rooms or to have paying part-time jobs.

The school has a great variety of social and recreational activities. Students participate fully in the planning, organization, and implementation of these activities. The patients who formerly occupied the hospital did not shoot baskets or run track. Thus the school does not have a gymnasium and will not have one until 1988. Nevertheless, there is an active intramural and interscholastic athletic program that includes every usual high school sport except football. Despite having limited practice time and using borrowed facilities, teams and individuals

make a respectable showing in the local high school athletic conference. In a recent season, the boys' soccer team was the conference champion and went to the quarterfinals in the state tournament. Two girls have set state records in track. Of greater importance, however, the athletic directors and coaches in the conference voted the NCSSM the Sportsmanship Award in 1986.

The opportunities for personal growth in all these areas are important parts of the living/learning concept of the school. They help our graduates adjust to college life, help them manage their time, and help build their confidence to undertake the responsibilities of leadership.

SUPPORT SERVICES

A number of programs provide both academic and personal support for the students. In addition to resident advisors, who are the first line of daily contact and support, each student has an academic advisor, and both of these advisors are backed up by a guidance and counseling department with three professional counselors on staff.

The assistant principal coordinates the student support activities, gathering information from teachers and advisors, as well as from attendance reports, grade reports, and the infirmary log, in order to be aware of the students' needs for academic or other counseling as they develop. When necessary, parents are invited in for conferences. Other activities, such as the orientation program at the beginning of the school year, an evening series for juniors on various aspects of adjustment to community living, a big brother/big sister program for incoming juniors, and host families in the community, contribute to the adjustment and personal growth of the students.

Despite these efforts, there is an attrition rate over the two years of about 8%. Roughly half of the students who leave the school before graduating do so for reasons of their own. Family circumstances change for some students; for others, the school experience was not what they had expected it to be. Some simply decide that they miss their home and community. The other half leave — or are not invited back after the junior year — because they are unable or unwilling to meet the academic or behavioral standards of the school.

PUBLIC SERVICE

The commitment of the school to sharing its resources with other schools throughout North Carolina is a very serious and important one. Workshops are held every summer for secondary school teachers in science, mathematics, and computer science and in the use of libraries and instructional media. More than 4,000 teachers have been involved in these workshops, either on the campus or in various locations around the state, and these teachers return to their home classrooms with software, laboratory experiments, and new ideas. As a follow-up to workshops for teachers who are teaching physics out of field, lab equipment is loaned to these teachers during the academic year through a statewide courier system.

The school also serves as a statewide distribution center for the software developed by the Minnesota Educational Computing Consortium. Every year, some 40 school districts benefit from this service.

In 1984 the NCSSM was placed under the governance of the University of North Carolina System as "an affiliate school of the University of North Carolina." One immediate result of this action was that summer programs for high school students were established on six different campuses of the university system. These programs are taught by university faculty members and local high school teachers, but they are administered and coordinated at the NCSSM. Each summer, more than 600 11th- and 12th-grade students take part in five weeks of a research- and laboratory-oriented experience at no cost to their parents other than transportation.

OUTCOMES AND COSTS

We are confident that the future contributions our students make to the state and the nation will be significant. Although it is too early to know the specific impact of the school on its graduates or on education in general, some positive indicators do exist.

Practically every graduate of the NCSSM has gone on to a university; two-thirds of the graduates have gone to one of the many fine public and private colleges and universities within North Carolina. The other third are widely distributed among the most selective

Communities should seek ways of providing some of these resources to academically talented students in local schools.

universities in the nation, including the military academies. The class of 1986 was offered about \$2.5 million worth of scholarships. The 138 graduates of the class of 1982 are part of the university class of 1986 and have gone on to graduate school or have entered the workforce. A preliminary survey indicates that about 80% of them are involved in study or work related to science or mathematics.

Although the cost of a residential school is higher than that of a day school, the state has been willing to continue to fund the school in recognition of the value of its programs. Some 90% of the school's annual budget of \$6 million is provided by a direct legislative appropriation. The remaining 10% comes from corporations, foundations, and individuals, including an active organization of parents. Donations from parents cover all the costs of an extensive co-curricular program and contribute to the professional development of the faculty and staff. This year more than \$125,000 has been pledged by parents. The total investment in the campus now stands at \$27 million, a figure that includes the \$8 million value of the original site, \$15 million in state construction funds, and more than \$4 million in private funds.

IMPLICATIONS FOR EDUCATION

The North Carolina School of Science and Mathematics, the first publicly supported residential school in the U.S., has become a model nationally and even internationally. Other states have followed our lead. Louisiana opened a sim-

ilar school in 1983, and Illinois opened its school in 1986. Delegations of legislators, educators, and business leaders from 35 states and 15 foreign countries have visited the campus. The Kingdom of Jordan is planning to open a similar school and has sent its director to spend a month in residence at the NCSSM. In each of the past two years, the Republic of Korea has sent teams of five science educators to spend two weeks in residence working with our science faculty.

Can every state afford to set up a similar school? Every state has parents, a business community, and a legislature concerned about the quality of education being provided to their young people who have the potential to lead. Every state has academically talented students who are unserved or underserved by their present schools. Every state has schools, large and small, in which the few students with deep interests in science and mathematics are not always appreciated by their peers and are not always challenged by their teachers or are not provided the resources required to develop their talents and interests.

One of the most important resources at the NCSSM is time. Being a residential school makes it possible for us to increase the time during which students have access to the school's facilities. Computers are available seven days a week; the library also remains open on weekends; teachers are on duty in the evening. Moreover, the schedule at the school is more flexible than that of public day schools.

But residential schools are not for everyone. Communities should look to ways of providing some of these resources to academically talented students in their own schools. Every community provides extensive after-school programs for athletically talented students. Why can't teachers, laboratories, computers, and libraries be made available as late into the afternoon — or even on Saturdays — as are coaches, gymnasiums, and tackling dummies?

The number of states with groups that wish to do something about education for the academically talented is increasing. They look to North Carolina for encouragement and assistance in exploring the possibilities offered by a residential school. The vision of a progressive and courageous governor is becoming clearer each year, as the effect of the school is felt throughout the state and the nation. K



Through its Women in Science Program, the Academy makes special efforts to encourage girls to explore possible careers in science.

Academy students enjoy mentorship placements at research laboratories, medical centers and educational institutions in the greater Chicagoland area.

Illinois Mathematics and Science Academy: "A Pioneering Educational Community"

by

Stephanie Pace Marshall, Ph.D., Director
Catherine C. Veal, Communications Officer

On September 7, 1986, the Illinois Mathematics and Science Academy opened with 210 students, 12 faculty members, nine resident counselors, 21 courses, no residence halls, no computers, no library books, limited funding, many unanswered questions and an uncertain future.

Since then, times have changed dramatically.

Today, approximately 500 talented mathematics and science students (sophomores, juniors and seniors) from Illinois attend the Academy. Although located in northern Illinois, the Academy is indeed a state school, enrolling students from all geographic areas.

Today, the Academy has 55 exemplary faculty, 22 dedicated resident counselors, 127 courses, five completed residence halls with two more under construction, approximately 20,000 library books, 300 computers, a graduating class, a collaborative outreach program for other teachers and students in Illinois, and a future full of options, possibilities and promise.

As the nation's only three-year public residential high school for students of exceptional talent in mathematics and science, the Academy has indeed come a long way in a short time. Today, in only its fourth year of operation, the Academy is well established and widely recognized as a national model of educational renewal, excellence and innovation.

Academic Program

The Academy's academic program fosters the development of

students as *apprentice investigators*. Group and individual research is encouraged. To help promote academic risk-taking and collaborative exploration of critical issues, neither grade point averages nor class rank are applied to Academy students.

Students move from prescribed courses during their sophomore year to elective courses during their junior and senior years. Some of the more unusual electives, rarely found in high school settings, include: *Differential Equations*, *Galileo: Science and Religion*, *Pathogenic Microbiology*, *Exploring Math Topics Using Mathematica™*, and *Theories of War/Theories of Peace*. This year, a special interdisciplinary course entitled *Science, Society and the Future* emphasizes problem-solving, decision-making and policy development within a global context.

In addition to opportunities provided in the curriculum, Academy students enjoy mentorship placements at research laboratories, medical centers and educational institutions in the greater Chicagoland area. Students meet on site with their mentors every sixth school day to write proposals, conduct research and design experiments. The mentorship program is a non-credit, non-graded extension of the junior / senior curriculum.

A six-day teaching cycle supports the goals of the academic program by providing time for individual and

group research, academic field trips and mentorship activities. Every sixth-day, known as Exploration Day, regular classes are suspended, enabling students and faculty members to pursue topics of special interest in-depth.

On campus, a fulltime resident scientist engages students in individual and group research above and beyond opportunities provided in the classroom. Because of the Academy's residential nature, students are able to use laboratory, library and computer resources on evenings and weekends.

Although the academic program emphasizes science and mathematics (at least 50% of a student's coursework must be in these areas), students also take challenging courses in social science, English, foreign languages, fine and performing arts, and health and physical education. An important goal is to help students forge interconnections among the various academic disciplines.

The Academy conducts a national search for "remarkable" teachers who can challenge and inspire gifted students, and who can nurture and support adolescents. Approximately 28% of the faculty hold a doctorate, and the average teaching experience is 12 years.

Student Achievements

Although the Academy is still in its infancy, students have already achieved numerous co-curricular

distinctions. Members of the first graduating class, which included 56 National Merit finalists, compiled state championships in Scholastic Bowl, JETS, Future Problem Solving Bowl, Knowledge Master Open and Chess. A mean ACT score of 29.5 placed the Academy first in the nation among the 5,856 American high schools in which 40 or more students took the test.

Other achievements by students during the Academy's initial years include a Westinghouse National Science Talent Search finalist, a White House Presidential Scholar, first place in the North Suburban Math League, two appointments to the U.S. Naval Academy, first place in the national SuperQuest competition, and several published authors and professional conference presenters.

Service / Support Programs

In addition to their academic and co-curricular responsibilities,



In addition to their advanced mathematics and science studies, Academy students enroll in challenging courses in the humanities and arts.

Academy students participate in required community and campus work service programs. Students donate 80 hours of their time and talent to approved social service and not-for-profit community agencies throughout Illinois, and work three hours a week on campus, as peer tutors and counselors, cafeteria workers, custodial assistants, groundskeepers, office assistants, tour guides, or lifeguards.

Many students also participate in interscholastic athletics (the Academy fields teams in 16 sports), and in Student Union and residential life social activities. Resident counselors, college and career counselors, social workers, academic advisers, and area host families provide a strong support network for the Academy's young scholars.

Admissions

Illinois students who have completed the equivalent of the ninth grade are eligible to apply for admission. A written application is required, along with recommendations from science and mathematics teachers, and guidance counselors or principals. Also considered are SAT scores, coursework and grades, co-curricular awards and achievements, extracurricular activities and interests, and statements from parents.

Each year, during the fall and winter months, admissions counselors coordinate intensive recruitment efforts. Informational meetings are held throughout the



The Academy's Computer Research Center and micro-computer labs in the residence halls enable students to conduct research during the academic day, at night and on weekends.

state, and four Open Houses for prospective students and their parents are held at the Academy.

As a state school, supported by legislative appropriation, tuition and most room and board expenses are provided. Parents are assessed a fee of \$650 to offset some of the cost of co-curricular programs and residential services. Full and partial waivers are available to families who demonstrate financial need.

IMSA Fund for Advancement of Education

Contributions from the private sector and individual donors provide the "margin of excellence" necessary for the Academy's continuing development as one of the premier institutions of its kind in the nation. Major grants from the Furnas Foundation, the Amoco Foundation, and the Hitachi Foundation have supported library / information resources, advanced organic chemistry, and a global education curriculum respectively.

Illinois Mathematics and Science Alliance

As a laboratory for the development, testing and dissemination of

As a state school, supported by legislative appropriation, tuition and most room and board expenses are provided.

The Academy's Office of the Illinois Mathematics and Science Alliance coordinates collaborative outreach programs for teachers and students throughout the state...

The Academy conducts a national search for "remarkable" teachers who can challenge and inspire gifted students...

innovative techniques in mathematics, science and humanities education, the Academy serves as a resource for other schools in Illinois. The Academy's Office of the Illinois Mathematics and Science Alliance coordinates collaborative outreach programs for teachers and students throughout the state, including a Summer "Ad" Ventures residential experience for students in grades 7-10; an annual statewide leadership conference for education, business and research leaders in Illinois; and numerous teacher training/development workshops and programs.

The Challenge and the Promise

The challenge and the promise of the Illinois Mathematics and Science Academy perhaps is best captured in the words of Dr. Carl Sagan who said:

"The need to understand how the universe works is fundamental to human nature. It is also essential for safely managing the human future; but foolishly, we have designed a society based on science and technology in which hardly anyone understands science and technology. This is a clear prescription for disaster.

Our future depends on producing and encouraging highly compe-

tent, ethically responsible young scientists, as well as a much greater scientific literacy in the general public.

The Illinois Mathematics and Science Academy in Aurora, Illinois, is dedicated to meeting this challenge...

It is a gift from the people of Illinois to the human future."

To learn more about the Illinois Mathematics and Science Academy, write to:

IMSA
1500 W. Sullivan Road
Aurora, IL 60506-1039
708/801-6000. □

Hope College and Ottawa School District Working Together to Serve Academically Talented

Educators and parents are continually looking for innovative ways of meeting the special needs of academically talented students. A success story may be found in Holland, Michigan where a school district and college have pulled together and developed a program whereby young students are given the opportunity to take advanced math and writing courses on a local college campus.

PATH, the Program for the Academically Talented at Hope, is a cooperative project of Hope College and the Ottawa Area Intermediate School District. It was developed in 1986 to serve academically talented seventh, eighth and ninth graders from greater Ottawa County by offering fast-paced accelerated instruction in writing and mathematics. Eleven public and about five private school districts participate, with forty to fifty students enrolled each year.

Students qualify for PATH by participating in the Midwest Talent Search at Northwestern University and taking the SAT (Scholastic



Aptitude Test). The SAT score criteria for PATH participation are: Math, SAT-M ≥ 500 and SAT-M + SAT-V ≥ 870 ; and Verbal, SAT-V ≥ 440 and TSWE 35.

PATH students meet on Hope's campus from 1:30 p.m. - 4:00 p.m. one afternoon a week throughout the school year. For most students PATH takes the place of a regular math or English class in their home school. Each student is charged a fee, with many districts paying all or part of the tuition. Each family is also responsible for their child's transportation.

The two-year PATH sequence

follows the traditional four-year high school mathematics curriculum, although it is at an accelerated pace. During the first year, PATH students study first and second year algebra, and during the second year they study plane and solid geometry, trigonometry and analytic geometry. Following two years of PATH math, it is hoped that the students are ready for Honors Pre-Calculus or Advanced Placement Calculus at their high school. Some students may even be ready for college level calculus.

Throughout the two-year math sequence, emphasis is placed on

For most students PATH takes the place of a regular math or English class in their home school.



ents

IGHTING A BRAIN DRAIN

Texas Program Gives Gifted Math and Science Students Chance to Finish School and Start College Simultaneously

By KATHERINE S. MANGAN

DENTON, TEX.

While their friends back home are beginning the new school year with pep rallies and parties, 163 Texas high-school juniors and seniors are getting a head start on college in a unique program for gifted mathematics and science students.

The Texas Academy of Mathematics and Science, created by the state Legislature and located here at the University of North Texas, is thought to be the only program in the country where students can simultaneously finish their last two years of high school and their first two years of college. Other advanced residential high schools that are springing up around the country allow students to focus on mathematics and science, but they do not offer college credit.

'I Really Want to Go to MIT'

The Texas academy's purpose is to attract bright students who might otherwise become bored with their high-school courses and to nudge them toward careers in mathematics and science. Educators and business professionals are concerned about a shortage of students going into those fields. They say the shortage could have dire consequences for the nation's economic future.

"We're hoping to give these students a jump by pushing and challenging them," says William T. Brady, director of the academy.

"We want to turn them on to math and science even more than they already are," he adds.

For students like Sherri Webb, the opportunity to get a two-year jump on her peers was too good to pass up.

"I really want to go to M.I.T., and I thought that this would be a great way



Sherri Webb (foreground), with Kristen Wukits: "I thought that this would be a great way to get my education started."

Students attending the academy take regular university courses with other University of North Texas students, live on campus in a dormitory, and eat in campus cafeterias. Unlike the university students, however, academy students live by strict rules: They must be in their dormitory by 11 p.m. on week-

days, they cannot leave the campus without getting approval from the academy's staff, and they are forbidden to date non-academy students without permission from their parents. Students of opposite sexes can visit in residence-hall rooms only on weekend after-

Continued on Following Page

Texas Students Start College While Completing School

Continued from Preceding Page
noons, and doors must be kept open during the visits.

While some students grumble about those and other restrictions enumerated in a thick handbook, most of them are enthusiastic about the program.

"I'm a little bit scared, but I'm really excited about the new scene," says Kristen Wukitis, who at 15 years old is one of the younger participants. Ms. Wukitis, who hopes to become a plastic surgeon, finished her freshman year of high school last spring, but took enough summer-school and extra courses to skip her sophomore year.

Ms. Wukitis says she isn't worried about fitting in with traditional-age university students.

"They just totally treat you like an older person," she says.

Mike Watts says he is learning new skills, including how to do his laundry. On a more serious note, he adds, "This is a golden opportunity to get ahead in school."

As for his fellow classmates, Mr. Watts was pleased to find that they don't all carry slide rules and spout logarithms. "They're mostly outgoing and friendly," says Mr.

Earning a B.A. Said to Have Big Impact on Older Women

Continued from Preceding Page
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The majority of these women got married when they were 18 to 20 years old, during the traditional college years and postponed their own college education," said Ms.

Watts, who is 17 years old. They're not all needs."

The Texas academy opened last year with \$500,000 in private donations. Most of the money came from local business leaders eager to attract talented students to the region. The only contribution from the state was the allocation of \$1,270 a student that would have gone to the students' school districts if they had remained at home.

\$2.1-Million From the State

Earlier this year, the Legislature kicked in \$2.1 million to cover the academy's 1989-90 and 1990-91 academic years.

The academy is loosely modeled

after the North Carolina School of Science and Mathematics, a residential school in Durham, N.C., that is not tied to a university.

Since the North Carolina school opened in 1980, gloomy forecasts about the dwindling supply of scientists and mathematicians have prompted legislators to approve similar schools in several other states, including Louisiana, Illinois, and Indiana.

The schools have proven controversial in some states, where legislators have branded them elitist. The critics argue that money spent on the academies would be better used in the public schools, many of which are already short of funds.

Some high-school educators have also protested that they do not

"The common factor is the exhilaration these students have being with each other. They can be academic and be appreciated for it."

want to lose their brightest students to the new academies. Supporters of the special schools, however, say that anything that will bolster the number of future scientists and mathematicians is worthwhile. To counter the criticisms,

some of the schools have shared their resources with the public schools in their areas.

While most of the special academies have their own faculty members who teach courses specifically for their students, the Texas school offers its students the chance to take university courses taught by university faculty members. Some of the other programs allow students to conduct research at nearby universities.

Julian C. Stanley, a professor of psychology at the Johns Hopkins University who has studied such programs, believes the Texas model has an advantage over the other academies: It is much cheaper to operate because it uses the university's faculty and facilities. Mr. Stanley directs an 18-year

WE CONCENTRATE ON YOU SO YOU CAN CONCENTRATE ON



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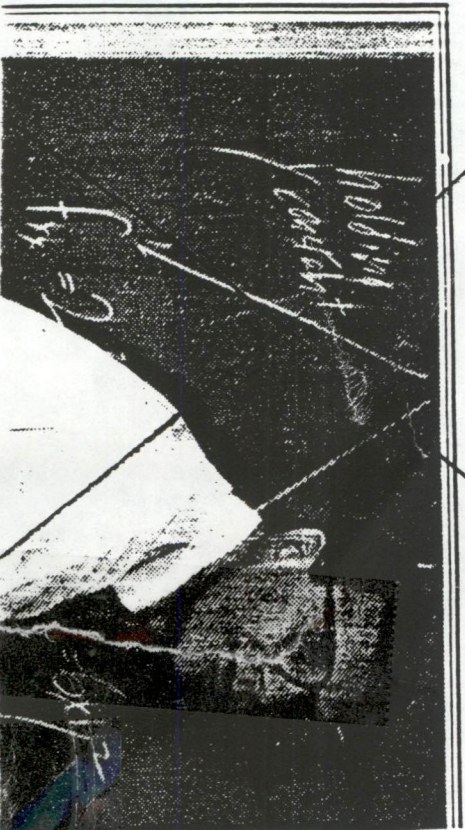
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old project at Johns Hopkins called the Study of Mathematically Precocious Youth. He also serves on the board of the Texas academy.

Compared with regular high schools, where being smart in math or science doesn't always count for much, all of the advanced academics offer a refreshing change for students, Mr. Stanley says.

"The common factor is the exhilaration these students have being with each other," he says. "They're not called nerds or whimps any more. They can be academic and be appreciated for it."

The nation as a whole benefits from programs that stimulate students' interest in math and science, he believes. "The biggest brain drain we have is in these fields," he says. "There isn't enough stimula-

tion for students. They just drop out and go into something else."

A Texas Recruiting Day

Tuition is free for students at the Texas academy, but room and board costs them each about \$4,000 a year. When they finish the program, students can either stay at the University of North Texas or transfer to other colleges or universities, where they will be ready for their junior year. Although many have set their sights on elite out-of-state universities, like the Massachusetts Institute of Technology and the California Institute of Technology, the academy's administrators hope that many more will opt to remain in Texas and help the state's faltering economy.

To that end, the academy held an

all-Texas recruiting day last week to give Texas colleges the chance to woo the students.

The university's chancellor, Alfred F. Hurley, says he is a strong supporter of the academy. "Our goal is to enhance our own economic development," Mr. Hurley says. "We hope these students will remain in Texas, or at least return to Texas and contribute to the economy."

Program Not for Everyone

Getting admitted to the academy is tough. The students, who are recruited from throughout Texas, need more than high Scholastic Aptitude Test scores and grade-point averages to be accepted. They must also convince the academy's administrators that they are

mature enough to survive the social and academic pressures they will face as youngsters on a university campus.

"This program isn't for everyone," says Annetta Ramsay, the academy's associate director for student life. "Some students should remain in high school. But these students, by and large, were sick of high school and bored with their classes."

Most of the academy students hold their own academically. Last year, the average G.P.A. of academy students was 2.9—slightly higher than that of regular freshmen at the university.

A survey of the academy's inaugural class found that students by and large found the courses to be difficult, but not unrealistic. The

mathematics courses were considered the toughest, because the academy students had not had some of the upper-level high school courses that their university classmates had taken.

Academy students follow a curriculum of mathematics and science courses, along with a few courses in the humanities. The curriculum is similar to what a traditional mathematics or science major would take, although the academy students do not declare majors. Of the 88 students who started the program last year, 16 did not come back this year. Some found the work too difficult, while others were barred because of discipline problems or opted to stay out for other reasons.

Most of the students say they are comfortable at the academy, but some were not willing to give up high school altogether. Kelly Southard, in her second year here, says she appreciated the substitutes that the academy organized for one traditional high-school activity: the school dance.

"I really wanted a prom and a homecoming, and we got both," she says. While academy students are encouraged to join the university's marching band and academic clubs, other activities, like fraternities and sororities or the university's sports teams, are off limits. Instead, the academy's staff came up with a variety of special outings and activities for their students.

"They keep us so busy," says Mr. Watts, "that there's no time to miss high school."

RESOURCE: The University of North Texas Research Magazine
FALL 1989, Vol. 6, No. 1.

THE TEXAS ACADEMY

CHALLENGING TOMORROW'S

SCIENTISTS TODAY

BY CONNIE PRYZANT
STAFF WRITER OF THE DALLAS MORNING NEWS



The 79 freshmen living on the third floor of McConnell Hall at the University of North Texas like to think of themselves as normal college students.

They attend classes, squabble with roommates, question authority and hunger for a good time on weekends. These students, however, are in a curious limbo between high school and college.

As the founding class of the Texas Academy of Mathematics and Science, they are high school age but smart enough for classes far beyond the scope of the schools they left.

They live on their own, yet are considered too young for traditional college freedoms. Hence they chafe under curfews and restrictions on travel.

Normal?

"They're probably the most watched-over, mothered, hovered-over group of students that ever came through here," said Rogers Redding, a UNT physics professor and the director of the academy.

They're also the newest participants in a growing national movement to create public, tuition-free residential schools focusing on mathematics and science

Editor's Note: This story was written before the Texas Academy of Mathematics and Science received legislative funding, and before Dr. Rogers Redding resigned as academy director. (Reprinted by permission of *The Dallas Morning News*.)

education for outstanding students. Texas is one of six states to have started such schools since 1980.

"I think these schools are the direct result of a national need that's being articulated and discussed at higher and higher levels," said Stephanie Pace Marshall, director of the Illinois Mathematics and Science Academy.

"Our students are not doing as well as other industrialized countries in terms of higher levels of mathematical reasoning, and application of math and science concepts."

Because of the growing importance of science and technology in an increasingly competitive world, many companies are seeking employees with strong skills in these areas. In Texas, for example, the demand for electrical engineers far exceeds the supply.

But recent studies have suggested that American students lack the mathematical and scientific literacy needed for the future, and international comparisons have shown that U.S. students lag far behind other countries in achievement.

Dr. Marshall, who also heads a two-year-old organization of specialized math and science high schools, said she anticipates that several more schools will open within a couple of years.

The Texas academy was approved by the legislature in 1987 and opened last fall with more than \$500,000 in private donations—enough, when combined with state allotments per student, to sustain the program for one year. Students take college courses such as axiomatic theory and differential equations and have access to resources unavailable at most high schools.

The academy, however, cannot continue without permanent state funding. Amounts ranging from \$2.1 million to \$2.8 million are included in the Senate and House versions of the appropriations bill.

"No issue in my experience at North Texas has received more enthusiastic support from individual legislators," said UNT Chancellor Al Hurley.

"I think there's widespread understanding that the graduates of this pro-

Facing page: The first class of the Texas Academy of Mathematics and Science. *Right:* Jenny Camp works as a research intern for Dr. Ming-chi Wu of the biochemistry faculty. *Below:* Dieutnu Nguyen receives some guidance from Dr. Neal Brand of the mathematics department.



Photos by Dan Santema



gram will be a source of help in dealing with the challenges faced by Texas as it becomes more competitive," he said.

As the first year of classes draws to a close, however, the students are preoccupied with matters closer to home than the state Capitol.

Like finals.

"There's nobody like your mom here to shake you and tell you to get up and go to class," said Stephen King, a 17-year-old from Victoria.

Stephen and his fellow students who had always sailed through tests in high school said they had a rude awakening to the rigors of college academics.

"In high school, you'd get a review sheet and make a 90 or 100 on a test," said Bailey Brewer, 16, of Fort Worth. "Here, you get a review sheet, but they also trick you on the test and show you something you haven't seen."

To enter, students must have a minimum Scholastic Aptitude Test score of 1,000 with a 550 or above on the mathematics section. The students are earning simultaneous high school and

college credit, and in 1990 will graduate with high school diplomas from the academy.

This year, nine students left the program for a combination of disciplinary, academic and personal reasons. Applications for the second class include a wider demographic and geographic mix of students, school officials said.

In some ways, the students are experiencing the normal difficult transition associated with freshman year. But they also are adjusting to a high school career cut short by two years.

For some it wasn't a minute too soon.

Michael Windham, one of four students to earn a 4.0 average the first semester, said he was on his way to being valedictorian of Mesquite High School. But the idea of the academy appealed to him because it was a way to pursue different opportunities in a new setting.

"Back home, I didn't really care about most of the things most high school students did, like social standing, cliques and things that don't have much bearing out of high school," he said. "I didn't

t's something that will be widely copied...."

—Dr. Julian Stanley

think high school was the world, and everybody else did."

But for others, the transition was more difficult.

"It was a real hard decision for me," said Mauri Garcia of Laredo, another 4.0 student.

"I want to go to medical school and thought that getting ahead two years would help me a lot," she said. "But my mom used to call me almost every day. I got homesick a lot last semester. It's much easier this semester."

The Texas school is the only residential school integrated with a college campus. The other schools—in North Carolina, Louisiana, Mississippi, South Carolina and Illinois—exist as separate institutions.

"It's an entirely novel conception," said Julian Stanley, a specialist in developing mathematics and science education for gifted students.

A psychology professor at Johns Hopkins University in Baltimore, Dr. Stanley has directed an 18-year-old project called the Study of Mathematically Precocious Youth. Spinoffs of his program include university talent searches for gifted students.

"It's something that will be widely copied across the country, if it's successful. It's so much more cost-effective."

Stanley said.

The academy—without a separate campus to support—costs \$5,000 per year, compared with more than \$11,000 at the North Carolina School of Science and Mathematics.

However, there are advantages to the freestanding schools, said William Youngblood, principal of the North Carolina school, the country's first specialized residential public school.

"Here, it's felt that it's more important to try to focus on such things as student research and independent study and developing those higher skills rather than to try to replace the undergraduate years," he said.

Dr. Youngblood and Dr. Marshall of the Illinois school said the schools are not easy to start and will almost certainly fail without support from governors and the most powerful elected leaders.

"Public school educators have not been the strongest supporters," Dr. Youngblood said. "The concerns are perceived competition for resources and a drain of talent from the public schools."

Those problems, however, have not materialized, Dr. Youngblood said. The Illinois and North Carolina schools have established outreach programs to share resources with their communities. In addition, he said, no more than a few students from any single school attend the specialized school, and new student leaders replace those who leave.

Dr. Redding said that in Texas, the academy probably received more widespread support because it didn't need a separate building and was able to operate for the first two years without additional state funds.

Despite the inevitable difficulties that accompany building a new community under intense academic pressure, several students said they would not return to their high schools.

"Up here, it's OK to be smart" said Rachel Renick of Bedford. "Before, I wasn't an outcast—I was admired because I was smart—but I didn't exactly fit in."

Her roommate, Kelly Ivors of Lewisville, agreed. "This summer, I'll be back in touch with my friends, but I'll find it hard to know what to talk about." ❀



Brady accepts academy directorship

Dr. Tom Brady, professor of chemistry at the University of North Texas, has been named director of the Texas Academy of Mathematics and Science at NT.

Brady replaces Dr. Rogers Redding, who is taking a one-year study leave at the Air Force Academy after heading the NT program since its inception in 1987.

"Dr. Brady has a wealth of administrative experience and an outstanding ability to work with people," said Dr. Robert B. Toulouse, interim provost.

TAMS receives legislative funding

The Texas Academy of Mathematics and Science at the University of North Texas will begin its second year of operation with two welcome additions: a new class of 89 high school juniors and more than \$1 million in state funding.

The new class will join the 79 students from the first class who will be completing their final year in the academy.

Academy officials have made special efforts to recruit minorities for each class. The new class contains two Blacks, 12 Asians and 12 Hispanics. The first class contains three Hispanics, five Blacks and 10 Asians.

The new class averaged 1,181 out of 1,600 on the Scholastic Aptitude Test, a national college entrance examination that measures math and verbal skills.

The Texas academy, an accelerated learning program that allows talented students to complete their last two years of high school and first two years of college simultaneously, was created in 1987 and opened in fall 1988 with 92 students. A second class of 89 students entered the academy this fall.

"I'm excited about the opportunity to work with academy students, faculty and staff," Brady said. "They're enthusiastic about what the academy has accomplished and its potential to help educate the next generation of scientists and engineers."

Brady received his bachelor's and master's degrees from NT and his doctorate from The University of Texas. From 1980 to 1983, he served as chair of the chemistry department, and in 1987 he was named a Regents Professor in honor of his outstanding record of teaching and research in organic chemistry.

In addition to his designation as a Regents Professor, Brady received the W.T. Doherty Award from the Dallas-Fort Worth chapter of the American Chemical Society in 1983 and was named a Student Association Honor Professor in 1985.

Although the incoming academy students took the SAT as high school sophomores, their scores are well above the state (879) and national (904) averages for high school seniors.

The academy also will receive its first special state funding this year. Although the Texas Legislature created the academy in 1987, it provided no special funding for the program at the time. The academy's first year was funded by the university, by the standard per-student allotment for high schools from the Texas Education Agency and by more than \$500,000 in donations from individuals, corporations and foundations.

However, during the last session, the legislature approved \$1.05 million for 1989-90 and \$1.05 million for 1990-91.

high school students two-year technical, scientific careers



the in the proportion of young people choosing careers in these fields. This is a trend under way for more than a decade, bodes ill for the U. S., which is trying to compete in the world marketplace.

Challenges before us today are revolutionary vistas offered by the new superconducting materials; the need to rebuild our physical infrastructure and restore our manufacturing strength; and stiff foreign competition in communication, computing, genetics and other fields. Whether we can respond to these challenges in creative science and engineering will depend critically on our technological power.

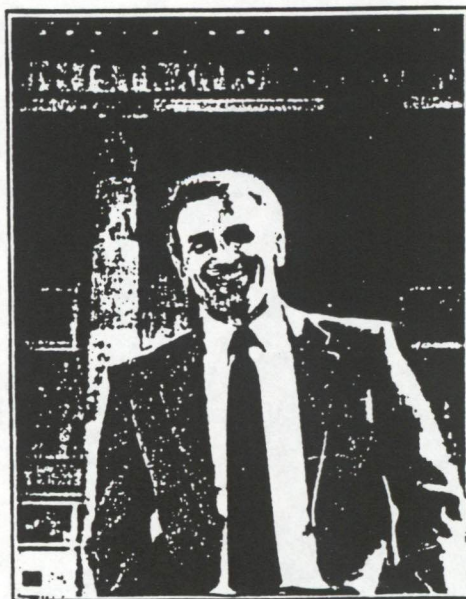
Our country graduates about 78,000 engineers per year. Japan, with only half our population, turns out roughly the same number. The Soviet Union produces about 335,000 or more than four times as many. At current rates, there will be about 100,000 fewer U.S. graduates in science and engineering over the next 25 years. The American Electronics Association forecasts a nationwide shortage of about 100,000 electrical engineers by the end of the decade.

Graduate schools in science and engineering increasingly have turned to international students to fill the void and keep research programs viable. They earn over half of the engineering graduate degrees awarded in the United States. About half of all doctoral degrees in physics are held by foreign nationals. We are fortunate to attract these talented students to our universities, for many of them remain in this country and make important contributions to research, development and education in science and engineering. Nonetheless, it is bad policy for our country to be dependent on an unpredictable resource and to fail to meet some of our needs with home-grown talent.

Science and mathematics education is particularly hard hit, a problem compounded by the alarming rate at which teachers of these subjects leave the profession - 18,000 in 1984 alone. Since 1981, fewer than 1,400 college students have earned degrees in mathematics and science education, which translates to less than one for every 10 school districts in the United States. By 1995, we will need about 100,000 new science and math teachers nationwide - more than the total now teaching in these fields.

A quick fix will reverse the decline in students choosing careers in mathematics, science and engineering. By establishing this academy, the Texas Legislature initiated a program that can be the state's starting point in drawing our finest young minds to key areas. Texas has a special stake in this as the state attempts to diversify its economy and move away from the traditionally heavy dependence on gas and oil industries. Over time, the academy can make a significant impact by identifying gifted youngsters early and providing the educational preparation that may steer them toward technical careers.

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Dr Redding

Math & science academy gives head start on college studies,

The Texas Legislature has established the Texas Academy of Mathematics and Science at the University of North Texas in Denton. The academy is a two-year, residential, early-admissions program for Texas high school students who are particularly talented in science and mathematics. Students are selected during their sophomore year in high school for admission to the academy the following fall semester, at the beginning of what would have been their junior year in high.

The University of North Texas will admit 90 students this fall. The plan is to admit another 100 students in 1989 and 200 annually thereafter. Thus, at full strength, the academy will enroll 400 students. There will be no charges for tuition or fees. However, in the absence of state funding for the program, academy students will be responsible for the costs of room, board and books. The university is engaged in a vigorous campaign to raise funds from private sources and the federal government to cover these costs for students who cannot afford them.

The academy provides highly-talented Texas students the opportunity to complete their last two years of high school and first two years of college concurrently in residence on the North Texas campus. The curriculum, consisting of freshman and sophomore university courses taught by regular full-time faculty members, completes the requirements for high school graduation and counts toward university degrees. Students successfully finishing the program will receive their diplomas from the academy and will have completed the first two years of college. Academy graduates will be rising college juniors at the time that their former high school classmates will be entering college.

Advanced residential high schools established for similar purposes are either operational or on the drawing board in several other states, including North Carolina, Illinois and Louisiana. The Oklahoma Legislature recently appropriated about \$5 million to begin such a school.

By contrast, the Texas academy is specifically a university program aimed at highly intelligent, motivated students. They will receive rigorous schooling in mathematics and the sciences, augmented by outstanding instruction in the humanities. Supplementing the formal classroom instruction will be enrichment opportunities including research projects with faculty members, field trips to area industrial laboratories, independent studies and lectures by outstanding visiting scientists and engineers.

In residence on the university campus, academy students will be immersed in a stimulating environment of research and instruction and will sense the excitement about science that is often missing in standard high school courses. They will live in residence halls separate from other university students, serviced by a residence staff to provide the necessary supervision, counseling and assistance for these younger students.

What is the rationale for such a program? Texas shares in a growing national problem. The health of science and engineering in the nation is threatened by a

Dr. Rogers Redding
Director,
Texas Academy
of Mathematics & Science,
University of North Texas, Denton



**A shortage
of 120,000
electrical
engineers is
forecast by
the end of
the decade**

"One's Reach Should Exceed One's Grasp, or What's a Heaven for?"¹

Julian C. Stanley

Study of Mathematically Precocious Youth (SMPY)
430 Gilman Hall
Johns Hopkins University, Baltimore, MD 21218

Thank you Dr. Hurley! I feel honored and privileged to speak at the first formal convocation of the Texas Academy of Mathematics and Science. It is a unique, innovative high school. You first and second-year students are both intrepid and fortunate: educationally intrepid, because you have risen to the considerable challenge of living away from home two years earlier than is typical, and extremely fortunate to reside in the only state of this country where you can get a superb education in all its aspects while telescoping four years of such schooling into two. Some of you may feel a bit like Harrison Ford as he sought the lost ark, the temple of doom, or the last crusader. Fortunately, there are fewer snakes in the groves of Academe. Cherish this opportunity, and make the most of it!

Let me pay tribute to the remarkable persons at the University of North Texas who spearheaded the move to create the Texas Academy of Mathematics and Science. Dr. James Miller, Dean of the College of Education, conceived the initial idea of having a high school with no teachers of its own. I had been seeking this model for more than fifteen years, but had not quite found it. No one else in the country had, either. In my opinion, the TAMS model is considerably superior educationally and financially to the non-university-based residential high school that a number of states such as North Carolina, Louisiana, Illinois, and Indiana have created.

¹Speech at the Convocation of the Texas Academy of Mathematics and Science, Denton, Texas, 10 September 1989.

Others on the faculty of the University and in its administration joined with Dean Miller to use the germ of an idea. I was greatly privileged to help with some of the planning and then to serve on the Advisory Board of the Academy. Thus, I saw the unparalleled cooperation of many persons, within and without the University, as they moved toward the fall of 1988, when the first students arrived. Without the continued strong support of Chancellor Hurley this could not have been done. You Texans have much reason to be proud of your state and of its concern for intellectually talented young people.

A great strength of the Academy is in the excellence of those who manage it. So far as I am aware, no other such school has been able to attract a staff of the academic caliber of physics Professor Rogers Redding, its first director; chemistry Professor Thomas Brady, the current director; biology Professor Manus Donahue; and widely experienced counselor Dr. Annetta Ramsay. Their willingness to serve testifies to the commitment of the University of North Texas to its Academy. The presence of distinguished business men, educators, and political leaders on its Advisory Board shows that the whole state of Texas is supportive.

In the rest of this talk I shall make many suggestions. You can't be expected to remember all of them. If you would like a copy of my remarks, see Ms. Jackie Stanczyk a few days hence.

Academic Success

The theme of my talk today is based on my slight revision of a line from the poet Robert Browning: "One's reach should exceed one's grasp, or what's a heaven for?" Extend yourself academically and socially. Aspire to excellence in everything you do! You came to the Academy and the University seeking better educational opportunities in the company of your true intellectual peers. About half of you found this last year. You are wiser now and better prepared to face the academic year. Those of you who are beginning have the advantage of being with these pioneers. They know the ropes and can help you avoid pitfalls.

Get a good start in your courses. In fifty-two years as an educator I have noted repeatedly in many different contexts that the difference between being an excellent student and an ineffective, harried one is proper attention to priorities. Do the important, difficult assignments promptly first. They can't be done right at the last minute, whereas easier ones might. Of course, it is human nature to take the pleasant road of the moment and have to pay the consequences of procrastination later. Transcend that!

Effective students use their time wisely, whereas most who earn low grades don't. As I remember from long ago, it is tempting to shoot the bull when one should be studying, instead. Then, toward the end of the semester one tries frantically to catch up, and all social activity has to cease. That's an unsettling way to live, and an unnecessary one. In the long run, efficient students have more spare time than inefficient ones do, and much more peace of mind.

Many of you are away from home on a prolonged basis for the first time. Nearly all of you will find college courses much more difficult than high school ones. You may also have trouble getting enough sleep, keeping your

clothes clean, etc. It is crucial that you master these quickly. Tackle the problems resolutely, as you might approach any daunting task such as taking a cold shower. Study ahead in your subjects, so that you will understand what the professor is saying because you perused the material for that day ahead of time. Learn how to take enough notes, but not too many, while still understanding the lecture or discussion. Review your notes soon after class, before they get "cold."

Above all, if you start to bog down academically, emotionally, physically, or socially, get help fast. See the appropriate counselor, tutor, nurse or physician, or Dr. Ramsay, Dr. Donahue, or Dr. Brady. Don't be like the high-IQ 15 year-old who entered Johns Hopkins and failed calculus the first semester because he never consulted the superb tutor who had been assigned and introduced to him the first day. Don't hesitate to cry for help.

Strive to make excellent grades: a 4.00 GPA if that is within your capabilities, or at least a 3.50 if that's what your extended reach attains. At minimum, stay above the 3.00 mark, especially if you want to transfer to another college or university after graduating from the Academy. You are bright enough to be a decidedly above-average college student, or you'd not have been admitted. Give your studies all you've got, from the beginning. They are the main reason you're here.

Avoid blaming your instructor if you do not do well in the course. If he or she is an excellent teacher, that is a bonus. If not, you are now a college student and therefore committed to learning, whether or not you find your instructor interesting and stimulating. It is your job to learn, not just to be taught. The "buck" stops with you. Many high school teachers predigest the material for their students. College teachers may expect you to learn a great deal of it largely on your own. Perhaps the most valuable skill

you can acquire in college is a lifetime habit of cognitive efficacy: the ability to learn promptly on your own whatever you need to know.

Also, remember that grades are earned, not "given." Don't excuse yourself by saying that the professor unfairly gave you a C in biology. Presumably, that's what you deserved.

Become Liberally Educated

In the process of earning good grades, be sure to get a broad, liberal education, in class and out. You'll acquire that here in science and mathematics. Some of the rest may have to wait for your junior year in college, at this university or elsewhere. Each person must live with himself or herself every minute of that individual's entire life, day and night, awake and asleep. You're "stuck" with yourself. To a considerable extent you have the choice as to whether your alter ego will be a bête noire (black beast on your back), an unpleasant Doppelganger, or a delightful companion. As psychiatrists tell us, we must learn to love ourselves before we can truly love anyone else.

Therefore, it behooves one to become especially interesting to oneself. A superb liberal arts education can help you do this. The young person

talented in mathematics or science needs to pursue those subjects vigorously and, for many such youths, professionally. This is crucial, but effective only in the context of also getting a good education, in the broadest sense of that word. Appropriate educational acceleration can help provide the extra time and leeway to develop you into a liberally educated, humane, self-actualizing adult who can contribute creatively and productively to a technical field while being a fine person, parent, spouse, relative, neighbor, friend, and civic improver. In other words, don't become merely a technical facade. Develop into an admirable human being so that at age 40 or

so you won't have to abandon the usual pursuits of life to go find your "true" self. Seek all along to be the self with whom you are comfortable and happy. Humanities, the arts, and the social sciences can help you do that. So can athletics, religion, and various aspects of social life.

Where to Go After Graduation

Let me say a few words about your transferring to another college or university after graduating from the Academy. Of course, the University of North Texas would be delighted for you to continue here toward a bachelor's degree, if you haven't made a nuisance of yourself. So would most of the other fine colleges and university in Texas. Yet, for various reasons, you may hope to transfer elsewhere. How feasible that will be depends heavily on the grades you earn and the recommendations you merit from your professors and the staff of TAMS. It also depends on the attitude that directors of admissions have toward the combined program of the Academy. At first, some may not believe you really took only regular college courses. They may be confused because you also earned a high school diploma during the same time. Those admission officers are going to need considerable "educating" this fall, as seniors at the academy apply here and there. Difficulties are likely to be greatest at highly selective private universities such as Harvard, Princeton, Yale, and Stanford. I've already briefed our admissions people at Johns Hopkins. They seem eager to have transfer applicants with excellent GPAs. I'll help at the other institutions, being well known at many of them because members of my "700-800 on SAT-M Before Age 13 Group" go almost everywhere and make excellent records.

At the most selective private institutions you may encounter a dilemma. There are few vacancies for transfer students at many of them, so your chances of being admitted as a beginning student, perhaps with sophomore standing, are

probably better. Harvard and the like don't usually want to give beginning students credit for college courses taken elsewhere. To get sophomore standing, take a number of Advanced Placement Program examinations each May. High scores on the right three of them may earn you sophomore standing at Harvard. Five APs should be enough at most other schools. Therefore, consider preparing to take AP exams in Calculus Level BC, Biology, Chemistry, Physics Level C (both parts), Computer Science Level AB, and whatever other subjects you learn well. Do as many at the end of the eleventh grade as feasible, so that you'll have those scores to show when you apply to the schools.

The Value of Contests

Highly selective private colleges and universities will expect a great deal more than merely an excellent cumulative GPA. Winning awards in various contests could help. Foremost among these is the Westinghouse Science Talent Search, open to all high school seniors. Ranking in the top 300 in it is prestigious. Being in the top 40 is even better. The top 10 win large college scholarships, from \$20,000 for first place to \$7500 for tenth. Only about 1400 students enter this competition, so the odds for persons working in a college environment should be good. Of course, you need not be thinking of transferring in order to enter the Science Talent Search.

Be sure to take the Preliminary Scholastic Aptitude Test (PSAT) in October of your first year in the Academy in order to try to qualify as a National Merit Semi-finalist. Many of you have a good chance to become National Merit Scholars, a prestigious designation, and perhaps to win some scholarship money. Also, you will help make TAMS look to the public like the collection of highly talented young people it is.

Each year, take the American High School Mathematics Examination. That

is the gateway to fame as a young math whiz. From the 400,000 who take the exam come the 3000 who take the American Invitational Mathematics Examination and the less than 100 of those who take the U.S.A. Mathematical Olympiad (USAMO) exam. Twenty-four will train for the U.S.'s team in the annual International Mathematical Olympiad, and six will be on that team to compete with the best from approximately 50 other countries. The brass ring on the carousel of mathematical competitions is a place in the top 8 in the country out of the original 400,000. The pinnacle of success is winning a gold medal in the International Mathematical Olympiad. Along the way is much learning of mathematics, lots of fun, and great sociability. Even getting to the USAMO enhances your chances of impressing the admissions director of a highly selective school. In addition, your achievement reflects favorably on TAMS, which for public relations purposes during its first few years needs all the academic luster it can acquire.

There are two other annual international Olympiads, one for chemistry and the other for physics. Also, there are many other competitions such as the Olympics of the Mind, the American Regional Mathematics League, the International Science Fair, and numerous computer ventures. As high school students, you should be eligible for all of these. As college students, you can enter the Putnam Competition in mathematics as an individual or try for a place on the University of North Texas three-person team. There are fascinating college computer competitions. Enjoy the best of both worlds, high school and college concurrently!

Your Summers

How will you spend your summers? Perhaps a few of you will need to take courses then in order to complete enough credits to graduate on time. Try diligently to avoid that by being an efficient, effective student during the

regular school year. Those who have the summer between the first and second year at the Academy free have a wide variety of stimulating possibilities. One of the best of these is to work closely with a faculty member or other research scientist on a project for submission in the Westinghouse Science Talent Search before December 15 of one's second year in the Academy. Another is to try to qualify for the six-week Research Science Institute in Washington, D.C., and serve an internship in that no-cost program for 70 top students from across the country and the world who have completed the eleventh grade. Only three or four can go from all over Texas, but why not try to be one of those if you have a superior academic record your first semester here?

There are three exceptionally fine pure-math institutes each summer: Professor Arnold Ross's famed eight-week one at the Ohio State University, the program at Hampshire College in Amherst, Massachusetts; and the recently established PROMYS (Promise) at Boston University.

You may be fortunate enough to secure a summer place in one of the country's great scientific laboratories such as Los Alamos, Argonne, or Bell Telephone.

Perhaps you'd prefer to be a mathematics or science teaching assistant in one of the six-week academic programs for ^{young} bright people offered by Duke University, Johns Hopkins University, and Northwestern University. Instead, you might like to try your hand at being a counselor at a summer camp. Just be sure you plan ahead to do something you'll enjoy and from which you will reap academic, social, or athletic benefits. Don't waste your valuable time. Once lost, it is gone forever.

Conclusion

I've thrown out a large number of suggestions, more than you could possibly absorb in this short while. I'd be pleased to follow up with you on

any of them. Some need to be implemented soon. It is my understanding that Dr. Brady and his associates have plans to do so. For those that can wait until the middle of January, I'll be back then for two months to teach a course about giftedness to gifted-child specialists and to lend whatever hand I can to the Academy and its students. Please feel free to visit with me then. I'm not omniscient, but do have ways to find what we need.

Thus, on the first day of the rest of your life I send you out into year or two of wonderful opportunities at this remarkable Academy to get a firm base for your future--as a poet said, "to seek, to strive, and not to yield." Rise to the challenge, and enjoy the experience. Education is not only a preparation for living, it is also life itself during what should be some of its sweetest times.

Remarks by Julian Stanley in Denton, Texas, on 21 February 1990, after an honorary Doctor of Educational Excellence degree was conferred on him by the University of North Texas:

Thank you, Chancellor Hurley, colleagues of the University of North Texas, and other friends. I feel deeply honored, especially in this hundredth year of your fine institution of higher learning. Dr. Hurley is, indeed, a distinguished "education president." His long-continued commitment to the Texas Academy of Mathematics and Science is an inspiration to me and others. The Academy is a vital, unique experiment at the interface of high school and college. It was inspired initially by Dr. James Miller, Dean of the University of North Texas College of Education. This already reknowned Academy is forging a link long missing in the usually vague, misguided, or overly optimistic national policy discussions about how to increase our country's supply of able scientists and engineers.

I see the Academy as the best model for residential state, regional, national, and international high schools for the mathematically and scientifically talented. How many boys and girls in the United States in a given age group could benefit greatly from spending two years in such a school as eleventh through fourteenth graders? The top 1 percent in a given attribute such as mathematical reasoning ability would number approximately 35,000 per year. Thus, even when the Texas Academy of Mathematics and Science reaches its goal of 200 entering eleventh graders per year, it will accommodate less than six in a thousand members of that large talent group. Of course, not all 35,000 would have the other characteristics and motivation necessary to cope with a chiefly required, rigorous college curriculum away from home two years before high school graduation. How many of us adults

passed two semesters each of biology, calculus, chemistry, and physics plus eight semesters of well-integrated humanities and social science courses, even at ages 18 and 19 during our first two years of college? It is a bit awesome to note that all Academy students must take at least these subjects and a total of 57 semester hours in order to receive the Academy's high school diploma. No student may elect to omit or drop any of the many required courses. Extremely few colleges specify this range of basic science. The Academy graduates who make good grades will have fine backgrounds with which to continue as college juniors in Texas or elsewhere.

Why does the United States sorely need the Academy-type option for those of the 35,000 each year who are eager to accept it? All of you hear repeatedly how poorly our country fares in international surveys of the mathematical and scientific knowledge of elementary-school and high-school students. Japan and South Korea tower over us in those comparisons. In mathematics, we usually rank at or very near the bottom, even when countries, provinces, or regions such as Ireland, Spain, and French-speaking Ontario are included.

Also, our mathematically ablest high school students, such as the six each year who represent the United States among the approximately 50 countries competing in the International Mathematical Olympiad (IMO), don't shed much luster on a country that spends a large percentage of its Gross National Product on education. In the 1988 IMO, the United States ranked sixth. War-ravaged, economically poor Vietnam ranked fifth! The team representing the People's Republic of China in just its third year of competition, compared with our 14th year, tied Romania for second place, behind only the Soviet Union. In 1989, China ranked first and we fifth.

During each of its four years China had a different woman on its team, and she scored well--one gold and three silver medals. The United States has never had a female IMO team member, even though its selection methods are largely objective. Probably, our ablest youths get far too little training specifically for the IMO.

The Academy model cannot solve all our country's mathematics, science, and engineering problems, but it can be a most important stimulus toward excellence. I salute the University of North Texas for its dedication to trying out and refining that model systematically. As an humble worker in the vineyards of academe, I am thrilled to be awarded a Doctor of Educational Excellence honorary degree as your remarkable university celebrates its centennial and also graduates the first class of its path-breaking Texas Academy of Mathematics and Science. Texans have much of which to be extremely proud!

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION/MEETING REQUEST DOCUMENT NUMBER: 9121985
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: NARUM, Jeanne L.: THE INDEPENDENT COLLEGES OFFICE

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/03/91

SUBJECT: A COPY OF THE FIRST VOLUME OF THE REPORT OF PROJECT
KALEIDOSCOPE AND A REQUEST TO MEET IN EARLY FALL. (
(She will get in touch with Marian)

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
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REMARKS: Enclosure to DAB

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FILE: *R* INTERNATIONAL-EDUCATION

1985

ICO THE INDEPENDENT COLLEGES OFFICE

WASHINGTON OFFICE OF
THE ASSOCIATED COLLEGES OF THE MIDWEST
THE GREAT LAKES COLLEGES ASSOCIATION
THE CENTRAL PENNSYLVANIA CONSORTIUM

RECEIVED
91 JUL 5 P 3:02

OFFICE OF THE
DIRECTOR

July 3, 1991

Dr. D. Allan Bromley
Assistant to the President for Science and Technology
Director, Office of Science and Technology Policy
Room 358
Old Executive Office Building
17th Street & Pennsylvania Avenue, NW
Washington, DC 20585

Dear Dr. Bromley:

Enclosed is a copy of the first volume of the report of Project Kaleidoscope, again with our great thanks for your significant contribution to our effort. The publication of the report has attracted national attention to the role of colleges and universities as critical partners in the effort to address the challenges facing the United States in science and technology. To attain such attention was, of course, one of the reasons we undertook this work.

I look forward to your comments on our report and to discussing with you and your colleagues the implications of this report for the national effort to strengthen science and mathematics at all educational levels. I will be in touch with Ms. Nida to see if there is a mutually convenient time to meet in early fall.

Thank you again for your contribution to the Project Kaleidoscope National Colloquium.

Cordially,



Jeanne L. Narum, Director

Enclosure

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VOLUME I: "WHAT WORKS: BUILDING NATURAL SCIENCE COMMUNITIES"

--Strengthening Undergraduate Science and Mathematics

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These publications report on a two-year project focused on developing an agenda for strengthening science and mathematics in the nation's liberal arts community, undertaken with support from the National Science Foundation, the Exxon Education Foundation, the Pew Charitable Trusts, the Kellogg Foundation, and the Camille and Henry Dreyfus Foundation.

These reports will be of interest to all responsible for developing, implementing, and supporting reforms in undergraduate science and mathematics: science and mathematics faculty, trustees, presidents, deans, and development offices at liberal arts institutions; staff of federal and state agencies and of private and corporate foundations; members of educational and disciplinary associations focused on liberal learning and/or the natural science and mathematics; institutional planners and architects.

VOLUME I presents a model of undergraduate science and mathematics that can be adapted to specific circumstances and institutional environments. (Available--June 1991).

VOLUME II includes Project Kaleidoscope research results, a bibliography of relevant reports and activities, and guidelines for and examples of successful facilities planning. (Available--Fall 1991).

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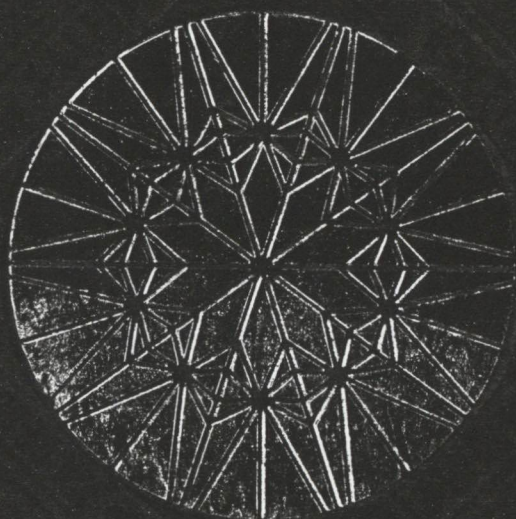
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What Works: Building Natural Science Communities

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Science and Mathematics

Volume One

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9121979

ORIGINATOR: 02

STATUS C

DIRECTORATE STATUS

FROM: ADOLPH, Charles E.

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/02/91

SUBJECT: NOTICE THAT THE REPORT MANDATED BY SECTION 246(b)
(PUB L 101-510) OF THE NATIONAL DEFENSE
AUTHORIZATION ACT OF FISCAL YEAR 1991 WILL MOST
LIKELY BE SUBMITTED TO DR. BROMLEY BY JULY 15, 1991.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

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DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

91 JUL 5 12:56

2 JUL 1991

OFFICE OF THE
DIRECTOR

Honorable D. Allan Bromley
Assistant to the President for
Science and Technology Policy
Executive Office of the President
Office of Science and Technology Policy
Washington, DC 20506

Dear Dr. Bromley:

Section 247(b) (Public Law 101-510) of the National Defense Authorization Act of Fiscal Year 1991 requires a report to you on actions that DoD may take to improve education in the scientific, mathematics and engineering skills necessary to meet the long-term national defense needs for personnel proficient in those skills. Section 2192 of Title 10, United States Code, as added by section 247(a) of the National Defense Authorization Act for Fiscal Year 1991 requires that we consult with the Secretary of Education on these actions. The report was due 180 days after enactment of the Act or May 6, 1991.

Because of the extent and multi-faceted nature of DoD science and engineering education programs, as well as the desirability of phasing and integrating them with the federal-wide plan under development through the Federal Coordinating Council on Science, Engineering, and Technology, I regret there will be a delay in transmitting the DoD report. I anticipate that the report will be submitted by July 15, 1991. I hope the delay will not cause any inconvenience to you.

Sincerely,

Charles E. Adolph

By Direction of the Secretary of Defense

"CORRESPONDENCE TRACKING"

TYPE: ACTION DOCUMENT NUMBER: 9121952
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: COMBS, David: CALIFORNIA MUSEUM OF SCIENCE & INDUSTRY

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 06/27/91

SUBJECT: REQUEST FOR PARTICIPATION IN THE EXHIBITION,
"CHILD'S PLAY: THE SCIENCE OF TOYS AND GAMES", BY
SENDING IN A PICTURE AND STATEMENT.

DIRECTORATE STAFF
ASSIGNED: D. Allan Bromley ASSIGNED:

ACTION
REQUIRED: AS APPROPRIATE STAFF
ACTION:

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OSTP DUE DATE: 07/15/91 STAFF DUE DATE
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June 27, 1991

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Jeffrey N. Rudolph
Executive Director

D. Alan Bromley, Ph.D.
Science Advisor to the President
Room 358, OEOB
17th & Pennsylvania Ave. NW
Washington, DC 20500

OFFICE OF THE
DIRECTOR

Dear Dr. Bromley:

The California Museum of Science and Industry is developing **Child's Play: The Science of Toys and Games**, a 4,000 sq ft traveling exhibition which will explore how playing with toys can stimulate an interest in science and have an important role in the process of science learning. In addition, the exhibit will demonstrate how science can be made an exciting and engaging activity for children by using toys to illustrate scientific principles.

The exhibit will open in Los Angeles in late November 1991 and continue until April 1992. After that, it will be on a 2 1/2 year tour of major science centers located in Boston, Chicago, Columbus, Charlotte, Ft. Worth, Los Angeles, Philadelphia, and St. Paul.

We are soliciting the collaboration of well-known scientists such as yourself in this exciting project. A portion of the exhibit will feature famous scientists with their favorite toy and an accompanying statement about how playing with this toy stimulated an interest in science and perhaps even motivated their later pursuit of a career in science.

Such anecdotal evidence of real-life examples will help parents make the association between toys and educational attainment. At the same time, the toy connection will make the presentation highly attractive to children who may feel that they share something in common with successful scientists.

The exhibit also includes user-friendly participatory displays where visitors will be engaged in activities derived from commercially available toys that illustrate science principles.

For example, in "Catch the Wind" children will learn about the Bernoulli principle by experimenting with different sail positions to find out how sail position affects a boat's ability to sail with the wind.

Parents and children will have opportunities to jointly take part in workshop activities such as making a flip book to see how pictures move; building a glider to find out how long it can stay air-borne; or a kaleidoscope to see how two mirrors and bits of plastic create colorful images.

A parents station will inform adult visitors about other toys and the science principles they illustrate and suggest simple hands-on activities that they can be done with children using readily available materials.

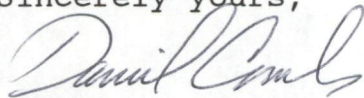
If you would like to assist us in this project, please submit the following materials for consideration by August 1, 1991.

- o A photograph or a slide of yourself holding your favorite toy. The photograph should be taken from the waist up against a white background. Please do not wear a white shirt or top.
- o A brief statement (60 words or less) about the favorite toy and how playing with it is related to your interest in science and/or pursuit of a career in science later in life.
- o A brief (4-5 sentence) biographical sketch.

Due to design and budget constraints only 8-10 scientists will be featured in this section. We apologize in advance should we be unable to include your photograph in the exhibit.

Your support and assistance are greatly appreciated. Please call if there are any questions.

Sincerely yours,

A handwritten signature in cursive script, appearing to read "David Combs".

David Combs, Ph.D.
Science Curator

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9121950
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: VEST, Charles M.: MIT

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 06/25/91

SUBJECT: A THANK YOU FOR THE DISCUSSION OF 06/20/91.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

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CHARLES M. VEST, PRESIDENT
ROOM 3-208
77 MASSACHUSETTS AVENUE
CAMBRIDGE, MASSACHUSETTS 02139-4307
617-253-0148

1950
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91 JUL 2 AM : 38

OFFICE OF THE
DIRECTOR

June 25, 1991

The Honorable D. Allan Bromley
Assistant to the President for Science and Technology
Old Executive Office Building, Suite 358
Washington, D.C. 20506

Dear Allan:

Thank you for the generous amount of time you spent with me on June 20. Still more importantly, thank you for the frankness and the wide range of our introductory discussion.

When I accepted the presidency of MIT, I did so in large measure because I considered it to be a call to national service. This continues to be my perspective and motivation. This defines both a certain kinship to you in your current role and a context within which we can work together in the coming years. Please feel free to call on me whenever you believe I might be of some assistance in the cause of enhancing science, technology, and education.

My colleagues and I are deeply grateful for your understanding of the extreme, if somewhat unique, importance of the currently allowable mechanism of supporting research assistant tuition remission through the employee benefit pool of the Institute. We are grateful for your intent to give this matter special and, insofar as is necessary, separate consideration and resolution. We are prepared to assist you in any way possible, and I will shortly be supplying you with additional detailed information. As you consider this matter, please be aware that we would strongly prefer that a prohibition of this mechanism not appear in the OMB's proposed guidelines when they are published in the *Federal Register*. My primary concern in this regard is that these proposed guidelines may be converted directly into legislation that would constrain the ultimate resolution of the matter.

Best wishes for continued success in your important federal service. I look forward to working with you during the years ahead.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Chuck", written in a cursive style.

Charles M. Vest

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9121708
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: DETWEILER, Robert C.: CALIFORNIA STATE UNIVERSITY, DOMINGUEZ
HILLS.

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 06/04/91

SUBJECT: RE: THE CALIFORNIA ACADEMY OF MATHEMATICS &
SCIENCE...ONE RESPONSE TO OUR NATION'S CHALLENGE IN
THE AREA OF INNOVATIVE MATH & SCIENCE EDUCATION
PROGRAMS.

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REQUIRED: ACTION:

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California State University
Dominguez Hills

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OFFICE OF THE
DIRECTOR

June 4, 1991

Dr. D. Allan Bromley
Assistant to the President for Science and Technology
Executive Office of the President
Office of Science and Technology Policy
Washington, D.C. 20506

Dear Dr. Bromley:

Knowing of your ongoing interest in innovative math and science education programs, I am writing to briefly describe one response to our nation's challenge in this area: The California Academy of Mathematics and Science.

As you are well aware, our nation faces a looming shortfall of qualified new workers in scientific and technological fields. Moreover, by the year 2000, eighty-five percent of the net new workers in the nation will be women and minorities -- groups which have been traditionally underrepresented in math and science.

An unusual alliance -- consisting of The California State University, a consortium of school districts, and the corporate community -- is responding to this challenge through the creation of the California Academy of Mathematics and Science. It is the first comprehensive, public high school emphasizing math and science in California, and the first such four-year high school in the nation to be located on a university campus. Its special mission is to bring more women and minorities into these fields of study.

The new school opened in the fall of 1990 with a class of 117 ninth graders. Each year approximately 120 ninth graders will be added, bringing the enrollment to between 400 and 500 at full operation. The students reflect the demographics of the Los Angeles Basin: approximately three-quarters are from underrepresented minority groups, and just over half are girls.

The new school serves primarily the youth from the inner city areas of Los Angeles, and exposes them to a rigorous and innovative interdisciplinary curriculum. Since the Academy's mission is to bring more students into the educational pipeline, these students are not selected from just the top two or three percent, but from a much broader spectrum. Many of the youngsters will be the first in their families to go to college.

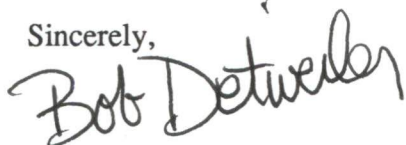
The Academy enjoys strong support from the local industrial and business community. A corporate advisory committee, representing 15 diverse companies, is actively involved in the school's planning. And to meet the considerable shortfall between state funding and the Academy's expenses, more than \$3 million in cash and computer equipment has been contributed or pledged already. Among our supporters are TRW, Rockwell International, Hughes Aircraft, Chevron USA, ARCO and others.

Dr. D. Allan Bromley
June 4, 1991
page two

I am enclosing a copy of the Academy's current newsletter to provide you with some additional information. Please do not hesitate to contact me at (213) 516-3301 if I may provide you with any further details about the project.

My best wishes in your important endeavors to improve math and science education for America's future.

Sincerely,

A handwritten signature in cursive script that reads "Bob Detweiler". The signature is written in dark ink and is positioned above the printed name.

Robert C. Detweiler
President

RCD:dgs
enclosure

DIMENSIONS

Pete Wilson Tours Academy

*New California Governor Meets
Students, Praises School*

California's new chief executive, Pete Wilson, got a firsthand look at the future of math and science education when he toured the California Academy of Mathematics and Science on October 1. During the visit, Wilson, then a U.S. senator, met with students and discussed careers in science with



Pete Wilson (center) talks with Academy students Carlos Rodriguez and Elizabeth Viger.

them. He and his wife, Gayle, a former science teacher, also observed a biology class and a two-way interactive video session in which a paleontology presentation by Academy science teacher Rod Raschke was transmitted

(continued on page 3)

Academy Recruiting New Students, Faculty

*New Ninth-Grade Class to Double
Young School's Size*

Since mid-January, Academy faculty, students and administrators have been actively recruiting the new students who will make up the class of 1995. The school is also recruiting new faculty members.

The Academy seeks current eighth-grade students who are highly motivated in math and science and who hope one day to have careers in science, math and engineering-related fields. It is strongly recommended that applicants also have completed a course in algebra.

Academy Principal Kathy Clark and faculty members are visiting most of the 62 junior high schools in the eight school districts that supply students to the Academy: Los Angeles, Long Beach, Compton, Palos Verdes Peninsula, Hawthorne, Torrance, Inglewood and Lawndale. Academy students who attended the schools are assisting in the presentations, which also include a complete overview of the school, a video presentation, a question-and-answer session and a step-by-step explanation of the application.

Because the expanding student body will require additional teachers, the Academy is also recruiting new faculty members. Teachers will be selected based on their content area expertise, their experience in curriculum

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Strategic Planning
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Meet Academy
Math Teachers





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California State University, Dominguez Hills

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Principal

Douglas G. Stewart
Director of Development and External Affairs

Academy Perspective

Robert C. Detweiler

*President of California State University,
Dominguez Hills, and Chair of the
Academy's Governing Board*



Of the many projects that have come to life since I joined California State University Dominguez Hills, in 1989, none makes me prouder than the California Academy of Mathematics and Science.

There are many reasons for my pride. The Academy's mission—to increase the number of women and underrepresented minorities who will become tomorrow's scientific and technological leaders—is vital to America's economic survival. It is a measure of the importance of that mission that the Academy even exists, because it was born out of an extraordinarily complex and diverse array of bureaucracies, all working together with a degree of cooperation previously unheard of.

I am also proud that CSU Dominguez Hills was chosen to host the Academy because I think it offers an ideal location for such an enterprise. We strive to be an interactive university in touch with people in the region, and the Academy substantially advances those aims. Beyond its central, accessible site, the campus has a heritage of serving a diverse student body, and our School of Education and School of Science, Mathematics and Technology have been working with local schools for many years.

In exchange for its participation, our university has reaped many benefits from the Academy. Its presence has enhanced the university's image in the community and brought the campus into the public and corporate consciousness. Dominguez Hills recently received an award as the CSU campus with the greatest increase in private support—an accomplishment that is unquestionably due to the fundraising associated with the Academy.

For the future, I anticipate an ongoing alliance based on the two institutions' complementary objectives. The Academy helps the university with external visibility, and university faculty will assist in curriculum development and participate in evaluating the school—tracking students and assessing how different educational techniques are working. The university will also play a role in helping to disseminate the school's successes in curriculum and teaching methods to schools throughout the region and beyond.

The Academy is destined to be a model school on many levels. As a cooperative endeavor, it is already a prototype, an example of partnership at its best.

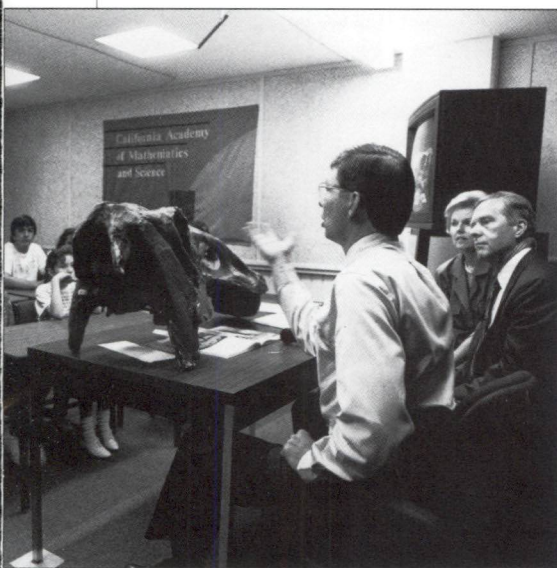
Robert C. Detweiler

Wilson

continued from page 1

over fiber-optic lines to a high school in nearby Compton.

Following the tour, Wilson held a press conference on the Cal State Dominguez Hills campus, where he discussed the Academy and his goals for education in California. "This is clearly a very special place," he said, citing the Academy and its programs, "and I hope that it can be replicated throughout the state and beyond."



Pete Wilson and his wife, Gayle (far right), look on as Rod Raschke leads a class incorporating interactive video technology.

Academy Principal Kathy Clark was quick to respond to Wilson's praise. "We are very honored that Senator Wilson was interested in visiting our school and pleased that he was impressed with what he saw," she said. "We will continue to do everything possible to earn his confidence."

Rockwell International Gives Academy \$250,000

Company Supports Academy as Part of Corporate Educational Initiative

As part of its public commitment to K-12 math/science education, Rockwell International has pledged \$250,000 to the Academy.

"Rockwell International is pleased to provide financial and human resources in support of the California Academy of Mathematics and Science," said Donald R. Beall, chairman and chief executive officer of the El Segundo-based corporation. "The cornerstone for building an effective, skilled workforce in America is quality education. We've come to realize that providing excellent learning climates will require sweeping changes in our educational systems, especially at the K-12 level. Innovative, well-conceived new programs and institutions like the Academy will be the key to laying the foundation for these important changes."

"Commitments of this type and magnitude set an example for the growing numbers of companies that are realizing the need to bolster precollegiate education," added Douglas G. Stewart, the Academy's director of development and external affairs.

As a diversified, high-technology company, Rockwell is especially concerned with poor student performance in mathematics and the sciences. The company, which recruits an average of 1,000 science and engineering graduates each year, is addressing that concern through programs aimed at students from kindergarten through graduate school. Currently, Rockwell and its employees support more than 200 education programs across the United States. During the

past decade, the company, its employees and trust provided more than \$50 million to these programs.

Rockwell's ties to the Academy, like those of many of the school's corporate supporters, transcend the financial, however. Two Rockwell employees, B. J. Snyder and Allen G. Bormann, serve on the Corporate Advisory Committee. Bormann is the committee's chair.

"This generous gift from Rockwell is an acknowledgment of the critical need the Academy is addressing for the future of American industry," said Robert C. Detweiler, president of California State University, Dominguez Hills. "The company's support will have a significant impact on the school and its students."

Academy principal, Kathy Clark, and Rockwell chairman and chief executive officer, Donald R. Beall.



Field Trips Introduce Students to Career Options

Off-Campus Learning Opportunities Enrich the Classroom Experience

Academy students continued to get first-class treatment by science professionals during two field trips last fall.

On November 2, by special invitation, they visited the regional conference of the National Science Teachers Association at the Long Beach Convention Center. There they were singled out at a general assembly and welcomed as future scientists and mathematicians. They then dispersed to take part in a full day's activities, choosing from a list of programs culled from the conference agenda by Academy science teacher Rod Raschke, including speakers, demonstrations and equipment displays appropriate to their interests.

Recruiting

continued from page 1

and staff development delivery, and their interest in interdisciplinary curriculum and a team approach.

"Our current faculty members have laid the groundwork," Mrs. Clark says, "and we are confident that we will be able to hire teachers of the same high caliber. They, in turn, will provide the incoming freshman class with the outstanding educational experience that makes the Academy such an exceptional institution."

Students and faculty interested in joining the Academy's growing family should contact the Academy at (213) 516-4025.

In anticipation of the independent science projects students will begin this spring, Raschke also included programs oriented toward student research projects. "The idea was also to begin encouraging some students to consider science teaching as a career," Raschke explains.

Three weeks later, on November 27, students visited TRW's Space and Defense Sector in Redondo Beach. Their host, a TRW scientist who works for the Hubble Space Telescope Institute,

the telescope's scientific ground support system, explained how the telescope works and described the kinds of data it is sending back to earth. Students also participated in two labs and learned how scientists analyze light to determine the composition of stars and objects in space.

"The trip proved very important to me," said Sunita Chatterjee. "The Hubble telescope has gotten me obsessed with astronomy, and I was honored to be there, to experience what has taken so many years to build."

"The trip to TRW helped me to understand how the Hubble telescope worked, and it helped me to realize what incredible discoveries could be made with it," added Darrick Ohata. "I felt really special that the people at TRW took their time to bring this information to us."

Academy Notes

- ▼ Academy Principal **Kathy Clark** has been appointed to a statewide advisory committee on implementation of Senate Bill 1274, a new initiative to improve student learning through school and district restructuring demonstrations. Mrs. Clark was appointed by State Superintendent of Public Instruction, Bill Honig.
- ▼ Approximately 200 adults attended two parents' meetings held at the Academy in October. The evening programs not only gave parents an opportunity to meet one another and Academy teachers but presented them with an overview of the Academy, including its counseling and guidance offerings.

- ▼ Three Academy students—**Cynthia Jones, Veronica Medina** and **Marlen Luna**—each received a cash award of \$100 from TRW late last fall as part of the company's "Bootstrap" tutoring program. The program, which is sponsored by company employees, was created to help students improve their math and science skills.
- ▼ Private support to the Academy now totals more than \$3 million. Recent contributions include \$25,000 each from **Chevron U.S.A. Inc.** and **Nissan Motor Corporation in U.S.A.** and a multi-year commitment of \$50,000 from **Southern California Edison.**
- ▼ **California State University, Dominguez Hills**, was recently named one of ten institutions nationally that serve as positive

STUDENT SPOTLIGHT

Students Learn Principles of Governance Firsthand

Officers and Council Represent Student Viewpoint

Sina Aiono enrolled in the Academy because she wants to be a doctor or an aerospace engineer. As the school's first student body president, however, she also tried her hand at politics, presiding over weekly student council meetings and serving as liaison between faculty, students and administration.

"Because the school is new, there are a lot of ways we can have some influence," she says. "I think the whole student council is playing a very large role in shaping the school's development."

role models for minority access and achievement in American universities. The selection was part of a three-year study sponsored by the National Center for Postsecondary Education.

▼ **Eunice Krinsky**, professor of mathematics at CSU Dominguez Hills and a curriculum advisor to the Academy, has been awarded a 42-month, \$576,023 grant from the National Science Foundation for her project called MERIT (Mathematics Enrichment and Retraining for Inservice Teachers). The project, which will address the shortage of qualified mathematics teachers in innovative ways, will involve teachers from a number of middle schools in the Academy's consortium.

Today, after a full semester term in office, Sina has handed the gavel to her successor, Chinyelu Udoh, and serves as the Academy's commissioner of student affairs. But the legacy she helped create continues to give Academy students an official voice in school affairs.

Student council meetings take place almost every Friday and are run according to Robert's Rules of Order. Topics such as spirit week, dances and the student council budget dominate the meetings, but students are also interested in academic and social issues. "They're really concerned about how they learn, what they want to learn, their electives, their extracurricular activities," Sina says. "They want to be able to have a good academic background but at the same time have a social life."

Backing up the council is Academy social studies teacher John Hollick, the group's faculty advisor.

"I think I need to wear several hats," he explains. "First, I view myself as a technical advisor, in the sense of giving them technical advice about motions and procedures. Second, I will raise issues that I think are of faculty concern. Finally, I am also there to hear the students' point of view, which I can bring to faculty meetings."

Hollick stresses the fact that the student council, like any American legislature, is open to members of the public, who may address the group as long as they have asked to be on the agenda. "We make it very clear that anyone can come into the student council because it is a democratic forum," he says.

The Academy's first student council officers: (front, from left) Redza Ibrahim, vice president; Sina Aiono, president; and Justin Reid, treasurer. (back row, from left) Adriana Diaz, secretary; Birma Gonzalez, commissioner of the arts; Eric Garduno, commissioner of student affairs; Tiffany Barnes, commissioner of publicity; and Jason Brown, commissioner of beautification and ecology.



CARY KUTWIAK

Students Excel in Special Class on Study Skills

Practice in Library Research and Writing Prepares Them for College and Beyond

Academy students are getting a jump on the research and writing skills they will need in college, thanks to a special class run by social science teacher John Hollick. Although the class, which meets twice a week, is similar to courses available at many universities, it is unusual to find it in a high school.

The nine-week course begins with a weeklong introduction to study skills. One of the CSU Dominguez Hills research librarians shows students how to use the university's library facilities, for which they all have cards. Then Hollick takes over. Using an 18-step procedure he devised, he directs students through the process of writing a research paper.

The key, as he sees it, is to establish a series of checkpoints, which help make the project more manageable for students and enable him to monitor their progress and assist with any problems. "What I have found in the past is that no matter how gifted students are, at least in the American setting, when it comes to writing, they just cringe," he says.

Although Hollick had successfully implemented the program with older students in other schools, before he taught the first class at the Academy, he wasn't sure whether ninth-grade students were sophisticated enough to handle the assignment.

He needn't have worried. "I was absolutely astonished at what these kids produced," he says. Topics for the five-

Strategic Planning Process Initiated

Academy to Draft Plan for Next Three Years

A 15-member committee convened last fall to begin developing a strategic plan for the Academy.

Made up of staff members and representatives from the Governing Board, Operations Board, Corporate Advisory Committee and The California State University Board of Trustees, the group, called the Strategic Planning and Resources Committee (SPARC), has been working with a management consultant to clarify the Academy's mission statement,

"Strategic planning is of the utmost importance if we are going to have a viable institution well into the future."

to ten-page papers have ranged from the Holocaust, teenage suicide, alcoholism and recovery, child abuse, criminality and gangs, to technical subjects such as the fourth dimension in geometry. Each centers around a thesis and includes footnotes and a bibliography. For the technical papers, Hollick enlists the help of Academy math and science teachers, who are better-qualified to evaluate them.

Hollick is convinced that one of the factors contributing to students' success is their access to the university library, with its supply of materials—an advantage that students at traditional high schools don't have.

"One of the problems we had at a conventional high school was getting appropriate materials," he says. "From that perspective, this is sort of heaven on earth."

identify its strengths and prepare a set of goals and objectives. The information SPARC generates will form the basis of the strategic plan.

Groundwork for the plan was laid during the 1989-90 academic year, which was devoted to planning and development. The strategic plan is being formulated to assess systematically the needs of the Academy over the next three years and map out a

strategy for meeting those needs. (These years are considered critical to the Academy's future because it is during this time that the school will grow to its full capacity of 500 students.) The plan will define institutional priorities and specify the resources necessary to achieve those priorities.

The strategic plan will be presented to the Academy's Governing Board in the spring.

"Strategic planning is of the utmost importance if we are going to have a viable institution well into the future," observes Walt Kirwan, manager of external affairs for ARCO and a member of SPARC and the Corporate Advisory Committee.

FACULTY CLOSEUP

Academy's Math Teachers Don't Teach by the Numbers

Jerry Flores and Ma. Lourdes Hobrock

Jerry Flores and Ma. Lourdes Hobrock may be the Academy's resident mathematics experts, but both teachers encountered some formidable obstacles along the way to making math education their career.

"I was pretty much a natural in math until I got to algebra," Flores says, recalling his first major mathematical challenge. "I overcame that hurdle and went into geometry, but that hurdle was twice as big." Flores admits that he got a D his first semester in geometry, but he also believes the experience changed him. "Something came into me and I was on a roll," he says, and in high school he decided he wanted to be a math teacher.

Ma. Lourdes Hobrock also stubbed her toes on geometry, but like Jerry

Flores, she persevered because she liked the challenge. "I stayed with math just to pursue it for me," she says. "It was my greatest fear, and I wanted to overcome it."

"I wanted to be a part of the pioneer group and to actually see it grow. We can do a lot of new things here."

Today, Flores's and Hobrock's stories stand as an inspiration for Academy students. Hobrock majored in applied mathematics at UCLA and taught at a Los Angeles junior high school for three years before joining the Academy's faculty.

Flores breezed through college, earning his bachelor's degree in math from CSU Dominguez Hills in 3½ years. He taught in the Los Angeles Unified School District for 20 years, including assignments at three high schools. Dur-

ing that time he also took on extra duties, such as curriculum and textbook evaluations, and working with other teachers and specialists. For two years he worked at the district's staff development branch, where he honed his teacher-training skills. He is the Academy's Mathematics, Engineering, Science Achievement (MESA) advisor.

Both Hobrock and Flores wanted to join the Academy's faculty for similar reasons. "I applied for this job because after participating in these other projects, I liked the idea of getting involved in a project from the beginning," Flores says. "I wanted to be a part of the pioneer group and to actually see it grow. We can do a lot of new things here."

Hobrock, too, was ready for a change. "Mathematics is so dynamic," she says. "I didn't want to keep doing the same thing every year."

Today both teachers work hard to pass on their enthusiasm for mathematics to their classes. "You have to be pretty animated," Flores admits.

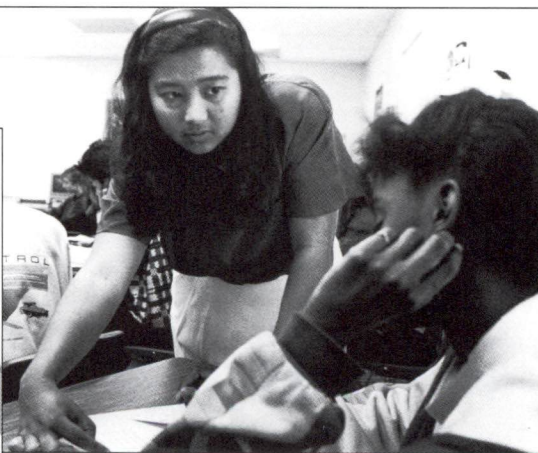
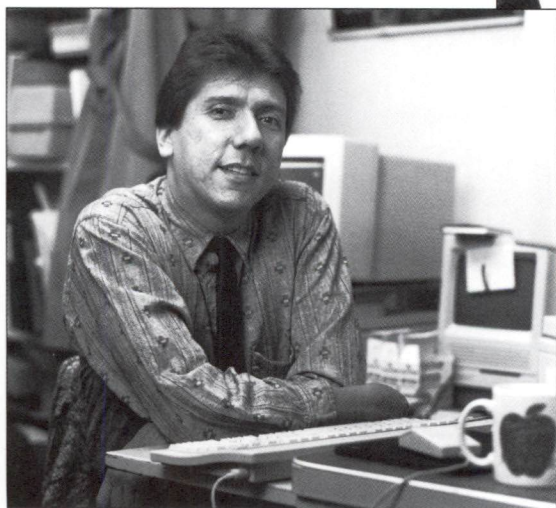
"When you walk in the classroom, you have to be pretty up."

"We start with their experiences," Hobrock adds. "We try to get them involved. We try to make the material as real-life as possible, and we use them as examples because that's what they're concerned with—themselves. At the same time, we're emphasizing the process rather than the product. We're as interested in how they got the answer as we are in the answer itself."

One way Hobrock relates the schoolwork to real life is as a role model, particularly for the female students. "I think they look up to me because I am a woman,"

she says, "and there are very few of us in the field. If they can see that I can make it, they can too."

(continued on page 8)



*(left) Jerry Flores,
(above) Ma. Lourdes Hobrock*



Dale Van Natta of TRW (right), shown here with CSU Dominguez Hills president Robert C. Detweiler, holds the Volunteer Leader of the Year award, which he received from The California State University at a reception at the Greater Los Angeles World Trade Center in January. The award honors his early involvement in the Academy, which was critical to the school's establishment. The statewide award was given last year to Allen G. Bormann of Rockwell International, who currently chairs the Academy's Corporate Advisory Committee.

Math Teachers

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The fact that there are two math teachers for the Academy's ninth-grade class means that students receive more personal attention, and in the classroom Hobrock and Flores divide their responsibilities using a team teaching approach. Fortunately, they share many basic attitudes about mathematics education, which makes their collaborations run smoothly. "We seem to finish each other's sentences or thoughts sometimes," Hobrock says.

Because there are students at several levels in the math classes, one of the teachers will often work with the more advanced students while the other leads the geometry class as whole. Other times, one will review the material with those students who are having the most difficulty, while the other presents the rest of the students with an enrichment activity. "It's a question of what the class needs at the time," Hobrock explains.

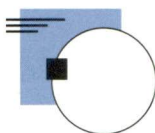
The school's emphasis on flexibility has been a refreshing change from conventional schools, and Flores and Hobrock view the theme-oriented, interdisciplinary curriculum as a welcome challenge. They also enjoy their shared preparation period and feel that their knowledge of what is going on in the other subjects makes them more aware of students' strengths and weaknesses.

Ultimately, however, their goal is to give their students the tools they need in order to solve problems.

"I'm trying to seduce the students into seeing that mathematics is a really fantastic world if they would just be open a little bit," Flores says. "It can be exciting and wonderful once they give it a chance."



Dimensions is the official newsletter of the California Academy of Mathematics and Science. Produced for the Office of Development and External Affairs by Creative License. Writing and Editing: Sarah Lifton. Design and Art Direction: Gary Hespenheide



**California Academy of
Mathematics and Science**

California State University, Dominguez Hills
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FROM: MIENTKA, Walter E.: AMERICAN MATHEMATICS COMPETITIONS

TO: Dr. D. Allan Bromley

DATE OF
CORRESPONDENCE: 06/03/91

SUBJECT: A SET OF THE EXAMINATIONS UPON WHICH THE 1991 USA
MATHEMATIC OLYMPIAD WINNERS WERE SELECTED AND A COPY
OF THE AMC INFORMATION BOOKLET.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE: OSTP DUE DATE:

DATE COMPLETED: DATE COMPLETED/DEPT:

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AMERICAN MATHEMATICS COMPETITIONS
GOVERNED BY A JOINT COMMITTEE OF THE SPONSORING ORGANIZATIONS

Dr. Walter E. Mientka, Executive Director
Department of Mathematics and Statistics
University of Nebraska
Lincoln, Nebraska 68588-0322 U.S.A.

TELEPHONE: 402/472-2257
BITNET: WALTER@UNLAMC
FAX: 402/472-6087

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American Junior High School Mathematics Examination
American High School Mathematics Examination
American Invitational Mathematics Examination
United States of America Mathematical Olympiad

91 JUN 3 PM 12:36

May 29, 1991

OFFICE OF THE
DIRECTOR

Dr. D. Allan Bromley
Office of Science and Technology Policy
Executive Office of the President
The White House
Washington, DC 20506

Dear Dr. Bromley:

The Mathematical Association of America (MAA) recently sent me the guest list for the reception to be held in honor of the eight winners of the 1991 USA Mathematical Olympiad.

Since the winners are selected on the basis of their results on the American Mathematics Competitions (AMC), which in 1990-91 were taken by over 610,166 students from 11,490 schools throughout the USA, American Schools abroad and Canada, I thought it fitting that you receive a set of the examinations.

In addition to these examinations, I have enclosed a copy of the AMC Information Booklet which contains a description and an historical account of the examinations.

I shall be pleased to answer any questions you may have relative to the American Mathematics Competitions, and look forward to meeting you at the Twentieth USA Mathematical Olympiad Awards Ceremonies in Washington, DC on June 10, 1991.

Very sincerely,

Walter E. Mientka

Walter E. Mientka
Executive Director

wmcwps505

Enclosures

Copy to: Dr. Marcia Sward, Executive Director of the MAA



20th United States of America Mathematical Olympiad

April 23, 1991

Time limit: $3\frac{1}{2}$ hours

1. In triangle ABC , angle A is twice angle B , angle C is obtuse, and the three side lengths a, b, c are integers. Determine, with proof, the minimum possible perimeter.
2. For any nonempty set S of numbers, let $\sigma(S)$ and $\pi(S)$ denote the sum and product, respectively, of the elements of S . Prove that

$$\sum \frac{\sigma(S)}{\pi(S)} = (n^2 + 2n) - \left(1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}\right)(n+1),$$

where the " $\sum$ " denotes a sum involving all nonempty subsets S of $\{1, 2, 3, \dots, n\}$.

3. Show that, for any fixed integer $n \geq 1$, the sequence

$$2, 2^2, 2^{2^2}, 2^{2^{2^2}}, \dots \pmod{n}$$

is eventually constant.

[The tower of exponents is defined by $a_1 = 2$, $a_{i+1} = 2^{a_i}$. Also, $a_i \pmod{n}$ means the remainder which results from dividing a_i by n .]

4. Let $a = \frac{m^{m+1} + n^{n+1}}{m^m + n^n}$, where m and n are positive integers.

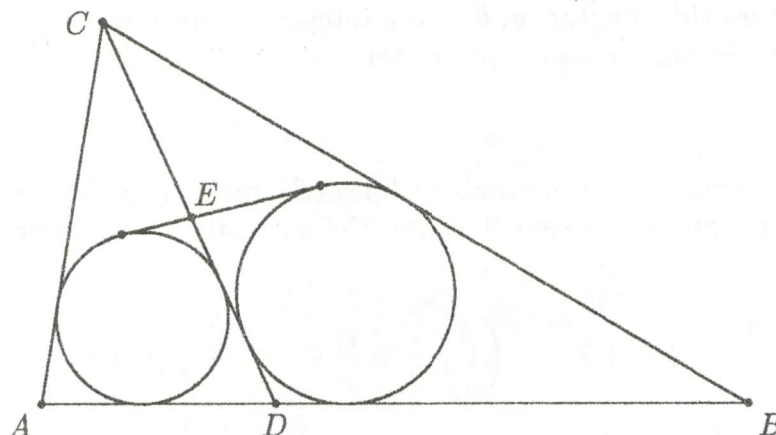
Prove that $a^m + a^n \geq m^m + n^n$.

[You may wish to analyze the ratio $\frac{a^N - N^N}{a - N}$ for real $a \geq 0$ and integer $N \geq 1$.]

Page 1 of 2 pages

20th United States of America Mathematical Olympiad

5. Let D be an arbitrary point on side AB of a given triangle ABC , and let E be the interior point where CD intersects the external common tangent to the incircles of triangles ACD and BCD . As D assumes all positions between A and B , prove that point E traces the arc of a circle.



1991 USAMO — solutions

- Let a, b, c be the sides opposite angles A, B, C , respectively. By the Law of Sines,

$$\begin{aligned}\frac{a}{b} &= \frac{\sin 2B}{\sin B} = 2 \cos B, \\ \frac{c}{b} &= \frac{\sin(\pi - 3B)}{\sin B} = \frac{\sin 3B}{\sin B} \\ &= \frac{(2 \sin B \cos B) \cos B + (2 \cos^2 B - 1) \sin B}{\sin B} \\ &= 4 \cos^2 B - 1.\end{aligned}$$

Hence $\frac{c}{b} = \left(\frac{a}{b}\right)^2 - 1$, from which

$$(*) \quad a^2 = b(b + c).$$

Since we are looking for the triangle of smallest perimeter, we may assume that a, b , and c have no common factor; otherwise a smaller example would exist. In fact, b and c must be relatively prime, for if they had a common prime factor, then it would follow from $(*)$ that this prime was also a factor of a .

Since $(*)$ expresses the square integer a^2 as a product of relatively prime integers b and $b + c$, it must be the case that b and $b + c$ are themselves perfect squares. Thus, for some relatively prime integers m and n , we have $b = m^2$, $b + c = n^2$, $a = mn$, and $\frac{n}{m} = \frac{a}{b} = 2 \cos B$.

The angle $C = \pi - 3B$ is obtuse, so

$$0 < B < \frac{\pi}{6},$$

$$\frac{\sqrt{3}}{2} < \cos B < 1,$$

$$\sqrt{3} < \frac{n}{m} < 2.$$

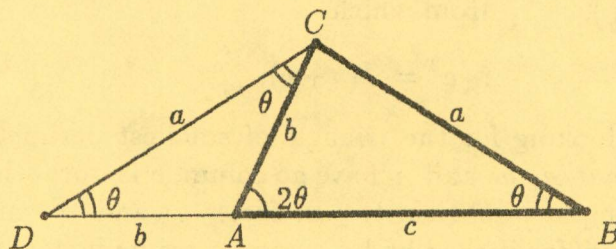
This last inequality has no integer solution with $m = 1, 2$, or 3 , hence $m \geq 4$, $n \geq 7$, and $a + b + c = mn + n^2 \geq 4 \cdot 7 + 7^2 = 77$. The pair $(m, n) = (4, 7)$ generates a triangle with $(a, b, c) = (28, 16, 33)$, and this triangle does in fact meet all the necessary geometric conditions, so 77 is the minimum possible perimeter.

1991 USAMO — solutions

OR

Let a, b, c be the sides opposite angles A, B, C , respectively. If we construct a strategic point D by extending line AB past point A by a length of b , we obtain a pair of isosceles triangles DAC and DCB as shown in the figure.

To see this, note that by construction triangle DAC is isosceles with $DA = AC = b$. It follows that $\angle ADC = \frac{1}{2}(\pi - \angle DAC) = \frac{1}{2}\angle CAB = \angle ABC$, and hence that triangle DCB is isosceles with $DC = CB = a$.



The isosceles triangles DAC and DCB are in fact similar, since they share a base angle at D . Thus we have $\frac{a}{b} = \frac{b+c}{a}$, or

$$(*) \quad a^2 = b(b+c).$$

For angle ACB to be obtuse, we must have $c^2 > a^2 + b^2$. Substituting $b(b+c)$ for a^2 leads to $0 > 2b^2 + bc - c^2 = (2b-c)(b+c)$. Therefore $c > 2b$, whereupon $(*)$ implies

$$a > b\sqrt{3}.$$

Also, we see from triangle DAC that

$$a < 2b.$$

For each integer $b = 1, 2, \dots, 15$, we can systematically verify that none of the integers a , with $a < 2b$ and a^2 divisible by b , also meet the condition $a > b\sqrt{3}$. For $b = 16$, the only suitable integer is $a = 28$, which gives a satisfactory triangle with $c = 33$ and perimeter 77. For $b \geq 17$, all solutions have

$$a + b + c = a + \frac{a^2}{b} = b \left(\frac{a}{b} + \left(\frac{a}{b} \right)^2 \right) > 17(\sqrt{3} + 3) > 80.$$

Therefore 77 is the minimum possible perimeter.

1991 USAMO — solutions

2. Let $\mathcal{P}_n$ be the collection of nonempty subsets of $\{1, 2, \dots, n\}$, and note that $\mathcal{P}_n$ can be partitioned into three disjoint classes:
 $\mathcal{C}_1$, the singleton set $\{n\}$;
 $\mathcal{C}_2$, the nonempty subsets of $\{1, 2, \dots, n-1\}$;
 $\mathcal{C}_3$, the subsets of $\{1, 2, \dots, n\}$ which contain n and at least one element of $\{1, 2, \dots, n-1\}$.

Class $\mathcal{C}_2$ is just $\mathcal{P}_{n-1}$, and class $\mathcal{C}_3$ is formed by taking the union of $\{n\}$ with each of the subsets in $\mathcal{P}_{n-1}$. Thus the sum given in the problem, $A_n = \sum_{S \in \mathcal{P}_n} \frac{\sigma(S)}{\pi(S)}$, can be partitioned and related to its predecessor A_{n-1} as follows:

$$\begin{aligned} A_n &= \sum_{S \in \mathcal{C}_1} \frac{\sigma(S)}{\pi(S)} + \sum_{S \in \mathcal{C}_2} \frac{\sigma(S)}{\pi(S)} + \sum_{S \in \mathcal{C}_3} \frac{\sigma(S)}{\pi(S)} \\ &= \frac{\sigma(\{n\})}{\pi(\{n\})} + \sum_{S \in \mathcal{P}_{n-1}} \frac{\sigma(S)}{\pi(S)} + \sum_{S' \in \mathcal{P}_{n-1}} \frac{\sigma(\{n\} \cup S')}{\pi(\{n\} \cup S')} \\ &= \frac{n}{n} + A_{n-1} + \sum_{S' \in \mathcal{P}_{n-1}} \frac{n + \sigma(S')}{n \cdot \pi(S')} \\ &= 1 + A_{n-1} + \sum_{S' \in \mathcal{P}_{n-1}} \frac{1}{\pi(S')} + \frac{1}{n} A_{n-1} \\ &= \left(1 + \sum_{S \in \mathcal{P}_{n-1}} \frac{1}{\pi(S)} \right) + \frac{n+1}{n} A_{n-1}. \end{aligned}$$

The formula given in the problem is easily verified for $n = 1$, so to prove the general result we need only establish as an inductive step the equation

$$\begin{aligned} A_n - \frac{n+1}{n} A_{n-1} &= \left[n^2 + 2n - \left(1 + \frac{1}{2} + \dots + \frac{1}{n} \right) (n+1) \right] \\ &\quad - \frac{n+1}{n} \left[(n-1)^2 + 2(n-1) - \left(1 + \frac{1}{2} + \dots + \frac{1}{n-1} \right) n \right], \end{aligned}$$

1991 USAMO — solutions

or

$$\begin{aligned}
 1 + \sum_{S \in \mathcal{P}_{n-1}} \frac{1}{\pi(S)} &= \left[n^2 + 2n - \left(1 + \frac{1}{2} + \cdots + \frac{1}{n-1} \right) (n+1) - \frac{n+1}{n} \right] \\
 &\quad - \frac{n+1}{n} \left[n^2 - 1 - \left(1 + \frac{1}{2} + \cdots + \frac{1}{n-1} \right) n \right], \\
 &= n^2 + 2n - \frac{n+1}{n} n^2 \\
 &= n.
 \end{aligned}$$

This result itself follows by a similar induction on n or, more directly, by observing that the left-hand side consists precisely of the terms which result from a certain algebraic product:

$$\begin{aligned}
 1 + \sum_{S \in \mathcal{P}_{n-1}} \frac{1}{\pi(S)} &= \left(1 + \frac{1}{1} \right) \left(1 + \frac{1}{2} \right) \left(1 + \frac{1}{3} \right) \cdots \left(1 + \frac{1}{n-1} \right) \\
 &= \frac{2}{1} \cdot \frac{3}{2} \cdot \frac{4}{3} \cdot \cdots \cdot \frac{n}{n-1} \\
 &= n.
 \end{aligned}$$

OR

Since $\sigma(S) = \sum_{k \in S} k$, the desired sum can be rearranged as

$$(*) \quad \sum_S \frac{\sigma(S)}{\pi(S)} = \sum_S \sum_{k \in S} \frac{k}{\pi(S)} = \sum_{k=1}^n \sum_{S \ni k} \frac{1}{\pi(S)/k},$$

where the " $S \ni k$ " denotes a sum over all the sets S which have k as an element.

For each $k = 1, 2, \dots, n$, we have (by product expansion)

$$\begin{aligned} \sum_{S \ni k} \frac{1}{\pi(S)/k} &= \sum_{S \ni k} \frac{1}{\pi(S - \{k\})} = \prod_{\substack{i=1 \\ i \neq k}}^n \left(1 + \frac{1}{i}\right) \\ &= \prod_{\substack{i=1 \\ i \neq k}}^n \left(\frac{i+1}{i}\right) \\ &= \left(\frac{k+1}{k}\right)^{-1} \prod_{i=1}^n \left(\frac{i+1}{i}\right) \\ &= \frac{k}{k+1}(n+1). \end{aligned}$$

Hence, equation (*) reduces to

$$\begin{aligned} \sum_S \frac{\sigma(S)}{\pi(S)} &= \sum_{k=1}^n \sum_{S \ni k} \frac{1}{\pi(S)/k} \\ &= \sum_{k=0}^n \frac{k}{k+1}(n+1) \\ &= (n+1) \sum_{k=0}^n \left(1 - \frac{1}{k+1}\right) \\ &= (n+1)(n+1) - (n+1)\left(1 + \frac{1}{2} + \dots + \frac{1}{n} + \frac{1}{n+1}\right) \\ &= n^2 + 2n - (n+1)\left(1 + \frac{1}{2} + \dots + \frac{1}{n}\right). \end{aligned}$$

OR

[This solution uses calculus, whereas the first two do not.]

Let

$$f(x) = \prod_{k=1}^n \left(1 + \frac{x^k}{k}\right).$$

Expanding this polynomial yields

$$f(x) = 1 + \sum_{S \in \mathcal{P}_n} \frac{x^{\sigma(S)}}{\pi(S)},$$

where $\mathcal{P}_n$ is the collection of nonempty subsets of $\{1, 2, \dots, n\}$. The derivative of $f(x)$ is

$$f'(x) = \sum_{S \in \mathcal{P}_n} \frac{\sigma(S)}{\pi(S)} x^{\sigma(S)-1},$$

from which we see that the problem is to calculate $f'(1)$. Returning to the definition of $f(x)$ in terms of a product, if we first take a logarithm and then take a derivative, we obtain

$$\log f(x) = \sum_{k=1}^n \log \left(1 + \frac{x^k}{k}\right)$$

and

$$\frac{f'(x)}{f(x)} = \sum_{k=1}^n \frac{x^{k-1}}{1 + \frac{x^k}{k}}.$$

Hence

$$\begin{aligned} \sum_{S \in \mathcal{P}_n} \frac{\sigma(S)}{\pi(S)} &= f'(1) = f(1) \sum_{k=1}^n \frac{1}{1 + \frac{1}{k}} \\ &= \left(\prod_{k=1}^n \left(1 + \frac{1}{k}\right) \right) \left(\sum_{k=1}^n \frac{k}{k+1} \right) \\ &= \left(\prod_{k=1}^n \frac{k+1}{k} \right) \left(\sum_{k=0}^n \frac{k}{k+1} \right) \\ &= (n+1) \sum_{k=0}^n \left(1 - \frac{1}{k+1}\right), \end{aligned}$$

from which the desired result follows as in the previous solution.

1991 USAMO — solutions

3. Our proof is by induction on n . The base case $n = 1$ is clear. Suppose the result has been proved for all integers less than n , and write $n = 2^k q$ with q odd.

A sequence which is constant mod 2^k and constant mod q will also be constant mod n , by the Chinese Remainder Theorem. Thus, since the sequence $\{a_i\}$ is eventually 0 mod 2^k , we need only prove that $\{a_i\}$ is eventually constant mod q .

If $q = 1$, the claim is trivial. If instead q is an odd integer greater than 1, then by a well known theorem of Euler there is a positive integer $r < q$ such that

$$2^r \equiv 1 \pmod{q}.$$

[In particular, Euler's theorem takes r to be $\phi(q)$, the number of positive integers $\leq q$ and relatively prime to q .]

Since $r < q \leq n$, the induction hypothesis implies that $\{a_i\}$ is eventually constant mod r . Since $2^r \equiv 1 \pmod{q}$, the condition $a_i \equiv a_j \pmod{r}$ implies that $a_i = a_j + rt$ and $2^{a_i} = 2^{a_j} (2^r)^t \equiv 2^{a_j} \pmod{q}$. Consequently, the sequence $\{2^{a_i}\}$ is eventually constant mod q . As we have seen, this means that the sequence $\{a_{i+1}\} = \{2^{a_i}\}$ is eventually constant mod n .

OR

If q is an odd integer greater than 1, then even without the full strength of Euler's theorem we can still prove the existence of a positive integer $r < q$ such that $2^r \equiv 1 \pmod{q}$. A direct argument for this result is as follows.

No power of 2 is exactly divisible by q , so the q numbers $2^0, 2^1, 2^2, \dots, 2^{q-1}$ must belong only to the $q-1$ nonzero congruence classes $1, 2, \dots, q-1 \pmod{q}$. By the pigeonhole principle, there must be some duplication; thus, there exist integers i, j with $0 \leq i < j \leq q-1$ such that $2^i \equiv 2^j \pmod{q}$. But this means that q divides $2^j - 2^i = 2^i(2^{j-i} - 1)$, and since q is relatively prime to 2^i , q must divide $(2^{j-i} - 1)$. So let $r = j - i$, note that $0 < r \leq q-1$, and then proceed as in the first solution.

Note. The $\{a_{i+1}\}$ at the end of the inductive step prevents us from inferring that the entire sequence $\{a_i\}$ is constant mod n .

1991 USAMO — solutions

4. If N is a positive integer and $a \neq N$, then of course

$$\frac{a^N - N^N}{a - N} = a^{N-1} + a^{N-2}N + \cdots + aN^{N-2} + N^{N-1}.$$

If $0 \leq a < N$, then this is the sum of N terms each less than or equal to N^{N-1} , and consequently

$$\frac{a^N - N^N}{a - N} \leq N^N.$$

Similarly, if $a > N$, then

$$\frac{a^N - N^N}{a - N} \geq N^N.$$

Since $a - N$ is negative in the first case and positive in the second, we obtain

$$(*) \quad a^N - N^N \geq (a - N)N^N$$

in both cases. Certainly this result is also true for $a = N$; thus the inequality $(*)$ holds for all $a \geq 0$.

We now use $(*)$ to establish the desired result by observing that

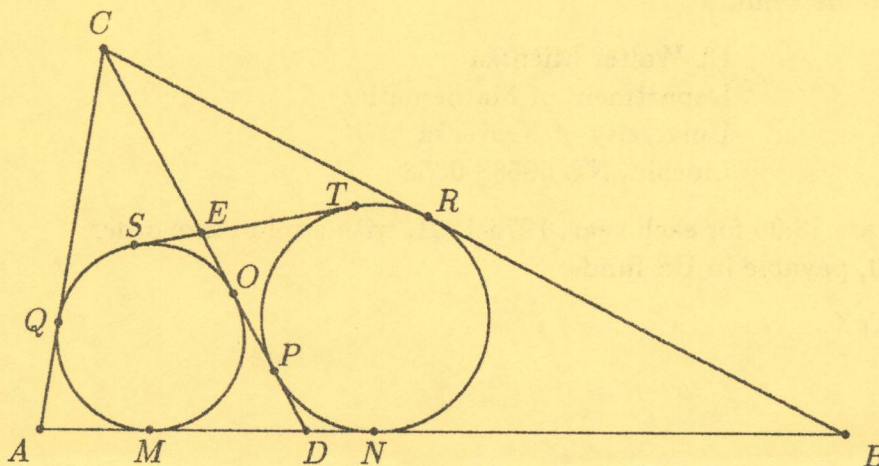
$$\begin{aligned} (a^m + a^n) - (m^m + n^n) &= (a^m - m^m) + (a^n - n^n) \\ &\geq (a - m)m^m + (a - n)n^n \\ &= a(m^m + n^n) - (m^{m+1} + n^{n+1}) \\ &= 0. \end{aligned}$$

Note. Inequality $(*)$ corresponds geometrically to the convexity of the function $y = x^N$ at the point (N, N^N) , so the result of the problem is actually valid for all real $m, n \geq 1$, with equality if and only if $m = n$.

1991 USAMO — solutions

5. Experimentation with straightedge and compass suggests that point E traces the arc of a circle with center C . We prove that this is in fact the case by showing that the length of segment CE is constant for all positions of point D . This we accomplish by systematically matching pairs of equal tangents in the figure, working from CE back toward the fixed lengths of triangle ABC .

Let M through T be the points of tangency shown in the figure.



By equal tangents,

$$CE = CO - EO = CQ - SE,$$

and symmetrically

$$CE = CP - EP = CR - ET.$$

Adding these and continuing the process, we obtain

$$\begin{aligned} 2 \cdot CE &= CQ + CR - (SE + ET) \\ &= (CA - QA) + (CB - RB) - ST \\ &= (CA - AM) + (CB - NB) - MN \\ &= CA + CB - (AM + MN + NB) \\ &= CA + CB - AB, \end{aligned}$$

therefore

$$CE = \frac{1}{2}(CA + CB - AB)$$

and the problem is solved.

The 1991 USAMO was prepared by Anne Hudson, Richard Paris, Gregg Patruno, Bjorn Poonen, Ian Richards (chair), Cecil Rousseau, Daniel Ullman, and Samuel Vandervelde.

The publication **Mathematical Olympiads 1991** will present comprehensive solutions to these problems, along with additional comments and the problems, solutions, and results of the 1991 International Mathematical Olympiad. This helpful booklet will be available from:

Dr Walter Mientka
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Copies are \$3.00 for each year, 1976-1991, with a minimum order of \$6.00, payable in US funds.

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1991

THE FORTY-SECOND AMERICAN HIGH SCHOOL MATHEMATICS EXAMINATION

THE NINTH AMERICAN
INVITATIONAL MATHEMATICS EXAMINATION
THE TWENTIETH USA MATHEMATICAL OLYMPIAD

Learning Mathematics Through Selective Problem Solving

SUMMARY OF RESULTS AND AWARDS

Examinations prepared by subcommittees of the
American Mathematics Competitions, and administered
by the office of the Executive Director

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1991-1992 EXAMINATION DATES

AJHSME—Thursday, November 21, 1991

AHSME—Thursday, February 27, 1992

AIME—Thursday, April 2, 1992

USAMO—Thursday, April 30, 1992

AMERICAN MATHEMATICS COMPETITIONS
AHSME SOLUTIONS PAMPHLET
FOR STUDENTS AND TEACHERS

42nd ANNUAL
**AMERICAN HIGH SCHOOL
MATHEMATICS EXAMINATION**
(AHSME)

TUESDAY, FEBRUARY 26, 1991

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This Solutions Pamphlet contains at least one solution to each problem on this year's Examination and shows that all the problems can be solved using non-calculus mathematics. Routine calculations and obvious reasons for proceeding in a certain way are often omitted to give greater emphasis to the essential ideas behind each solution. When more than one solution for a problem is provided, this is done to illustrate a significant contrast in methods, e.g., algebraic *vs* geometric, computational *vs* conceptual, elementary *vs* advanced. These solutions are by no means the only ones possible, nor are they necessarily superior to others the reader may devise.

We hope teachers will share these solutions with their students, both as illustrations of the kinds of ingenuity needed to solve nonroutine problems and as examples of good mathematical exposition. *Remember that reproduction of these solutions is prohibited by the copyright.*

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AMERICAN MATHEMATICS COMPETITIONS
AIME SOLUTIONS PAMPHLET
FOR STUDENTS AND TEACHERS

9th ANNUAL
**AMERICAN INVITATIONAL
MATHEMATICS EXAMINATION**
(AIME)

TUESDAY, MARCH 19, 1991

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We hope that teachers will share these solutions with their students, both as illustrations of the kinds of ingenuity needed to solve nonroutine problems and as examples of good mathematical exposition. Routine calculations and obvious reasons for proceeding in a certain way are often omitted. This gives greater emphasis to the essential ideas behind each solution. *Remember that reproduction of these solutions is prohibited by copyright.*

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AMERICAN MATHEMATICS COMPETITIONS
**AJHSME SOLUTIONS PAMPHLET
FOR STUDENTS AND TEACHERS**

**6th ANNUAL
AMERICAN JUNIOR HIGH SCHOOL
MATHEMATICS EXAMINATION
(AJHSME)**

THURSDAY, NOVEMBER 29, 1990

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This Solutions Pamphlet gives at least one solution for each problem on this year's Examination and shows that all the problems can be solved using material normally associated with the seventh and eighth grade mathematics curriculum. The solutions are by no means the only ones possible, nor are they necessarily superior to others the reader may devise.

It is hoped that teachers will find the time to share these solutions with their students.

Questions and comments about the problems and solutions (but not requests for the Solutions Pamphlet) should be addressed to:

Professor Thomas Butts, AJHSME Chairman
Science Education Department
The University of Texas at Dallas
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AMERICAN MATHEMATICS COMPETITIONS

American Junior High School Mathematics Examination
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INFORMATION BOOKLET

Also includes information on the
International Mathematical Olympiad
and the
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ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: MCLUHAN, Mary: MARSHALL MCLUHAN ON GLOBAL COMMUNICATIONS

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 05/29/91

SUBJECT: A THANK YOU, RE: THE MARSHALL MCLUHAN DISTINGUISHED
TEACHER'S AWARDS.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

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Dr. D. Allan Bromley
Science Advisor to the President
The White House
Washington, D.C. 20500

Dear Dr. Bromley:

It was a delight for me and Carla to meet with you and Mr. Ratchford last week and to have the opportunity to acquaint you with the first U.S. 1992 "Marshall McLuhan Distinguished Teachers Awards" program. I very much appreciated the time that you were able to spend with us.

I want to thank you for your offer of assistance in providing the McLuhan Center with a letter from President Bush in support of the "Marshall McLuhan Awards".

I look forward to keeping in touch with you on the progress of this first major initiative honoring excellence in teaching across the United States.

With warm regards,

Mary McLuhan
Chairman/Founder

*P.S. It was truly a great pleasure to meet
with you and I look forward to seeing
you again soon. Mary.*

"CORRESPONDENCE TRACKING"

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DOCUMENT NUMBER: 9121551

FROM: JERNIGAN, John M.: CENTER FOR PROFUNDITY FUNDITY FAMILY FRIENDS
AND INTERFACE '91.

TO: DR. BROMLEY

DATE OF
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SUBJECT: THE FAILED EDUCATION PROCESS IN THE USA AND THE
INTENT OF ADDING DR. BROMLEY NAME TO THE INITIAL
ROSTER FOR INTERFACE EXCELLENT '91.

ASSIGNED TO:

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REMARKS:

DATE RECEIVED: 05/29/91

FILE: EDUCATION

9121551

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4973 Red Pine Court Tara Woods Jacksonville Florida 32210 904/772-7990

91 MAY 29 P 4: 35

Dr. Allan Bromley
Presidential Science Advisor
THE WHITE HOUSE
Washington D.C. 20001

OFFICE OF THE
DIRECTOR

A CHALLENGE THAT FITS !

Dear DR. Bromley :

I congratulate you and C&EN Reporter Wil Lepkowski on the May 20, 1991 3 pg on Science Policy. You appear to be making progress toward President Bush's ability to capitalize on , and utilize our Industrial, Scientific and Technological capabilities. Certainly, DESERT STORM was a near perfect example..

We, as do you, ^{KNOW} that more than Science and Technology was involved. Lurking in the background was, and always is, the failed Public Schools, and the functional and/or scientific illiterates.

In 1982 and 1983 Interface Excellence '82 and President Reagan's Bell Commission Report "A NATION AT RISK" convicted the Public School Systems of FAILURE !

Even more importantly, the Reports showed, but did not emphasize enough, the basic cause of the PUBLIC SCHOOL FAILURE!

It is that: TOO MANY HOMES, AND THE MAJORITY OF THE PUBLIC SCHOOL SYSTEMS HARM, DENY, AND KILL THE INNATE CURIOSITY AND DESIRE TO LEARN OF CHILDREN.

In 1982 Dr. Charlotte Ward brilliantly Keynoted "CHILDREN ARE BORN SCIENTISTS !".

President George Bush wants to be "THE EDUCATION PRESIDENT". IF he, his administration, and his friends among the 90% Judeo-Christain Majority can analyse the problems correctly, design the revised systems, "sell" it to the same majority,, and put it into operation, NO ONE COULD SUCCESSFULLY DENY him of "EDUCATION PRESIDENT" ! Possibly, even more importantly, we will have atoned for a heinous crime that is being perpetrated on our children, for several generations !

Somewhat obviously, "social engineering", welfare, and schools fashioned under the failed and discredited values of the ungodly religions of MARXIST SOCIALISM, COMMUNISM, and SECULAR HUMANISM must be overhauled. The re- admission of the 90% majority to the social decision making will assure that, again in this representative democracy, the majority decide controversial matters.

All of the above, and more, point to YOU volunteering, as I, to participate in INTERFACE EXCELLENCE '91. I am attaching some of the information previously mailed to the INITIAL ROSTER, and will add your name, if you do not object.

Sincerely,

John M. Jernigan

John M. Jernigan, Chrm, CPC, CChE, Elder, PC USA; CC Others.

Incl: Pres. & Mrs. Bush, D. James Kennedy

JOHN MILTON and JOSEPHINE MILLER JERNIGAN
CENTER for PROFUNDITY FUNDITY FAMILY FRIENDS and INTERFACE EXCELLENCE '91
4973 Red Pine Court Jacksonville Florida 32210 4/25/91

TO: THOSE ON THE INITIAL ROSTER OF INTERFACE EXCELLENCE '91, including
EDUCATION PRESIDENT GEORGE BUSH and MRS. BARBARA BUSH, and
Dr. CHARLOTTE WARD, Author of "CHILDREN ARE BORN SCIENTISTS !"

MEMO ON : THE FAILED EDUCATIONAL PROCESS IN THE UNITED STATES OF AMERICA.

Dear DR. Broomley;

The FINDINGS of INTERFACE EXCELLENCE '82 and of President Reagan's Bell Report
"A NATION AT RISK" include this horrifying information : "The Family and the Public
School Systems have contributed to killing the innate curiosity and desire to learn
of our CHILDREN."!!!

In 1982 it was estimated that more than 50% of the entire population was functionally
and/or scientifically illiterate. In 1991 it is estimated that up to 70% are function-
ally and/or scientifically illiterate.

In 1982 it was estimated that up to 90% of the High School Graduates were functionally
and/or scientifically illiterate.

In 1990 the United States was 14th. among 14 NATIONS in science tests to students !

Since the Nationwide headlines of 1982-83 have expired, a few Public School Systems
have rigorously made improvements, some to a degree which allows them to be a MODEL of
good PUBLIC SCHOOL, with their Graduates able to demonstrate the success of their education.
One or more of these successful Public School systems will be featured at INTERFACE
EXCELLENCE '91.

Disastrously, many Public School Systems have accepted increased funding, but have
not reached the "MODEL" Standards, hence the failed system!

Good TEACHERS, pursuing their high and noble calling can, and do find CHILDREN's
innate desire to learn; fan it toward a good education.

However, even one bad or incompetent teacher can destroy the desire to learn. This
discovery uncovered an old South Alabama Truism "You can no more teach something you don't
know than you can come back from some place you 'aint been !"

INTERFACE EXCELLENCE '91 is conceived as a CONGRESS OF Free Americans
working in Seminar to redress the grievous wrongs done to millions of
our children by a failed public school system.

We are buoyed by President Bush and the Governors making statements of
support for education. The President, members of Congress and the HEADS
of our great corporations are invited to participate. Our scientific,
technical and professional societies will be represented..

Those receiving this memo are asked to confirm their participation in
INTERFACE EXCELLENCE '91, and to solicit others to participate; scheduled
for October 9-12, 1991. We must stop the Nation's slide into illiteracy.

John M. Jernigan
Sincerely John M. Jernigan, Chrm, INTERFACE EXCELLENCE '91

*PS: I can send you other information. Our needs now are committed
PARTICIPANTS. Possibly, this is the greatest opportunity we will have to
overcome, and reverse 50 yrs of "TAX & Spend" LIBERALISM; for the COMMON GOOD!*
John

INITIAL ROSTER FOR INTERFACE EXCELLENCE '91 as of 5/5/91 3rd. Ed. 5/91
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