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ABSTRACT

This testimony, supported by data from several national surveys, was presented by Sarah E. Klein (president of the National Science Teachers Association) regarding the elimination of science education from the National Science Foundation (NSF). Issues and topics addressed include: (1) statement of the crisis in science/mathematics education, focusing on science/mathematics teacher shortage, decline in numbers of individuals prepared to teach science/mathematics, and employment of unqualified science/mathematics teachers; (2) quality of science/mathematics education; (3) prior NSF support of science/engineering education; (4) NSF curriculum development projects and their effectiveness; (5) comparisons of U.S. and U.S.S.R. science/mathematics education; (6) critical problems at the pre-college level; (7) NSF science/engineering programs; (8) NSF 1982 budget for science/engineering education; (9) Special Commission of Science/Engineering Education; (10) a suggested NSF program for 1983, addressing such problems as teacher shortages and in-service programs; (11) public support for science education (ranked ahead of national defense); and (12) a suggestion that science education programs could be financed by holding the proposed total research budget to 2% rather than 8.7%. (JN)

TESTIMONY

TO

COMMITTEE ON LABOR AND HUMAN RESOURCES

OF

THE UNITED STATES SENATE

IN REGARD TO

1983 AUTHORIZATION
FOR
THE SCIENCE EDUCATION COMPONENT
OF
THE NATIONAL SCIENCE FOUNDATION

PRESENTED BY

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DATE: APRIL 15, 1982

The following testimony is presented by Sarah E. Klein, President of the National Science Teachers Association (NSTA). The NSTA is the largest science education organization in the world. It is the only science education organization that is concerned with the professional aspects of science education at all levels for all science disciplines.

Mrs. Klein is an 8th grade general science teacher at Roton Middle School, Norwalk, Connecticut. She is currently on leave to carry out her responsibilities as President of NSTA. Mrs. Klein has been active in NSTA for many years, and over the past year has visited schools, talked to teachers, and participated in numerous science meetings throughout the United States, Canada, England, and France. Mrs. Klein wishes to acknowledge the efforts of Bill Aldridge, Executive Director of NSTA, and of James Shymansky, of the University of Iowa, for documentation and preparation of this testimony.

The Crisis in Secondary School Science and Mathematics Education

Our nation faces unprecedented problems in science and engineering education. Most severe of these problems are at the secondary school level where there is a critical shortage of qualified science and math teachers. The paucity of supplies, resources, appropriate materials, and support have reduced the quality of science and mathematics education at the secondary school level to a point that U.S. national security and the nation's efforts toward improved productivity are dangerously threatened.

Shortages of Secondary School Science and Math Teachers

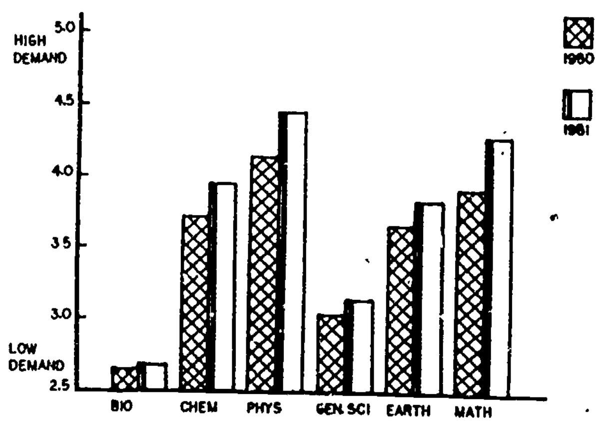
In the fall of 1980 and again in the fall of 1981, Howe and Gerlovich (1) surveyed the 50 state science supervisors to assess supply and demand for secondary school science and math teachers. Shortages were found for 1980-1981, and those shortages have become more severe in 1981-1982. As shown in Table I, this problem is national in scope, and the shortages are critical in physics, mathematics, and chemistry.

SUBJECT	Critical Shortage		Shortage	
	1980-1981	1981-1982	1980-1981	1981-1982
PHYSICS	21	27	22	15
MATH	16	18	19	25
CHEMISTRY	10	9	25	29

TABLE I

When the science and math teacher shortage problem is expressed in terms of demand, as indicated on a scale from 0 to 5, the results, shown in Figure 1, lead to the conclusion that the shortage was critical and has worsened in the last year.

DEMAND FOR SCIENCE/MATH TEACHERS

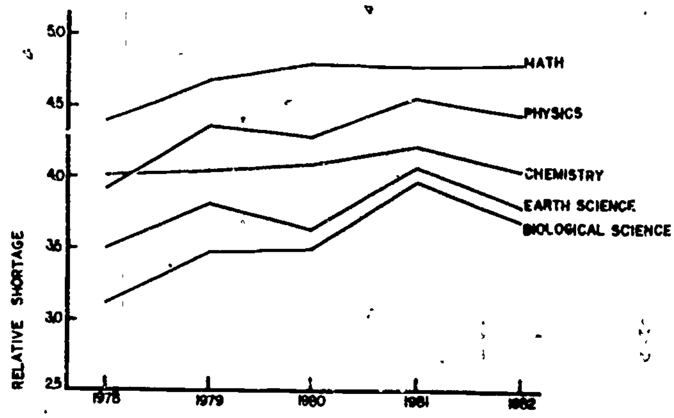


Based on a survey of state certification departments From Trevor G Howe and Jack A. Gerlovich, "National Study of Estimated Supply and Demand of Secondary Science and Mathematics Teachers." Iowa State University, 1982

Figure 1

In surveys of placement officers conducted by James Akin (2) from 1978 to 1980, "considerable shortages" of teachers were found for math, physics, chemistry, and general science.

DEMAND FOR SCIENCE/MATH TEACHERS



Based on a survey of teacher placement officers. From James N. Akin, ASCUS Report, "Teachar Supply/Demand," 1981.

Figure 2

Severe Decline in Numbers of Persons Prepared to Teach Science and Math

In December, 1981, the NSTA surveyed 600 colleges and universities that have teacher training programs (3). Year-by-year data were acquired for the ten-year period of 1971-1980. The results shown in Table II and Figures 3 and 4 are shocking. There has been a 77% decline in the number of math teachers and a 65% decline in the number of science teachers prepared to teach in secondary schools. As shown in Table II, not only has the supply of persons trained to teach science and math severely declined, but the fraction of those trained who do go into teaching has also declined.

The combined effect is a 68% reduction in newly-employed science teachers and an 80% reduction in newly-employed math teachers since 1971.

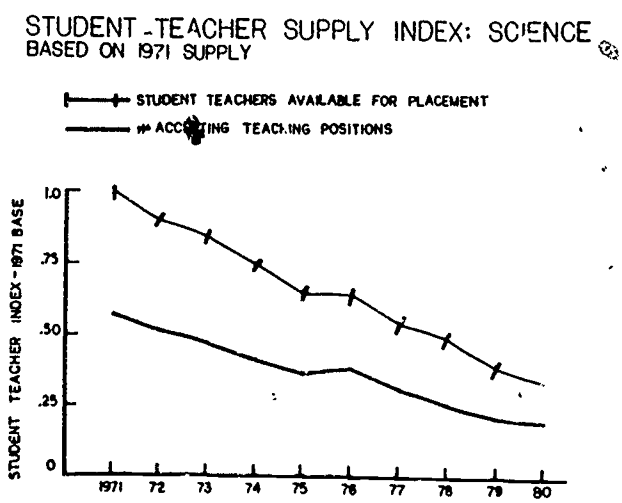
SCIENCE/MATH TEACHER SUPPLY DATA 1971-1980*

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
SCIENCE	Graduating Teachers	100	90	85	75	65	65	55	50	40	35
SCIENCE	% Entering Teaching	59	58	58	55	56	59	56	52	54	54
MATH	Graduating Teachers	100	91	86	73	60	45	36	27	27	23
MATH	% Entering Teaching	63	68	64	65	62	61	63	59	60	55

* Values represent percentages indexed to 1971.

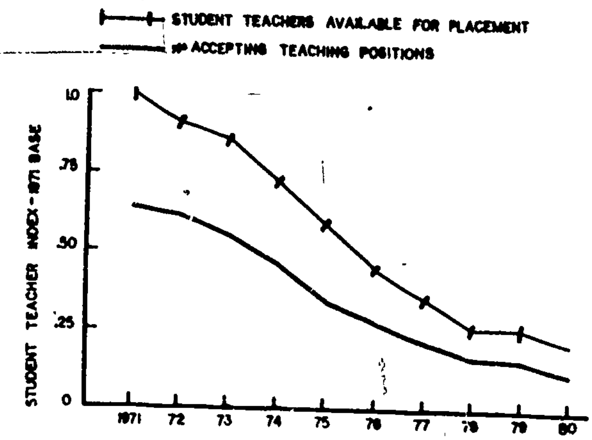
** Based on data from a nationwide sample of 140 university/college placement officers.

Table II



Based on NSTA survey of college and university placement officers. Conducted by J. A. Shymansky, The University of Iowa, 1982

Figure 3



Based on NSTA survey of college and university placement officers Conducted by J. A. Shymansky, The University of Iowa, 1982.

Figure 4

Employment of Unqualified Science and Math Teachers

In another NSTA survey (4), also conducted in December, 1981, and analyzed by James Shymansky of the University of Iowa, secondary school principals provided the information. Among newly-employed science and math teachers, 50.2% were unqualified to teach science or math. They were employed on an "emergency basis" because no qualified teachers could be found. When these data are examined by census regions, the results are especially bad in states where high technology industries require the best-trained science and math personnel. Table III shows, by census region, the percentages of newly-employed science and math teachers for the school year 1981-1982 who are unqualified to teach these subjects.

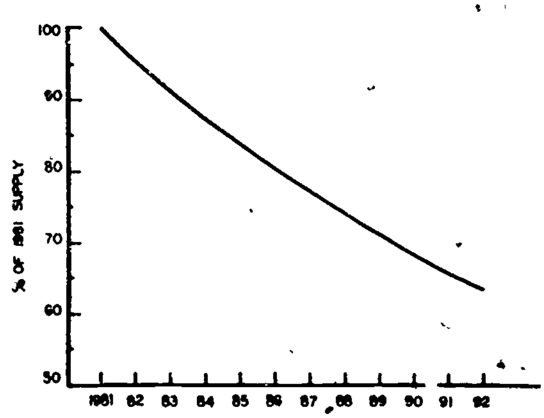
	Percentage of Newly-Employed, But Unqualified Science and Math Teachers	
Census Region	1980-1981	1981-1982
Pacific States	75%	84%
Mountain States	44	43
West North Central States	26	43
West South Central States	63	63
East North Central States	23	32
East South Central States	43	40
Northeastern States	11	9
Middle Atlantic States	40	46
South Atlantic States	48	50
NATIONWIDE	45%	50%

Table III

Ages, Experience, and Plans of Science and Math Teachers

The evidence of a severe shortage of science and math teachers at the secondary school level is overwhelming. To compound this problem, results of an NSTA survey of science teachers show that schools have an aging faculty and that one in four of the younger faculty plan to leave teaching completely. The average age is 41, and the average experience is 16 years. Almost 5 times more science and math teachers left teaching last year for employment in non-teaching jobs than left due to retirement. If the present exodus of qualified science and math teachers from secondary schools continues, the nation will have a net loss of 35% by 1992.

EXODUS FROM THE CLASSROOM
-A PROJECTION-



Based on the 4% rate at which science and math teachers left classroom teaching in the years 1980 and 1981.

Figure 5

School Populations - Increasing or Decreasing?

Analyses of population data and of school projections compiled by the National Center for Educational Statistics suggest science and math teacher demand will increase over the next several years.

Elementary school enrollments bottomed out in 1981 and are now on the rise. Secondary school enrollments will by 1996 have dropped only by 24% from their high in 1977. Then they will increase again for several years. The declines in qualified science and math teachers has already exceeded these enrollment declines by a factor of three.

Conclusions about Teacher Shortages

Independent recent surveys all show a severe shortage of secondary school science and math teachers. There has been a catastrophic decline in the number of persons prepared to teach science and math, and of those prepared, many do not take teaching positions. Secondary schools are employing record numbers of unqualified persons for science and math teaching positions because qualified teachers cannot be found. The problems are most severe in regions of the country where the greatest efforts will be made for defense preparedness and high technology industry. Thus there is a dangerous mismatch between scientific and technological training capability and national need.

Quality of Science and Mathematics Education

The severe shortages of secondary school science and math teachers and the resulting employment of unqualified teachers on an emergency basis is a major factor in the decline of quality in secondary school science and math education. For the teachers who remain in the science and math classroom, there are other constraints which have made the situation deteriorate further.

From the recent NSTA survey, we know that 60% of science teachers report recent cuts in their budgets for supplies and equipment. These cuts occur at a time when school labs are already obsolete, and when computers and other components of modern electronics are essential in an up-to-date curriculum. From the same survey, we learned that 79% of these teachers had not completed at least a 10-hour course or workshop in over ten years. Also, 69% have never attended a computer course or workshop. Finally, 40% have not attended a course or workshop since they began teaching, which has been an average of 16 years.

In another recent national survey conducted by NSTA, elementary school teachers provided the responses (5). Approximately 51% report that their undergraduate training did not prepare them to teach science. Furthermore, 71% of the school districts had no inservice training for science, and 64% no longer had science consultants assigned to their schools.

There has been much public discussion of declines in SAT scores, but less attention has been given to declining scores in the national assessment. There has been a decline in recent years, and now those declines are affecting even our best science and math students.

Prior NSF Support of Science and Engineering Education

There is, among those in the Administration, and among many others, the mistaken belief that science education has received substantial support, especially in recent years, and that since we now see all of these serious problems, the infusion of massive federal support has been a failure. The facts are quite the opposite. The NSF support for science and engineering education has been declining steadily and steeply for the past 22 years. Figure 6 shows how science education's share of the total NSF budget has dropped from a high of 47% in 1959 to its present low of 2%.

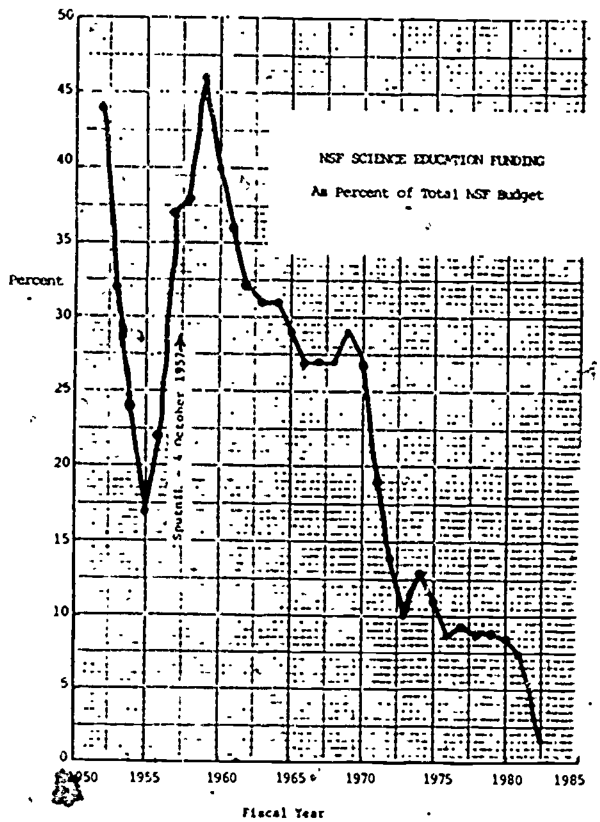


Figure 6

Support for pre-college science education has dropped even more sharply, from 72% of the science education budget in 1959 to 22% in 1980. In terms of the total NSF budget, the pre-college share has dropped from 34% in 1959 to its present low of less than 1%.

The NSF support for secondary school science and math has fallen to a negligible level, and the present cluster of national problems in secondary school science and math education can in large part be attributed to NSF's negligence of this component of their Congressionally mandated mission. Figure 7 shows how the decline in NSF support at the pre-college level correlates with declining achievement in science as measured by the National Assessment of Educational Progress. Although correlations do not necessarily mean cause and effect, coupled with all the other evidence, this correlation may well be as good an indicator as smoking and cancer.

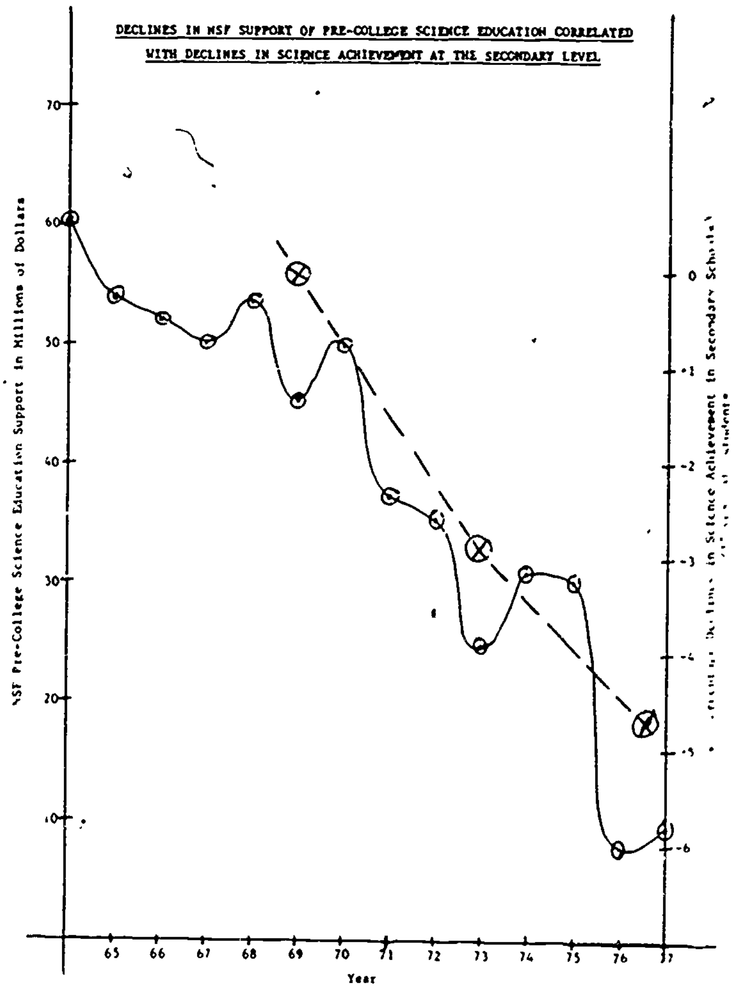
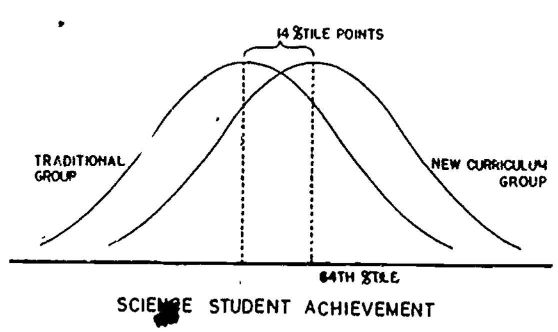


Figure 7

NSF Curriculum Development Projects

Much of the demise of NSF's science education support has resulted from criticisms of curriculum development activities. There are legitimate criticisms that one can make of the "new curricula" produced under NSF support: These projects often purged applications, concentrated heavily on pure science, and appealed mainly to the brightest students. Their difficulty level contributed to the reduction in the numbers of students studying science and mathematics in recent years. Yet, according to preliminary results of a very recent project (6), the new curricula were far more successful than most people realized. In this project, an analysis was made of 105 studies involving 45,000 students. Comparisons were made between students enrolled in new science curricula and traditional curricula. On every kind of measure, including achievement, attitude, and process skills, students taking the new NSF curricula scored overall 14% higher. For the BSCS Biology and Chem Study materials, the students scored higher by more than 17%. What is most significant is the fact that students from low socio-economic groups scored 24% higher using new NSF-supported curricula than traditional curricula. Thus, since a larger proportion of our minority population are in the low socio-economic categories, the new curricula, supported by NSF, gave minority children a decided edge over similar children exposed to traditional materials.

EFFECTIVENESS OF NEW SCIENCE CURRICULA



Composite effect of student performance across all new science curricula based on student sample, N=45,000. From Anderson, et al., NSF Grant SED 80-12310

Figure 8

These studies covered a period of several years in the 1960's and 1970's. Few teachers are left in the schools now who are qualified to teach such curricula, and essentially none have been given the in-service training to do so since NSF abandoned that kind of program several years ago. Also, the materials are badly in need of revision and modification to take into account computers, modern electronics, and applications to technology. The problem of offering appropriate science to less able children also must be addressed.

Comparisons of U.S. and U.S.S.R. Science and Math Education

Recent comparative studies (7) in science and engineering education between the Soviet Union and the United States suggest a major offensive by the U.S.S.R. to increase its economic productivity and defense preparedness through science and engineering education. The U.S.S.R. offers its pre-college students sequences of course material in science and mathematics starting with an intuitive level of understanding. Then students progress to empirical levels; finally, they are ready for the formal axiomatic and theoretical understandings. The actual time spent begins with only a couple of hours per week and changes gradually over three or four years until students spend four to five hours per week in class. Thus the Soviets not only offer all students quantitatively more contact with the sciences and mathematics, they do so systematically to ensure that students progress in a way that matches stages of intellectual development. In U.S. secondary schools, and in colleges, students enter a course in physics or chemistry and are immediately introduced for the first time to the highest levels of abstraction, without any intuitive basis or prior empirical knowledge. Thus many find these subjects hopelessly difficult and fail or drop out. Most students simply avoid taking these subjects, having heard how difficult they are. The lack of application in science curricula and their failure to relate to personal and societal problems and issues further alienate students.

What are the Priority Problems?

The most critical problems are at the pre-college levels, especially in secondary school science and mathematics. Those problems are, in order of priority:

1) Critical shortage of physics, mathematics, and chemistry teachers at the secondary school level;

2) Substantial numbers of unqualified persons are teaching science and mathematics in secondary schools;

3) Most certified science and mathematics teachers at the elementary and secondary levels are badly in need of in-service training;

4) New sequences of science and math courses and materials are needed which match stages of intellectual development of children;

5) Elementary school science consultants are needed who understand science, stages of intellectual development of children, and who know what resources are available;

6) Elementary and secondary schools need access to micro-computers and low-cost supplies and other resources; and

7) Science curricula need revision, and teachers need training in using new materials and new methods of sequencing content.

Can Low-Budgeted NSF Programs Help Solve Science Education Problems? Are There Too Many Programs?

Among the reasons given for eliminating science education from NSF is one that is specious at best. It takes a form something like the following:

The NSF science education effort had grown into many diffuse, low-funded programs without coherence and were therefore ineffective in dealing with the worsening problems.

This argument is usually offered by the very persons who have assisted in reducing the support for science education or by those intent on eliminating science education support for ideological, not economic or even political reasons.

Now consider the facts. The 28 or so "programs" of the Science Education Directorate were not programs any more than are the 28 "programs" listed for the Engineering Directorate in the 1982 NSF Budget document.

Just as Engineering has four main programs with 6 or 7 program elements for each main program, science education had four main programs:

I. Science Personnel Improvement

II. Science Education Resource Improvement

III. Science Education Development and Research

IV. Science Education Communications

The various components fit in a reasonable and coherent way to the program thrusts.

The average science education program element was budgeted at about $2.86 million in 1980. In the 1982 Engineering Directorate, the average of those 28 program elements is budgeted at $2.75 million.

	Science Education Directorate 1980	Engineering Directorate 1982
Main Programs	4	4
Program Components	28	28
Budget	$80 million	$77 million
Average Program Element Budget	$2.86 million	$2.75 million

Table IV

If one looked at the individual engineering sub-elements in 1982, he could easily draw the conclusion that the Engineering Directorate was diffuse and ". . .targeted at specific, limited problems without any very clear connection to a larger conception," a statement made recently by Dr. John Slaughter in referring to science education.

The preemptive NSF reorganization, effective March 21, 1982, will eliminate the Science and Engineering Education Directorate, replacing it with an Office of Science Personnel and Education. Staff will have been reduced from over 100 in 1980 to 15 in 1983. This elimination of the science education mission of NSF, if allowed by the Congress to occur, will have been effected by the OMB, with tacit, if not explicit approval and cooperation by a majority of scientists in and out of NSF whose main concern is to protect research support at all costs. For most of the people who have ever heard of NSF or have been directly affected in positive ways by NSF, their contact has been through NSF science education programs. This abandonment of science education will ultimately prove short-sighted in the extreme.

NSF's 1982 Budget for Science and Engineering Education

Of the $20.4 million appropriated for NSF science education for 1982, $15 million was for graduate fellowships. Some $700,000 was designated to support a "commission," and the balance was used to meet "prior obligations."

Staff of the Science Education Directorate have already been reduced from over 100 to about 50, and by March 21, will be reduced to 10 or 12 persons. Since graduate fellowship support is but another form of support for scientific research, the NSF has essentially eliminated all science education activities. The Administration has successfully forced NSF to abandon one of the missions required by its enabling legislation. It is time that NSF either ask Congress to change the organic act and delete science education from its mission or stop the deception that graduate student support alone is somehow equivalent to support of science education at all levels and proceed with its responsibilities by providing a budget which addresses serious national problems in science education.

The Special Commission on Science and Engineering Education

The only new activity for science education in the 1982 budget was $700,000 to support a special commission on science and engineering education. The NSF spent upwards of $3 million over the past five years for studies at the pre-college level. There is ample evidence of what the problems are and what is needed to solve them. What is needed is federal action to address documented and serious national problems. A major problem, like the crisis in secondary science education, which is national in scope, cannot be broken into 50 smaller problem pieces and sent back to the states to solve. Both the commission charter and the National Science

Board Policy statement that brought the commission into existence specifically recognize that NSF programs could result from work of the commission. However, the proposed 1983 budget has no funds to act on recommendations of the commission. Indeed, there are not even funds to continue the commission itself. One can only conclude that this commission is but another gratuitous, empty gesture toward meeting NSF's obligations to science education.

An NSF Science Education Program for 1983

The critical shortage of secondary school science and math teachers cannot be solved in 1983. However, this problem is closely related to the problem of unqualified and marginally-qualified teachers who are now teaching science and mathematics. Because there are overall reductions occurring in the numbers of teachers needed in some other fields, many of the newly-appointed, but unqualified science or math teachers are recruited from these other areas.

The long-term shortages must be addressed by stimulating new entrants to teacher training programs in science and mathematics. This can be accomplished through NSF scholarships and NSF-supported programs of publicity on the need for teachers.

In the short term, the NSF should support summer and academic-year courses and workshops for marginally-qualified science and math teachers, so that they may reach some minimal level of qualification to teach the assignments they have been given. The level of support should be limited to grants for tuition, books, and materials, up to a maximum of 20 semester hours' credit equivalent per year. No support should be given to colleges for this program, since the tuition grants provide indirect support and cover the costs of that instruction.

The problem of establishing new sequences of science and math courses to match the stages of intellectual development of children is most difficult to solve. The most cost-effective solution would be for the NSF to support development and implementation of a model sequence in two or three school systems. These models would be carefully developed in cooperation and with assistance of scientists and science education experts at universities. Detailed guidelines for establishing the sequence would be prepared and widely disseminated. The NSF would provide support only for consultant services to schools that chose to implement the approach following the guidelines which had been developed.

The problem of upgrading qualified science and math teachers can be solved by offering short courses and workshops. The NSF has models of these already in operation and could easily continue these programs.

The need for low-cost supplies and other resources can be addressed by NSF through a program of support for area Science Instruction Resource Centers, modeled after the one created by Douglas Lapp in the Fairfax, Virginia School District.

Microcomputers could be supplied through an NSF program of partial support. Even a level of support by NSF of 25% of the cost could have great leverage in bringing larger numbers of microcomputers into the schools. Given the availability of in-service programs for teachers, proper utilization could be assured.

The revision of curricula to bring them up to date and to accommodate to the new technology, applications, and societal problems, can be accomplished through conventional, but carefully monitored, curriculum development projects.

The problems of elementary school science are immense, but a high-leverage approach, with relatively low cost, would be an NSF program of summer and in-service studies for science consultants. Also, some modest grant support could be provided to school districts that were willing to reinstitute a science consultant program for their elementary schools.

<u>Does the American Public Think that Tax Funds Should be Used by NSF to Support Science Education and Basic Research or Just Basic Research?</u>

The Thirteenth Annual Report of the National Science Board, <u>Science Indicators 1980</u>, dated March 31, 1981, offers much interesting and useful information.

The table below is taken from that NSF report. According to this report to the President, the Public would rank science education second as its choice "to receive science and technology funding from tax money." The Public would rank basic scientific research tenth in its choice to receive such tax money. Science education is even ranked ahead of national defense.

Given clear evidence of public preference for spending tax money for science education over spending it for basic research, and given the Congressional mandate in the organic act of NSF to support science education at all levels, it is most difficult to understand why NSF is forced by OMB to ignore this responsibility.

Appendix table 6-10. Areas the public would most like to receive science and technology funding from tax money: 1972-79

Area	Percent in 1979	Rank[1] 1972	1974	1976	1979
Improving health care	50	1	1	1	1
Developing energy sources and conserving energy	46	(2)	(2)	(2)	(2)
Improving education	39	5	4[3]	3[3]	2
Reducing crime	36	3	2	2	3
Developing or improving methods for producing food	23	(2)	(2)	(2)	(2)
Reducing and controlling pollution	22	2	3	3[3]	4
Developing or improving weapons for national defense	16	10[3]	11[3]	8[3]	5[3]
Preventing and treating drug addiction	16	4	4[3]	5	5[3]
Developing faster and safer public transportation within and between cities	13	7	7	7	7
Improving the safety of automobiles	9	6	6	6	8
Finding better birth control methods	9	8	9	8[3]	9
Discovering new basic knowledge about man and nature	8	9	8	10	10
Exploring outer space	6	10[3]	11[3]	11	11
Predicting and controlling the weather	4	10[3]	10	12	12
	(N = 1,635)				

[1] In 1979, respondents were asked to limit themselves to three areas, and slight changes in the wording of some items were made.
[2] "Developing energy sources and conserving energy" was not included in the listing prior to 1979 and "developing or improving methods for producing food" was not included prior to 1976. These areas were therefore omitted from the rankings.
[3] Tied for the indicated rank.

SOURCES: *Attitudes of the U. S. Public Toward Science and Technology*. Study III (Princeton, N.J.: Opinion Research Corporation, 1976), pp. 56-57; Jon D. Miller, Kenneth Prewitt, and Robert Pearson, *The Attitudes of the U.S. Public Toward Science and Technology* (Chicago: National Opinion Research Center, University of Chicago, 1980), p. 137.

Where are the Funds for Science and Engineering Education?

The Administration's proposed NSF budget calls for a total of $1,072.8 million in 1983, an increase of 7.7% over 1982. Needed science education programs could be financed by holding the total research and related activities budget to a 2% increase instead of the 8.7% increase which is proposed. This will free up $65.5 million for science education activities.

NSF Science and Engineering Education Recommended Program Elements for 1983

NSF Undergraduate Scholarships for Math and Science Teaching (4,000 @ $1,500 each)	$6.0 million
Science and Math Teaching Careers Publications and Dissemination	1.5 million
Tuition, Books, and Materials for Summer and Academic-Year Courses and Workshops (5,000 marginally-qualified teachers @ $2,000)	10.0 million
Model Sequences for Science and Math Courses (3 projects @ $2 million)	6.0 million
Short Courses and Workshops for Upgrading Qualified Science and Math Teachers (10,000 teachers @ $1,000)	10.0 million
Model Science Instruction Resource Centers (50 @ $200,000)	10.0 million
Partial Support Grants for Microcomputers (25% of $2,000 for 10,000 schools)	5.0 million
Curriculum Revision and Enhancement Projects	12.0 million
Programs for Science Consultants for Elementary Schools	5.0 million
TOTAL	$65.5 million
Graduate Fellowships	15.0 million
TOTAL	$80.5 million

One of the major arguments used to eliminate science education support is that the problems are too great and these NSF funds too small to have a significant effect. Yet this budget, of only $65.5 million would directly affect 19,000 science and math teachers and 10,000 schools. It would indirectly affect another 50,000 teachers and millions of science and math students in their classes. The program elements of the Science Education Directorate have been and can be the most cost effective of all federal programs. They are more competitive than the NSF research program. Where 5 - 10% of science education proposals have been funded, some 30 - 40% of research proposals are funded. The NSF science education programs have been and can be of high quality because they are competitive and have never been administered as entitlements. It is the prestige and high quality of the NSF programs which offer the strongest reasons why NSF and not another federal agency should offer these programs.

Sources

(1) T. G. Howe and J. A. Gerlovich, "National Study of the Estimated Supply and Demand of Secondary Science and Mathematics Teachers," Unpublished Paper, November 6, 1981.

(2) J. N. Akin, "Teacher Supply and Demand: A Recent Survey," (ASCUS, Box 4411, Madison, WI 53711) 1980.

(3) Preliminary results of December, 1981, NSTA Survey of 600 Colleges and Universities with science and math teacher training programs.

(4) Random sample of 2,000 U.S. secondary school principals in December, 1981. Analysis done by Dr. James Shymansky using staff and computers at University of Iowa.

(5) Preliminary results of survey undertaken in January, 1982, by Kathleen M. Donnellan, NSTA Preschool/Elementary School Division Director, Springfield, Massachusetts Public Schools.

(6) Ronald Anderson, James Shymansky, et. al. Preliminary Results of Project NSF SED 80-12310, February, 1982.

(7) C. P. Ailes and F. W. Rushing, <u>The Science Race: Training and Utilization of Scientists and Engineers, U.S. and U.S.S.R.</u>, Chapters I, II, (Crane Russak, New York) 1982.