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ABSTRACT

Precollege programs for alleviating the severe underrepresentation of American Indians, Blacks, Mexican Americans, Puerto Ricans, the disabled, and/or women in scientific and engineering professions are evaluated in this document. Both the quantity and quality of programs are assessed, and criteria for exemplary programs articulated. The results of mail questionnaires to the relevant groups are tabulated and a synthesis provided of the results in terms of: (1) the nature of exemplary programs; (2) the kinds of schools involved; (3) curriculum and teaching; (4) parent involvement; (5) and (6) the role of museums, colleges, and universities; (7) business and industry sponsorship; (8) informal learning procedures (television); (9) new technology (computers); and (10) bridge programs. A breakdown is offered of the needs and success rates of the different groups: women; the disabled; and minorities. Cases in which intervention efforts for women and/or minorities have been institutionalized are also examined, in addition to causes for concern isolated by project directors. Specific recommendations are addressed to: (1) the Federal government; (2) State and local government; (3) colleges and universities; (4) business and industry; (5) community organizations and professional societies; and (6) program implementers. A sample survey form is provided. Appendices include the detailed work plan for the study, survey form and results for science camps/computer camps, and lists of programs responding to the intervention survey and of programs visited during the study. (RDN)

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Equity and Excellence: Compatible Goals

Education in the Sciences

American Association for the Advancement of Science

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CIETY FOR CYBERNETICS ■ AMERICAN SOCIETY FOR ENGINEERING EDUCATION ■ AMERI-
CAN SOCIETY FOR HORTICULTURAL SCIENCE ■ AMERICAN SOCIETY FOR INFORMATION
SCIENCE ■ AMERICAN SOCIETY FOR MASS SPECTROMETRY ■ AMERICAN SOCIETY FOR
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ICAL SOCIETY OF AMERICA ■ FOUNDATION FOR SCIENCE AND THE HANDICAPPED ■ GAMMA
ALPHA GRADUATE SCIENTIFIC SOCIETY ■ GAMMA SIGMA DELTA ■ GENETICS SOCIETY OF

EQUITY AND EXCELLENCE: COMPATIBLE GOALS

An Assessment of Programs That Facilitate Increased Access and Achievement of Females and Minorities in K-12 Mathematics and Science Education

A Study Conducted for the
NSB Commission on Precollege Education in Mathematics, Science and Technology

Contract Period: April 1 - July 31, 1983

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Preface

When we responded to the request for proposals from the National Science Foundation to do a study of intervention programs for females and minority students, we could not have known the extent of the commitment we were making—where this study would take us and where it continues to take us. There were aspects of the study that we did not like, but we figured out ways to deal with them: the short turnaround time, the lack of money to support dissemination of the report, and the fact that this study did not include support of a study of programs for disabled students. We put more people on the job, worked longer hours and weekends; we got permission from NSF to print and disseminate the report if we could find the money and found another funder who also thought this report should be more widely available. We supported the review of programs for disabled students out of AAAS funds and offered this to the Commission as a "bonus."

More than a year after its completion we offer this report to all those who believe that we must develop fully the human potential of this country. We must educate women, minorities and disabled persons in science and mathematics for the careers that they might then be able to choose, as well as for the lives they most surely will live in the 21st century. A group of hearty educational pioneers have discovered a lot about how we can do this.

This report is possible because dedicated persons believed that quality and equality in education were inextricably connected and gave us the program examples to study.

What we say in this report may seem like good "common" sense or may seem to fly in the face of prevailing rhetoric. There are over 3.7 linear feet of documentary materials which formed the backbone of this report. At some point analysis always meets the experience of the researchers. We feel comfortable with our conclusions because a number of different people who went out into the field at different times, to view different projects, to talk to different staffs, shared a common protocol and achieved consensus about what they saw and what it meant.

We were grateful for this chance to extend our knowledge of precollege education in mathematics and science for students who are female, who are students or members of racial or ethnic minority groups or who have physical disabilities.

November 1984

Acknowledgements

Working under tight deadlines with "politically sensitive" materials can be a harrowing experience. I wish to acknowledge the assistance of all those who made it happen so well and so quickly. My thanks to a dedicated and hardworking staff, for whom the term "overtime" is an understatement: especially to Michele L. Aldrich, who told us what we should do in developing the survey instrument, based on her previous experience, and then tabulated, analyzed and reported on hundreds of surveys; to Paula Quick Hall, who overcame her aversion to "prying" and discovered that she liked site visiting; to Patricia Boulware, who developed a really close relationship to the word processor and kept track of lots of us in the field, complete with complicated travel and expenses; to Virginia Stern who, along with Pat, tried to see just how quickly a meeting could be arranged from identifying participants to cleaning up the post-meeting details, and who made major contributions to the section of this report which deals with disability; to the rest of the staff who remained good-natured despite the hectic pace, especially the unflappable Dara Scott, without whom we would have been even more frantic. My special thanks to all those consultants who helped us think through our plan and who then crisscrossed the country to ferret out and interpret this story: my thanks to Patty Casserly, Alma Lantz and Joe Halpern, Diana Marinez, Benson Penick, and Westina Matthews. My thanks to other AAAS staff who understood our deadlines and came through with comments, reactions and assistance, and to the families and friends of project staff and consultants who understood the weekend work, the late nights, the early mornings, the broken luncheon dates and the basic crankiness. The staff of the NSF Commission were always there when we needed them, especially Melvin Thompson, our project monitor. A number of the Commissioners took a special and particular interest in our work, giving us needed feedback: Commission Co-Chair Cecily Cannon Selby, Commissioner Arturo Madrid, and the liaison from the National Science Board, Lloyd Cooke. Special thanks to Mary Prescott, the editor who put the public face on this document with the skill and sensitivity needed, and to Barbara Nelson of the Ford Foundation who recognized the need to "get this report out onto the streets" and approved funding to do just that.

Thanks to all of those who have used the report to support the need for further research, work and funding of these programs. That this report has helped to generate activity and support makes worthwhile what we all went through in producing it. And finally, to all the project people (staff and students) who trusted us enough to bare their programs and their souls to OOS staff and consultants goes our sincerest appreciation. Without them none of this would have been possible.

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EXECUTIVE SUMMARY

Special programs in science and mathematics for minorities and females came out of the civil rights movements for these groups and out of a recognition of their severe underrepresentation in such careers. Thus, most of the intervention programs were aimed at producing American Indian, Black, Mexican American, Puerto Rican, and/or women scientists and engineers. The response from government, universities, industry and the professions was to create efforts outside these institutions. Seldom were the institutions themselves changed to include these groups. The programs began mainly as local initiatives, based on locally identified needs and dependent, for the most part, on locally derived resources. Only later did such efforts gain national attention or attract federal or foundation dollars. The timing of this movement to move minorities and women into science and engineering careers was in some ways unfortunate, coming as it did after the major national effort had wound down and as budgets for support of such initiatives were declining.

Intervention programs for minorities and women long ago implemented the idea of consortial arrangements among business and industry, government, universities, and schools. They long ago involved teachers in training and in extracurricular activities for students, in strongly unionized as well as in nonunionized districts. They showed that students can, when given the proper tools, compete favorably despite previous disadvantagement, and that equity and excellence are compatible goals.

The primary feature of successful programs for minorities and females seems to be that they involve the students in the "doing" of science and mathematics and convey a sense of their utility. This would be equally true for programs focused on careers and those focused on science literacy.

Exemplary programs are sensitive to the group or groups they are intended to serve and address these audiences' fundamental needs for academic enrichment and career information. They also tie into the long-range needs and goals of the target group. Exemplary programs for minorities recognize the deficiencies in performance many students are likely to have and stress rigorous academic preparation in mathematics, science, and communications. Computers are a growing aspect of these projects as well. Students are carefully selected and grouped in ways so that they enjoy early success. Program participants are given the opportunity to work in teams on projects. Student research provides an excellent opportunity for students to develop and use multiple skills, integrating the knowledge they have already gained and stimulating them to independent effort.

Projects for females focus heavily on career awareness -- on the utility of mathematics and science to whatever they might want to do. Young women are encouraged to take the courses available to them in high school. They are shown models of science and engineering professionals and students who "are making it" in these fields. In investigating these projects, the research base for women and mathematics programs was closely connected to intervention efforts. The same was not true for most minority projects. There is still a lack of fundamental research on mathematics and science learning by these populations and on the programs intended to address this.

Although programs often start outside the school system, they usually end up inside. Because of the crucial role which the teacher plays, she or he must be "enabled

to enable" the students under her or his guidance. Efforts are made to sensitize teachers to classroom practices which might have a negative effect on minority and female students. Project directors find it important to provide teachers with information on the types of teaching methods most effective with minority and female students in addition to helping them increase subject area competence. They also are given specific information on the careers in which one uses the sciences or mathematics.

Although they vary greatly in nature, longevity, base of operation, sources of support, goals, and quality, intervention programs have demonstrated that there are no inherent barriers to the successful participation of minorities and women in science or mathematics. The evidence gathered to date indicates that if minorities and women are provided early, excellent, and sustained instruction in these academic areas (all other factors being equal), their achievement levels parallel those of white males. In addition, the program models developed in these efforts have proved to be effective in delivering quality education to all students.

Other findings of the study include the following:

- Unless programs "for all" specifically assess the status of, articulate goals for, and directly target educational access problems of females and minorities (and also disabled youth), they are unlikely to be effective with these populations.

- The magnitude and complexity of the problem require a large and continuing effort that specifically targets large sectors of our society - minorities and women - that are educationally "at risk".

- Mainstreaming the concerns of these groups is possible and desirable, but only after specific targeting, followed by institutionalization of program elements critical to achievement of minorities and females and monitoring to assure that participation levels are maintained.

- Successful intervention programs are those that have strong leadership, highly trained and highly committed teachers, parent support and involvement, clearly defined goals, adequate resources, follow-up, and evaluation. For the positive effects to be sustained, these programs must eventually be institutionalized, that is, made part of the educational system.

- Scientists and engineers from the affected groups must be involved in the planning as well as in the implementation of projects.

- Although careers have been the driving force behind most of the special programming in science, mathematics, and engineering education for minorities and females, there is good reason to believe that literacy can also serve as the focus for intervention.

- Intervention programs must begin early and must be long-term in nature; "one-time" or short-term efforts do have a place for motivational, informational, supplemental, or transitional purposes.

Research on cognition is needed to determine the most effective teaching styles for various groups of students. Research has shown some differences in male and female learning styles. There has been very little study of language minorities or the effects of cultural differences on learning styles.

Teachers are the key to quality and equity in science and mathematics education, and programs for their training and retraining should reflect both these concerns. Some persons expressed doubt that the shortage of qualified mathematics and science teachers was shared equally by all school systems and called for data collection in order to determine this for urban, suburban, and rural schools.

Parents must be involved in programs targeted for minority, female, and disabled youth. Their potentially positive impact on their children's decision-making with regard to courses and careers cannot be overstated.

Many programs previously supported by the National Science Foundation (both targeted and nontargeted efforts, such as Resource Centers for Science and Engineering and Student Science Training Programs) contained elements supportive of the movement of minorities and young women toward science and mathematics.

More support is needed for dissemination of information about successful programs or replication of effective models.

The current system of education in the sciences and mathematics has failed minority, female, and disabled students as well as a large number of white males. More work needs to be done to test methods shown to be effective with minority, female, and handicapped students on other student populations poorly educated or motivated in science and mathematics.

The Executive Summary of this report also appears in Educating Americans for the 21st Century: A plan of action for improving mathematics, science and technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995, Sourcebook, The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, September 1983.

INTRODUCTION

Education in the Sciences for Minorities and Women

Minorities and women are greatly underrepresented among the populations of scientists and engineers in the United States. In 1978, women, who make up 51% of the population, made up slightly less than 10% of the science and engineering work force, and racial and ethnic minorities, who comprise nearly 20% of the population, made up less than 5% of this work force. (Asian Americans, less than 20% of the population, comprise over 2% of the science and engineering work force.) If these statistics are confined to minority groups that are underrepresented in science and engineering--American Indians, Blacks, Mexican Americans, and Puerto Ricans, who constitute 18% of the population—the numbers amount to about 2% of the science and engineering work force. Although these statistics are disturbing, they still do not indicate the wide differences in participation rates in various scientific and engineering fields.

The patterns of underrepresentation of minorities and women differ for different fields. For example, in 1981 the percentages of bachelor's, master's, and Ph.D.'s received by women were 24.6, 20.5 and 12 in the physical sciences; 11, 8, and 4.1 in engineering; 42.8, 34.1, and 15.7 in mathematics; almost 44, 38.9, and 28.3 in the biological sciences; and 50.2, 45.8, and 35 in the social sciences.[1]

These percentages represent steady improvement since 1970, especially in the so-called hard sciences and engineering. For instance, in 1970 women received only 0.8% of bachelor's, about 1% of master's, and less than 0.6% of Ph.D.'s in engineering. This substantial progress in the past 10 years reflects a number of social and educational changes: revised perceptions of careers for women, educational equity legislation, and special efforts to introduce young women to possible careers in science and engineering early enough so that they can choose these majors in college. But although the progress of women over the past decade has been dramatic, the numbers remain far short of women's 51% representation in the population as a whole.

Blacks represent approximately 12% of the U.S. population. In 1981 the percentages of bachelor's, master's, and Ph.D. degrees received by Blacks were 3.78, 2.05, and 1.02 in the physical sciences; 5.27, 2.61, and 1.24 in mathematics; 5.2, 1.69, and 0.40 in computer specialties; 3.27, 1.59, and 0.94 in engineering; 4.07, 2.44, and 1.65 in the life sciences; 8.10, 5.30, and 3.93 in psychology; and 8.08, 5.16, and 3.21 in the social sciences.[2]

The striking difference in distribution among scientific and engineering fields by Blacks is further illustrated by the following data. While the social and behavioral sciences constituted 42.7% of all bachelor's, 34.2% of all master's, and 34.6% of all Ph.D. science and engineering degrees for the U.S. population as a whole. for Blacks these figures were 60.8, 58.1 and 59.8% respectively.

Hispanics are approximately 6.5% of the U.S. population. In 1981 the percentages of bachelor's, master's, and Ph.D.'s received by Hispanics were 1.69, 1.05, and 0.7 in the physical sciences; 1.67, 1.56, and 0.82 in mathematics; 2.00, 1.45, and 0 in computer specialties; 1.91, 1.70, and 0.90 in engineering; 2.14, 1.32, and 1.13 in the life sciences; 3.20, 2.24, and 2.20 in psychology; and 2.87, 2.35, and 1.67 in the social sciences.[3]

Data on American Indians are unreliable, but there is every indication that their participation rates are as bad as, if not worse than, those for Blacks and Hispanics.

The underrepresentation of minorities and women in science and engineering fields is a reflection of the quality and quantity of their precollege education. But while American Indian, Black, and Hispanic males and all women share the problem of access to these fields, the nature and manifestation of the problem, and the programs and strategies designed to address it, have differed for the various groups. Any study that attempts to determine what approach is successful (and why) must deal directly with this fact. The type of career information available, presence of role models, and motivation are also significant factors.

Clearly, quality education in the sciences, mathematics, and technology is important for minorities and women because it determines their participation in the science and engineering work force. It is equally important because of this country's need for a scientifically and technologically literate citizenry. All students must be given a solid grounding in science, mathematics, and technology in order to participate fully in our increasingly technological society. More than 62% of these students are members of minority groups and/or women. When it is recognized that they are the majority both of the voting electorate and of the "scientifically illiterate," the need for immediate attention to the scientific, mathematical, and technical education of minorities and women is evident.

Quantity of Precollege Education

A recent study of high school seniors by the National Center for Education Statistics (NCES) found that roughly equal percentages of males and females reported taking at least one year of mathematics (94% and 92%, respectively) and science courses (91% and 89%, respectively). Only 28% of females and 40% of males reported taking three years or more of mathematics, and only 19% of females and 27% of males reported taking three years or more of science. The numbers are discouraging overall when compared to high school preparation in other countries. Few young women take the specific science and mathematics courses in high school that they would need to become science, mathematics, or engineering majors in college or even to be trained for employment in a number of areas both traditional (e.g., word processing) and non-traditional (e.g., skilled trades).

The NCES study, showed that 33% of White students, 35% of Black students, 27% of Hispanic students, and 22% of American Indian students report taking three years or more of mathematics in high school; the corresponding numbers are 23%, 19%, 14% and 12% reporting three years or more of science. While we lack data on which courses comprise the "three or more years" of mathematics taken by minority students, it is evident from Table 1 that few are taking college preparatory courses in mathematics and science or are acquiring the level of literacy in these areas needed for many other jobs.

Quality of Precollege Education

The formation of the NSB Commission on Precollege Education in Mathematics, Science and Technology reflected concern about the state of education in the sciences in this country. Indicators of a decline in quality affecting all students include inadequate facilities, lack of laboratories and instrumentation, declining numbers of qualified teachers, reduced offerings of advanced classes, increased numbers of remedial classes, lack of in-service training opportunities for teachers, curricula that have not

TABLE 1. Percentages of High School Seniors Taking Specific Mathematics and Science Courses in 1980*

Course	All seniors	Male	Female
Algebra I	79	79	79
Algebra II	49	51	47
Geometry	56	8	55
Trigonometry	26	30	22
Calculus	8	10	6
Physics	19	26	14
Chemistry	37	39	35

Course	Hispanic	Black	White	American Indian
Algebra I	67	68	81	61
Algebra II	38	39	50	32
Geometry	39	38	60	34
Trigonometry	15	15	27	17
Calculus	4	5	8	5
Physics	15	19	20	17
Chemistry	26	28	39	24

*(From NCES, High School and Beyond.[4]

kept pace with new technologies or the progress of science, and poor counseling. The educational system has traditionally provided poorer training and even less motivation for minority and female students. Participation of these students in science and mathematics is not encouraged and is even discouraged by the expectations and attitudes of teachers, differential access to instrumentation and educational technologies, and counseling away from science and technical careers. Minority and female students who are interested in science and engineering are often ignored but more often dissuaded from their interests.

Examples of educational inequities abound:

- American University researchers Myra Sadker and David Sadker reported that even in the earliest elementary grades, male and female students experienced different reactions from teachers supportive of male students', but not necessarily of female students', later participation in science and mathematics.

- National Assessment scores in mathematics and the sciences have been lower for female and minority students than for white males, although performance levels of 9- and 13-year-old females approach parity with those of males (see page 22) and minority performance has improved significantly in areas where there are compensatory education programs.

- Black, Hispanic, and American Indian high school students take significantly more remedial classes in mathematics and significantly fewer advanced classes in mathematics than their white counterparts.

- Some current research suggests that not all student populations have equal access to computers. Even where available, computers are often used for drill and practice for minority students, and for programming courses for majority students.[5] Teachers have observed that female students are often pushed away from terminals by more aggressive male students.

INTERVENTION PROGRAMS

Over the years, so-called special programs have been developed and implemented to improve the quality and quantity of science and mathematics education for women and minorities. These efforts were driven largely by the civil rights movements of these groups and the response to these movements by government, academia, the professions, and industry.

Except in a few instances these were not national efforts but local initiatives reflecting locally identified needs and drawing heavily, though not exclusively, on local resources. Program development was based largely on trial and error, the experience of educators of such students, and "gut reaction." Little research was available on how minority or female students learn science and mathematics and how this might differ from the way majority male students learn these subjects.

Although women, like minorities, had limited access to scientific careers, the barriers they faced were quite different, reflecting the larger societal view of suitable roles for women. Local intervention programs for women might not have been so successful without a larger movement for women's rights and access. But the larger movement alone would never have moved as many women into science and mathematics.

The Women in Science Program of the National Science Foundation (NSF) was a primary source of support for women's intervention programs, funding 136 projects between 1976 and 1981. The Women's Educational Equity Act program established in 1974 at the Department of Education, though not specifically directed at science, has funded several science-related projects. Five sets of science and math publications are listed among the products available from WEEA-funded projects.

Early in the development of women's intervention programs, the need for documentation of results was recognized. These programs quickly became associated with research on the way in which mathematics and science are learned. There was a constant feedback in this: research influenced intervention, and intervention suggested new research questions. These research efforts became part of a larger educational research focus, and results were published and presented at national meetings, including forums sponsored by the National Institute of Education and the National Academy of Sciences.

American Indian, Black, Mexican American, and Puerto Rican populations each faced quite different barriers, related to their economic and social conditions in general. Federal programs to address the disparity between the proportion of minorities in the total labor force and their numbers in the scientific labor force were largely directed at the college level. However, these groups required major interventions specific to the populations at the precollege level, since the schools that served them often lacked the most basic of science programs, reflecting society's expectation that they would likely have little to contribute in science and technology. Precollege interventions were later in coming and were often grassroots efforts.

This was the context in which intervention programs for women and minorities were developed. What is there about these programs that makes them work? What specific elements contribute to their success? In this project we have attempted to answer these questions. We are ready to make recommendations to the NSB Commission which reflect years of accumulated program experience in working with women and

minorities and which are appropriate to the various underrepresented groups. In addition, we know that the many programs undertaken to move minorities and women into scientific and engineering careers provide some direction for the general improvement of education in the sciences and mathematics for all persons.

Exemplariness

If we consider exemplary programs as those worthy of imitation, clearly a prime criterion for judging a program's success should be whether it has been copied. The programs we selected for review are considered special by those who know and run programs. This does not mean they are without problems, only that they address a felt need and meet their educational objectives. Programs are almost never transferred exactly— they are adapted to the resources and problems of each particular community. Sometimes this results in improvements on the model which can be fed back into the network of persons running similar projects.

For example, although a career-day model for women in science and engineering may be fairly standard in its format (career information presented by role models, questions and answers, followed by demonstrations in the laboratory), it may take different forms with a population of young Mormon women in Utah, young Black women in Alabama, or young suburban women in Bloomfield Hills, Michigan. We are aware of specific programs such as these. The format is even the subject of an NSF-supported guide which was prepared by the director of math and science education for women at the Lawrence Hall of Science in Berkeley, and which reflects the accumulated experience of program developers.[6]

Criteria that we used to assess the exemplariness of special programs included:

1. Achievement of primary goals as measured by staff, participants or external evaluation;
2. Length of time of program operation;
3. Ease in attracting outside support;
4. Ratio of project applicants to project participants (program popularity);
5. Reputation of program with area scientists from affected groups;
6. Program "imitation" or internal expansion; and
7. Cost effectiveness.

Plan of Work

Drawing on previous inventories of mathematics, science, and engineering programs for women and minorities developed by the AAAS Office of Opportunities in Science and other projects, we compiled a list of precollege intervention programs for these groups. We asked the directors of the programs to update the information we had. By mid-June some 110 surveys, representing about 24% of these projects, had been returned. Follow-up letters were sent to the remaining projects to encourage return of the survey. We eventually had a better than 50% return rate, and project information continues to come in. The data from forms received by July 20, 1983 are summarized on the following pages.

External consultants and staff visited more than 50 exemplary projects across the United States ...uding northern and southern California, Colorado, Arizona, New

Mexico, Texas, Michigan, Wisconsin, Illinois, Georgia, New York, Pennsylvania, and the District of Columbia. Among these were special projects in museums and universities, specially developed external consortia, and programs of professional societies and schools (both magnet schools and those with advanced placement programs in science), which have a good record in educating minority and/or female students.

Early in the study we identified a need to look at the growing number of camps that offer academic programs in science and computing. With the aid of the American Camping Association, we obtained the names of a number of such camps and asked them to provide information about the nature of their programs and of the youth that they serve. We received 19 replies from 78 camps surveyed, a response rate of 24.4%. The summary information from the camp survey is contained in Appendix B.

On July 25 and 26, we assembled a meeting of project staff, consultants, and directors of projects (half site-visited and half not site-visited). The findings presented below represent a synthesis of these activities, and incorporate results from other relevant research. A detailed work plan is given in Appendix A.

PRECOLLEGE PROGRAMS IN SCIENCE, MATHEMATICS, AND ENGINEERING FOR WOMEN AND MINORITY STUDENTS: Tabulation of Mail Questionnaires

The results below are based on tabulations of questionnaires received from 54 women's projects, 95 minority projects, and 18 "general" projects (those which targeted both groups, or were for the general population but had some special features relevant for these groups). The three minority women's projects for which we have forms are not included. The topics appear in roughly the order of the data on the forms; a copy of the questionnaire is appended.

Projects discussed here may or may not be exemplary according to the criteria outlined in the report. Indeed, the features of this larger sample sometimes present an instructive contrast to the smaller group of exemplary projects on matters such as involving parents in intervention efforts.

The rate of return questionnaires was approximately 50 percent. Non-respondents differed from respondents on at least two points. First, a lower proportion of women's contacts than minority contacts replied. Second, there were fewer responses from contacts at state and private universities than from those at other sites.

Institutions That Housed Projects. Universities and museums or research centers provided homes for a majority of the projects. In Table 2, museums, science centers, research institutes, and science institutes are in the same category because many organizations, such as the Lawrence Hall of Science, perform more than one of these functions. However, there is no double counting: Lawrence is not also counted as a state university, and Math/Science Resource Center is not also counted as a women's college. For the minority projects, the high number of state universities reflects the placement of NSF-funded Resource Centers there.

TABLE 2. **Institutions That Housed Projects**

	General		Women		Minority	
	No.	%	No.	%	No.	%
Private university	5	27.8	6	11.1	12	12.5
State university	6	33.3	12	22.2	48	50.0
Women's college	0	0.0	3	5.6	0	0.0
State college	0	0.0	1	1.9	0	0.0
Private coed college	0	0.0	1	1.9	3	3.1
State junior college	0	0.0	4	7.4	1	1.0
Precollege school system	1	5.6	3	5.6	4	4.2
Museums and science centers	4	22.2	18	33.3	20	20.8
Business and industry	1	5.6	1	1.9	2	2.1
Scientific society	1	5.6	5	9.3	5	5.2
Indian reservation	0	0.0	0	0.0	1	1.0
Total	18	100.1	54	100.2	96	99.9

Location. Figure 1 is a map indicating the geographic distribution of projects. The data points are entered to indicate states, not cities; the letters show categories of projects and the numerals the number of projects in that category in the state. Since many projects are nationwide in scope, one cannot infer geographic balance (or lack thereof) by glancing at a map such as this. However, the scant representation in the plains, Rocky Mountain, northern New England, and Southern border states raises questions about the coverage of rural areas by projects for minority and female students.

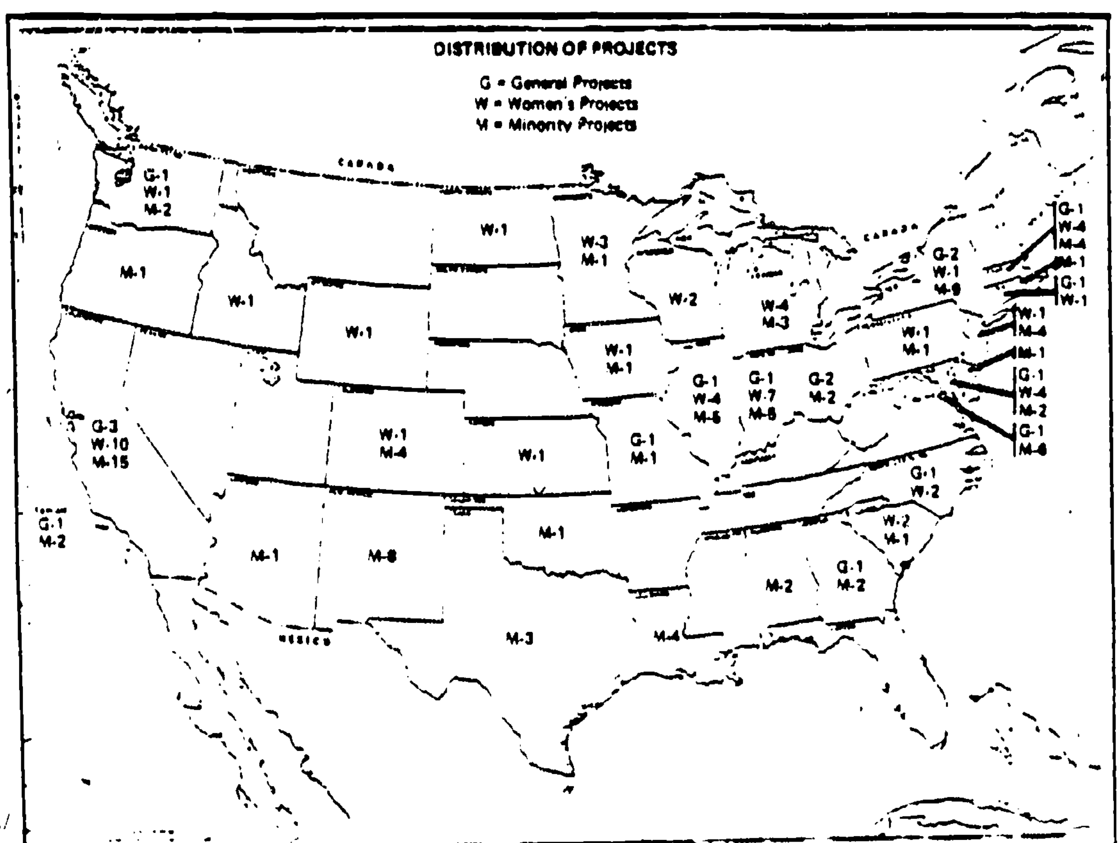

Fig. 1. Location of projects for minority and female students

Chronology

At the time of the survey, most projects were still running - 14 (77.8%) of the general projects, 35 (64.8%) of the women's projects, and 85 (89.5%) of the minority projects. Many of those that have ended had a finite task, such as producing curriculum materials, but are still actively distributing the results of their program. Other projects that have stopped could not find funding to continue and intend to resume operations if money is obtained. Table 3 shows the distribution of starting dates of projects. Note that minority projects started sooner than women's projects, and that both kinds of projects followed the start of their respective civil rights movements by a number of years.

TABLE 3. Starting Dates of Projects

Dates	General	Women	Minority
1965 - 1969	1	0	8
1970 - 1974	3	6	11
1975 - 1979	8	27	37
1980 - 1984	6	22	35

Scientific Disciplines Covered

Most projects addressed mathematics and engineering, with the physical and biological sciences not far behind. Only the social and behavioral sciences were thinly covered, perhaps because job opportunities are less promising in those fields or because of a belief that women and minority students already go into those specialties in sufficient numbers. For the "other" category of fields on the questionnaire, ten minority projects (10.5%) wrote in some kind of communications skills (reading, writing, English). During the project directors' conference held in conjunction with this report, it was agreed that the teaching of communications skills is valuable, but the participants stressed that these skills must be taught with scientific or technical topics. The disciplines covered are outlined in Table 4.

TABLE 4. Scientific Disciplines Covered by Projects*

	General		Women		Minority	
	No.	%	No.	%	No.	%
Mathematics	9	50.0	38	70.4	72	75.8
Earth and Astronomical Sciences	8	44.4	25	46.3	29	30.5
Physics	10	55.5	28	51.9	65	68.4
Chemistry	8	44.4	28	51.9	65	68.4
Biological and Medical Sciences	7	38.9	27	50.0	39	41.1
Social and Behavioral Sciences	2	11.1	19	35.2	6	6.3
Engineering	8	44.4	32	59.3	61	64.2

*The percentages here add up to more than 100 because most projects covered more than one discipline.

Eight (44.4%) of the general, twenty-two (42.3%) of the women's, and seventy-one (74.7%) of the minority projects gave participants "hands-on" experience with computers. Fourteen (77.8%) of the general, thirty-two (60.4%) of the women's, and eighty-four (88.4%) of the minority projects gave the participants other hands-on experience, involving laboratories and field trips. Elizabeth Stage, program evaluator at Lawrence Hall of Science, and others have identified a potential future problem with women in computer fields if girls are not given early access to computer hardware. The relatively low incidence of computers in the women's projects may be of some concern to those who work in the field. It may be due to the fact that many women's projects are one-day workshops designed to impart career information, where it is difficult to make computer experience part of the program. At the project directors' conference it was suggested that these brief programs can incorporate computers if they are held at a site where existing facilities can be borrowed for a few hours.

School Grade Levels

Table 5 shows the number of projects that reached different school levels and adult groups concerned with schoolchildren. It is surprising how few targeted parents; the project directors who met in conjunction with this report thought that parent and community involvement was so important as to be an indication of an exemplary project.

TABLE 5. Precollege Grade Levels and Adults Reached by Projects

Level of group	General	Women	Minority
Elementary school	6	16	13
Junior high school	8	26	36
Senior high school	12	46	79
Teachers and Counselors	8	26	45
Administrators	2	12	15
Parents	2	15	22

Since Table 5 counts projects that overlapped levels, it may be useful to have information on how many projects were devoted exclusively to one level of schooling. This information is given in Table 6, which includes projects that may also have reached adult populations concerned with each level. The numbers suggest a relative paucity of efforts at the elementary and junior high levels for both minority and female students. The large number of high school projects includes "bridge" programs for graduating high school seniors to give them a head start on freshman college work, as well as programs run by colleges to recruit female and minority high school students as science and engineering majors.

TABLE 6. Projects Devoted to Only One Level of Schooling

	General		Women		Minority	
	No.	%	No.	%	No.	%
Elementary school only	1	5.5	2	5.5	6	6.3
Junior high school only	1	5.5	3	5.5	6	6.3
Senior high school only	7	38.9	23	42.6	48	50.5

Numbers and Diversity of Participants

Data on the gender and ethnicity of the students and adults who took part in projects are very poor. Many respondents left part or all of this question blank because they did not gather evidence on the populations involved in the program. Most often skipped were the questions involving adult population, where the wording may have puzzled the project directors (we were seeking the numbers of teachers, counselors, parents, and so on, not the number of students over 21 years of age). About one-fifth of the projects provided usable data on adult participants, too few for tabulation here.

Table 7 shows the student population in minority projects. Contrary to the belief of some, minority projects succeed in enrolling high proportions of female students. The low number of projects covering Puerto Rican students can be accounted for in part by the fact that questionnaires from the Puerto Rican Resource Center had not arrived in time for tabulation.

TABLE 7. Gender and Ethnicity of Students in Minority Projects

	Number of Projects						
Percent of students in ethnic group	American Indian	Black American	Mexican American	Puerto Rican	Asian-Pacific	Percent of female students in minority projects	Number of projects
0.0 - 9.9	58	9	45	56	53	0.0 - 9.9	0
10.0 - 19.9	3	1	4	2	2	10.0 - 19.9	0
20.0 - 29.9	1	2	1	0	4	20.0 - 29.9	3
30.0 - 39.9	1	2	3	0	1	30.0 - 39.9	6
40.0 - 49.9	0	2	2	2	1	40.0 - 49.9	15
50.0 - 59.0	0	6	0	1	0	50.0 - 59.0	31
60.0 - 69.9	0	8	3	0	1	60.0 - 69.9	8
70.0 - 79.9	0	8	1	0	0	70.0 - 79.9	1
80.0 - 89.9	0	6	0	0	0	80.0 - 89.9	1
90.0 -100.0	4	21	0	0	0	90.0 -100.0	0

Only 14 (25.9%) of the women's projects provided data on numbers of minority women students in their program. Of these, four reported no minority female students, five reported less than 10%, two reported 10% to 20%, and three reported more than 20%. These data suggest that minority women are underrepresented in projects designed for all women, especially since many of the projects reporting these data were in locations with significant minority populations.

Disabled Participants

The answers to this question are disheartening. Only three (16.7%) of the general, sixteen (29.6%) of the women's, and fifteen (15.8%) of the minority projects said they had any physically handicapped participants in their program. The numbers of disabled students were very low in the projects that knew how many they had. The director of one Saturday program with a great many computers, on being asked what arrangements he had made for blind students, said, "None; I only deal with one problem (being minority) at a time." (Unfortunately, female disabled and minority disabled children do not have the option of separating their problems.)

Funding

Only two general projects, eight women's projects, and six minority projects said they had no funding from their sponsoring institution. For outside funding, the projects drew on a wide variety of sources, as shown in Table 8. Women's projects depended more on student fees than did minority projects. Foundations supported a higher proportion of minority than women's projects, while the Department of Education supported more women's projects, due in part to the Women's Educational Equity Act. Federal support for minority projects outside Education and the NSF was greater for minority than for women's projects; the agencies in this category included the Department of Energy, the Department of Health and Human Services, NASA, and various branches of the military. The data on funding by state agencies led to a lively discussion at the project directors' conference. Two California projects represented at the meeting had obtained state money to continue their work, and the director of one of them urged others to seek funds from the states. A director from the Southwest reported trying and failing twice to get state support, but he was going after the source a third time. Directors from the Southeast, especially those with projects headquartered at traditionally Black colleges, were skeptical of the possibility of persuading state agencies to underwrite their programs. Seven (38.9%) of the general projects, eighteen (33.3%) of the women's projects, and forty-six (48.4%) of the minority projects reported that their funding sources had changed over time.

TABLE 8. Sources of Outside Funding for Projects*

	General		Women's		Minority	
	No.	%	No.	%	No.	%
Women's Education Equity Act	0	0.0	6	11.1	0	0.0
Other U.S. Department of Education	3	16.7	5	9.3	2	2.1
National Science Foundation	5	27.7	9	16.7	20	21.1
Other federal sources	1	5.5	0	0.0	18	18.9
State agencies	2	11.1	3	5.6	6	6.4
Schools	2	11.1	2	3.7	7	7.4
Student fees	3	16.7	11	20.4	3	3.2
Foundations	5	27.7	19	35.2	32	33.7
Industry	5	27.7	19	35.2	46	48.4
Scientific societies	1	5.5	4	7.4	6	6.4

*The percentages here add up to more than 100 because projects often had more than one source of funding.

Project Publications

Six (33.3%) of the general, seventeen (31.5%) of the women's, and forty-six (48.4%) of the minority projects reported that part or all of their program had become "mainstreamed" or institutionalized into their regular curriculum or business, becoming available to the entire population served by the sponsor. Some of these are intriguing case studies which are mentioned elsewhere in this report. The projects compiled an impressive record of tangible products from their work. Eight of the general projects, sixteen of the women's, and thirty four of the minority projects created media products (videotapes, films, and slide shows). Only three general projects, twelve women's projects, and twenty-three minority projects indicated they had issued no publications. For those who published, the record is as shown in Table 9.

TABLE 9. Publications of Projects

Type of publication*	General	Women's	Minority
Books, manuals, workbooks	4	7	10
Articles in journals	2	8	15
Reports (including evaluation)	9	10	40
Brochures and pamphlets	5	5	18

*Several projects also issued newsletters.

WHAT WE HAVE LEARNED: A SYNTHESIS

By using a number of different study methods, we have gained insight into (1) the range of programs offered to improve the precollege education of women and minorities in m matics, science and technology and (2) the inner workings of a sample of such pro s. The following represents a synthesis of this information.

Th ature of Exemplary Programs

  and Objectives. Most of the programs identified have at their core the movem nt of the target group(s) into careers based on mathematics, engineering and science or into employment opportunities that depend on having skills in these fields. This is opposed to programs with a primary focus on literacy. Perhaps this reflects the fact that most programs focused on students at or above the junior high school level, where careers start to be important, as opposed to younger populations.

The long- and short-term goals of the truly exemplary programs are well articulated. They are expressed in terms of the needs of the populations to be served. The best of these programs measure movement toward these goals as a way of achieving accountability and of determining which parts of programs should be changed.

Target Populations. Programs primarily for minorities seem to do a better job at including minority females than do programs primarily aimed at women. This appears to be less true for Mexican American populations than for Black and Puerto Rican populations. Disabled participants are conspicuous by their absence from these targeted efforts. Most programs serve an audience that consists of more than one group (e.g., students and teachers, Blacks and Puerto Ricans, Mexican American males and females) and tailor some aspect of programming accordingly (e.g., different hand-outs for teachers and students, availability of brochures in Spanish, use of female and male role models). Although programs have a target population or populations, they are usually not "exclusive." White males have been participants in many such efforts. Students from low-income families, regardless of race, are often included in programs.

Program Structure. Programs are either school-based or non-school-based. School-based programs include special schools, magnet schools, and special enrichment programs external to school but residing in it, such as clubs. Sometimes school-based and non-school-based programs overlap (e.g., MESA and PRIME). There are often multiple precollege programs in a given locale, with the elements of one complementing those of another (or a precollege and college program). Programs range from long-term (where students are with the program from junior high until graduation from 12th grade) to short-term, one-time efforts. All have a role that depends on the audience, location, and problems to be addressed.

The greater the investment in the student (long-term program) the greater is the likelihood of rigorous selection criteria that include not only interest but also demonstrated performance in some courses or on some examination. Long-term programs often require the student (and the parents) to make a commitment to "hard work" and regular attendance, for example, by requiring that a pledge or contract be signed and adhered to and by making the student subject to expulsion. Long-term programs usually include substantial academic components -- mathematics, a science, and communications, with opportunities for extensive hands-on experience--as well as tours, visits by minority and women scientists and engineers, and information on careers, on

test taking, or on financial aid. They tend to be integrative (the same topic may be used to stress science, mathematics, applications, writing, and speaking skills). The focus is on higher-level cognitive skills related to problem solving, understanding, and applications. The science and mathematics components are the subject of the communications component, as opposed to simple drill and practice or exercises in grammar.

Long-term programs usually end up involving the schools (teachers, counselors and sometimes administrators) to affect the overall learning environment of the targeted students. Training for teachers and counselors includes the relevance of science and mathematics to life's work and careers in science and engineering. Teacher training is also often focused on subject matter competence and teaching techniques.

Short-term projects usually focus on providing career information or course information relevant to careers to students, teachers, and/or parents. This information is often conveyed by role models. There is sometimes an opportunity for limited hands-on activities and demonstrations. These programs are most effective when other systems are present in the community after the intervention program has been completed to support the students' information and educational needs.

Intervention programs for women and minorities provide enrichment rather than remediation (or at least move rapidly toward this trend). A problem or a project rather than drill becomes the key, with as much attention to the process of science as to the accumulated body of knowledge.

In summary, the characteristics of exemplary academic-based programs are as follows:

1. Strong academic component in mathematics, science, and communications focused on enrichment rather than remediation;

2. Academic subjects taught by teachers who are highly competent in the subject matter and believe that students can learn the materials;

3. Heavy emphasis on the applications of science and mathematics, and on careers in these fields;

4. Integrative approach to teaching that incorporates all subject areas, hands-on opportunities, and computers;

5. Multiyear involvement with students;

6. Strong director and committed and stable (low turnover) staff who share program goals;

7. Stable, long-term funding base with multiple funding sources (so that staff do not spend most of their time hunting for money);

8. Recruitment of participants from all relevant target populations in an area;

9. University, industry, school, etc. cooperative program;

10. Opportunities for in-school and out-of-school learning experiences;

11. Parental involvement and development of base of community support;

12. Specific attention to removing educational inequities related to gender and race;

13. Involvement of professionals and staff who look like the target population;

14. Development of peer support systems (involvement of a "critical mass" of any particular kind of student);

15. Evaluation, long-term follow-up, and careful data collection; and

16. "Mainstreaming"—integration of program elements supportive of women and minorities into the institutional programs.

Schools

Special Schools. It is important to remember some history when one focuses on the special science high school as an intervention model. Such a school, unless it is fairly new, has probably at some time in its history been designated as "all boys" or carries a legacy born of past sex discrimination and low minority enrollment. This is true of some of the most famous of the special science schools such as Bronx High School of Science in New York. Although their alumni are quick to point out that there were corresponding "all girls" high schools, the emphasis on math, science, and engineering and the resources devoted to these areas were considerably less in the girls' than in the boys' schools. In more recently developed special schools, populations have usually been carefully constructed to reflect the general population of the area that the school is intended to serve.

It is likely that in the long run such schools, usually at the high school level, will be much more important to majority females than to minorities of either sex. Since admission to such schools is usually by examination, early deficiences that limit minority students' performance limit their access to special school programs, unless they are located in cities where minorities are the majority of the school population and criteria in addition to examinations are factored into selection.

Magnet Schools. Another bit of history that bears repeating is the relationship of the educational concept of the magnet school to the sociopolitical goal of school desegregation. Such schools, which offered high-powered instruction in attractive, status fields, were usually placed in minority neighborhoods to lure students (usually White) from wherever they lived to wherever the school was, often the ghetto or barrio. The magnet school, because the students must choose it, stresses motivation and interest as opposed to proved academic competence. Unfortunately, many such schools have become both successful and overwhelmingly White in the absence of policies to stop student inflow when the school populations mirror those of the larger district and to strongly recruit minority students. Where this broader view is taken, magnet schools can be much more significant in the education of minority students in science than special schools at this time. The quality of the science, mathematics and technology education at many of these institutions testifies to the fact that excellence and equity can and do share the same program. These schools have usually had the benefit of federal funds granted to states expressly for the purpose of assisting in desegregation. It is not clear, therefore, whether state or local resources alone would be sufficient

to replicate models of the magnet school concept. On the other hand, since the targeted schools have usually been particularly disadvantaged, less capital expenditure (in terms of start-up costs) might be needed to implement programs in schools that have not been so severely disadvantaged.

Hybrids. Several programs use the concept of the independent club or program (especially in minority schools) as a motivational tool. But getting into the program and staying may depend on academic performance in a certain number and type of courses. A science or mathematics teacher is often the sponsor, and may or may not receive additional compensation for his or her involvement. The program or club is highly selective and participation conveys status in addition to responsibilities and "perks." The presence of such a program or club changes the character of the school, since it guarantees a cadre of highly motivated, able students who will populate upper level science and mathematics courses. It focuses attention on academics, and makes other students wish to join. Benefits of projects organized by club or program members often accrue to the entire school. Thus, the entire learning environment in the institution may be affected.

Mainstreaming equity. Sometimes one will find a "regular" high school with a good record of providing quality education in science and mathematics to females and males or to minorities and non-minorities alike. Institutions that provide quality education in science and mathematics to males and females alike have been studied in some detail by Casserly.[7] She has found the following characteristics of such schools: large amounts of informal interaction regarding students among a cohesive staff, provision of extensive hands-on activities, teacher concern with and communication of information on careers to both the students and their parents, and multiple learning experiences. Such characteristics were noted in schools that were visited in this study where equity in participation in science classes had been achieved. In addition, extracurricular opportunities in science, clearly stated equity goals, measurement of the achievement of those goals, and commitment from department leadership and faculty were evident.

Curriculum and Teaching

Most of the exemplary programs and school curricula in science and mathematics stressed utility and practical applications rather than heavy reliance on theory. Hands-on, laboratory- and activity-oriented are accurate descriptions of most programs. The glaring exception to this statement is the SEED model of William Johntz, where a trademark of the program is demonstrating minority students performing highly theoretical mathematical manipulations with little focus on applications. This type of program shows that with an extremely competent and knowledgeable instructor (usually a scientist or mathematician in the case of the SEED model) such performance is attainable. Other "Socratic", discovery learning programs used successfully with minority students depart from the Johntz model and teach teachers who are not scientists or mathematicians to incorporate these pedagogical styles into their work. Again, most models focus on applications and real-life problems; many incorporate the interests, concerns, and problems of the targeted group. The careers stressed to the target groups often reflect this curriculum style; for instance, the emphasis is on physician, engineer, and health professional rather than research scientist. Based on data from the National Assessment of Educational Progress (NAEP) on the mathematics performance of minorities and women, these are the correct skills to stress, since the lowest achievement scores were in the higher cognitive areas of "understanding" and "applications."[8]

Teachers and teacher training. One cannot understate the importance of the teacher, particularly to minority and female students. A hallmark of exemplary programs has been that the academic components were delivered by persons who were both competent in the subject matter and confident of the students' ability to learn. Programs for women and minorities, particularly long-term intervention programs, offered a range of training models for teachers. Examples were:

1. Science teaching by a team of scientists and engineers from industry as well as by teachers, with instruction provided by the professional and follow-up provided by the classroom teacher. The teacher is enabled to provide this follow-up by involvement in the instruction, on-site teacher training, or summer training programs.

2. The creation of the master teacher--a strong classroom manager who achieves subject competence through summer classroom and laboratory experiences, academic year research projects, and development of activities to be used in the classroom. This person is usually charged with returning to his or her school and serving as a resource person.

Counselors and counselor training. Many of the programs try to influence the counselors by giving them information on careers in science and engineering or careers in which science and mathematics are used. By exposing counselors to information on careers, minority and women scientists and engineers, and college programs, projects have attempted to remove their negative-gatekeeper influence.

Parents

The exemplary programs of science, mathematics, and technology that worked with females and minorities sought to involve parents in some fashion, at least as advocates, monitors, or facilitators of their children's participation in the program. Parents had to pledge to monitor attendance, provide time for the student to do homework, and provide or arrange transportation for weekend activities. Many parents served as chaperones on tours or field trips. In several cases parents received information about the program through a newsletter; in one case parent volunteers even produced the newsletter for parents. Parents must at least actively consent, and they must be considered in the recruitment process. In cultures where the movement of young females is greatly restricted and controlled by the parents (e.g., Mexican American girls), parents' advocacy and participation are essential. Some programs are looking at the parents as possible reinforcers of career or achievement goals. "Expanding Your Horizons"--career information workshops for young women--provided carefully constructed separate programming for the parents and/or teachers who might have accompanied the students. Often the parents were given an opportunity to "play around" with microcomputers while the young women were left unrestrained to ask questions about life as a scientist or engineer (even ones that might not be considered polite, such as "How much do you make?"). Lawrence Hall of Science, as part of its program for minorities and women in science, has developed a program called Family Math, which actively involves parents by showing them how they can help teach mathematics to their children.

Museums

As suggested above, some museums have been quite instrumental in providing innovative programs in science, mathematics, and technology for women and minorities.

Over 25% of the projects surveyed were sponsored by museums or research centers, which were second only to universities in such efforts. The focus of these institutions as resources to the communities and schools seems to have stimulated many to look critically at the extent to which they have served all of the community. The development of culture-sensitive exhibits (such as the Smithsonian's "Black Women Against the Odds"), specific programs aimed at girls (such as the Lawrence Hall "Math for Girls"), and hands-on experiments and exhibits for minority students and their teachers (such as those at the Brooklyn Children's Museum) demonstrates an awareness by these institutions of the communities they serve.

Colleges and Universities

Colleges and universities remain the major sponsor of precollege programs in science, mathematics, and technology for women and minorities. Many projects that started out as little more than public relations and recruiting efforts changed to incorporate the goal of intervening early to avoid college level remediation, a costly programmatic and policy decision for any institution.. With this philosophy, the emphasis has been on college-bound students. While such programming has been consistent with the goal of increasing the numbers of women and minorities among scientists, engineers, and biomedical professionals, it has almost never addressed the issue of the scientific and technological literacy of those who are pursuing degrees in nonscientific fields, or of non-college-bound students.

Business and Industry

In at least four cases, industries were the reported sponsors of programs for women and minorities. An example is the Xerox Science Consultants Program, which was identified from the inventory of minority programs published by this office in 1976. Almost 42% of all programs identified industry as a source of funding, but most of that funding is usually specified for program activities (as opposed to salaries for program staff) or involves only small amounts of money. There are excellent examples, especially from some of the minority projects, of the so-called business/industry-university-school cooperative relationship. In the Philadelphia/Camden-based program PRIME and the Rochester PRIS^{2}M program, industry involvement is extensive, from fund raising to providing scientific and engineering personnel to working with teachers in "adopt-a-school" programs. We have learned through such targeted efforts how to make the concept of the cooperative relationship work in concrete terms.

Informal Learning (Television)

The Lawrence Hall EQUALS/SPACES program has an exercise for young school children (kindergarten to 3rd grade) that asks them, "Draw a picture of yourself when you are grown up and at work." The results indicate that little has changed in sex stereotyping in the past four years for this age group. For students in the next age group, concerted attempts have been made to develop a realistic portrayal of scientists and engineers and what they do, to counteract the idea that these are all jobs for white males. Using the medium that may have helped originally to shape the stereotyped message -- television — programs such as "3-2-1 CONTACT" and "SPACES" (a different program from that listed above) were developed expressly to convey information about science and technology, scientists and engineers, and the diversity of persons who work in these fields. The AAAS Office of Opportunities in Science has, over the years,

worked with the production staff of such programs to assist them in locating minority, female, and disabled scientists and engineers who might serve as role models in the programs.

New Technology

The new technology holds much promise for the education of minority, female, and handicapped students. Microcomputers in the classroom are a coming educational phenomenon, but their uses with underserved populations must be carefully monitored. Although many minority schools have computers, one must ask how they are being used-- for drill and practice, or for computer education courses. Research suggests that there have been real performance gains by minority students using computer-assisted instructional techniques[9]. The problem arises when computer-assisted instruction and drill and practice routines are seen as the only appropriate role for the computer in the education of minority students. There is evidence that computers have the potential to stimulate the interest of minority students in science, mathematics, and technology. Most intervention programs for minorities have recognized this fact, and almost 75% of the projects surveyed give such students computing experience. The Third National Mathematics Assessment showed an increase in the number of 17-year old Black students who reported having taken at least 1/2 year of computer courses, from 5.2% in 1978 to 11.3% in 1982. Comparison figures for White students during this time were 4.9% and 9.6%. The figures for females are 4.1% in 1978 and 8.6% in 1982 (5.9% in 1978 and 11.1% in 1982 for males). Female students are not found in computer classes in the same proportion as male students. Some researchers point to problems of simple physical access (they are pushed aside by more aggressive males and become discouraged); others point to psychological access. Some (such as Henry Becker, research scientist at the Center for Social Organization of Schools at Johns Hopkins University) suggest that if computers were used in the lower grades, before they became identified with males, it might be easier to get young women into the classes. Early introduction to computers is often through games, which may unconsciously be aimed at young men. Fewer science and mathematics intervention programs (42.3%) for women than for minorities included computers, which may be a cause of concern for those who work in this area.

Bridges

Programs were identified that spanned the full range of the target population (kindergarten through 12th grade), though less at the early end of the scale. At the upper end are programs for students who have graduated from high school but have yet to enter college, the so-called bridge programs. These programs seek to hone academic skills in mathematics, science, and communications (speaking, writing, listening); provide test taking and study skills; and give an orientation to the campus, its facilities and resources. In a recent study of minorities in engineering programs by the National Action Council on Minorities in Engineering, the presence of a bridge program was one of three elements (and the only precollege matriculation element) closely associated with improved retention of these students. That is, giving students who are entering difficult academic programs "a leg up" seems to increase minority students' chances of successfully completing these college programs. For example, the exemplary bridge program at Spelman College in Atlanta, Georgia, has been supportive of that institution's development as a significant producer of Black women scientists, engineers, and medical professionals.

PROGRAM AUDIENCES

Women and Girls

When the movement toward educational equity for women began, an early problem was the low level of participation by women in mathematics, science, and engineering careers. After sociologist Lucy Sells' work at the University of California, Berkeley, in identifying mathematics as a "critical filter" for women's participation in these fields, attempts were made to remedy this situation. The initial strategy was to encourage young women to take the mathematics courses that are offered at the high school level, so that their career options would remain open. Interestingly, the movement to get women into nontraditional vocational (noncollege) programs also identified deficiencies in mathematics as a major problem. Thus, with the voices of "careerists" and "vocationalists" joined in agreement on this issue, researchers and program implementers set out to devise strategies to affect high school mathematics course-taking by young women.

First, lack of knowledge of the connection between early course-taking and later career decisions was identified as a major problem. Young women needed to know the utility of the courses they were being directed to take. This was addressed through career education workshops to inform students, parents, teachers, and counselors and through attention to mathematics as a filter in books, magazines, films, and film strips, newspapers, and so on. Sex equity programs in the states included mathematics and science among their concerns. The state programs, which resulted from federal enforcement of Title IX (legislation which prohibits discrimination based on sex in education programs receiving federal support), were assisted by a program based in the headquarters of the Council of Chief State School Officers. When Sells made her study of women freshmen at the University of California at Berkeley in 1972, she found that only 8% had completed 4 years of high school mathematics (compared to 57% of males). The effects of the 10-year movement to correct this imbalance are evidenced by the result of the National Assessment of Educational Progress (see Table 11), which show an increase in the enrollment of women in almost all mathematics courses surveyed. Although the level of mathematics courses taken by both 17-year-old males and 17-year-old females is far too low, parity has been achieved in courses through Algebra 2. Trigonometry, precalculus/calculus, and computer courses are the only ones remaining where parity has yet to be reached. There are still differences in performance scores between female and male 17-year-olds (males outperform females), even where course-taking is controlled, but these differences are decreasing. Even more encouraging is the fact that there are few performance differences for 9- and 13-year-olds at all cognitive levels, except that 9-year-old females outperform males on exercises measuring knowledge, a difference that has increased since the 1978 assessment.

Table 11. Changes in Percentages of 17-Year-Old Males and Females Taking Mathematics Courses*

Course	Percentage who have taken at least 1/2 year	
	Males	Females
General or business mathematics		
1978	44.3	46.8
1982	47.3	52.6
Prealgebra		
1978	46.4	45.3
1982	44.3	44.5
Algebra 1		
1978	70.7	73.6
1982	69.4	72.2
Geometry		
1978	52.1	50.5
1982	51.8	51.8
Algebra 2		
1978	37.8	36.1
1982	38.9	38.0
Trigonometry		
1978	14.7	11.1
1982	15.0	12.7
Precalculus/calculus		
1978	4.7	3.1
1982	4.7	3.6
Computer		
1978	5.9	4.1
1982	11.1	8.6

*From The National Assessment of Educational Progress.[10]

The most serious performance differences that remain are on exercises that measure higher cognitive levels such as "understanding" and "application." Researchers have proposed a number of possible explanations for these differences, including greater opportunities for males to obtain hands-on experience outside school, as in hobbies and games; bias in tests toward using examples from male experience; and differences in

classroom treatment and teacher expectations. There is research supporting each of these points. For example, tests are created mainly by psychometricians with the assistance of area specialists (these experts are mostly males). Where test items in science draw on historical figures, they are likely to be males. The effect of such a combination of signals on girls and young women is difficult to assess. Research into the ways in which mathematics and science are learned and taught may reveal the styles that are most supportive of learning by students from different cultural and social backgrounds.

An examination of the patterns of course-taking in science shows that young women more often take courses in the life sciences than in the physical sciences. We found schools in which female and male parity in physics and chemistry classes had been achieved. In those cases parity in enrollments was a stated goal, courses were developed that emphasized practical experience, and teachers were trained to teach in this format. Junior high school boys and girls went to "open houses" with demonstrations in the physical sciences conducted by female and male high school students. The faculty recognized low participation by young women in these classes as a problem, analyzed the nature of the problem, and set out to change the pattern. It is doubtful that efforts to increase physics enrollments for "all" would have achieved this result for young women students.

Disability

Physically disabled persons have a critical need for scientific and technological literacy. For disabled people, knowledge and use of technology affect life itself and are key factors in improving the quality of life. Competence in science and technology opens a wide range of careers to handicapped people. For those who do not choose a career in science, scientific and technological literacy is as significant as it is for other segments of the population. Finally, for disabled people in any work situation, technology and the adaptations available to standard equipment make it possible to hold jobs and become tax-paying citizens.

There is evidence that in some cases handicapped precollege students are being denied physical access to science classes, particularly to science laboratories. Physically disabled high school students are being "counseled out" of laboratory courses because of the misconception of counselors and administrators that they could not function safely in a laboratory or that they never could work in a science setting. This is a violation of the law, and as a practical matter it represents a lack of knowledge, as all aspects of laboratory work have been adapted to make it possible for physically disabled students to participate fully. The science and math teachers who are least confident and competent in their subject matter are probably already so uneasy about their classes that they are unable to deal with the addition of a disabled student who might require some adjustment or adaptation.

The staff of the Office of Opportunities in Science is aware of a number of exemplary programs for physically disabled students. Some examples are:

1. The Student Science Training or SST summer science programs for high school students sponsored by the National Science Foundation at Wallops Island, Virginia, and Marist College, Poughkeepsie, New York. These programs gave disabled students in-depth experience in laboratory and field work, and stressed communication skills about science as well as hands-on experience in a residential setting.

2. The Lawrence Hall of Science development of special materials, Science Activities for the Visually Impaired/Science Enrichment for Learners with Physical Handicaps (SAVI/SELPH), for visually impaired elementary and middle school students. These materials are used in a classroom for all students, including those who are disabled. The Lawrence Hall has also presented an exemplary series of career days in science and mathematics for physically disabled high school students, with wide support from technically based industries in northern California; these career days are particularly significant because of the role-model participation of physically disabled scientists and students from Bay Area universities.

3. The classes for elementary-age students at the Little Rock Museum of History and Science and the California Museum of Science and Industry in Los Angeles. These classes have been successful in including physically disabled students in existing summer and Saturday programs. The emphasis was on recruitment of students and their families, and only minimal adjustments made the programs accessible.

4. The Out of School Programs in Science Project, funded by the National Science Foundation and conducted by the AAAS Project on the Handicapped in Science in 1981. The aim was to give disabled students access to programs that already existed — the NSF SST programs and other programs in science centers. Emphasis was on identification and recruitment of motivated handicapped students through school systems and parent networks, technical assistance to the project directors, and follow-up of the students. All the 11th grade students who participated in the project in 1981 are now attending college. Most of them have chosen scientific and technological fields of study. Publications from this project have been distributed nationally.

Community and youth organizations such as 4-H Clubs, Boy Scouts, Girl Scouts, and Camp Fire International have science, environmental, and health programs that include disabled youth in a mainstreamed or targeted organization.

Race and Ethnicity

The variability among racial and ethnic groups and within any particular group is likely to be very great. Successful intervention programs learned early to smooth out the differences and at the same time to be sensitive to them. For example, California MESA may seem like one program, but its manifestation was different in every single school that was visited. Culture-sensitive adaptations are made, based on a general format that stresses higher levels of achievement in mathematics and science. Thus widely diverse populations can be served and the programs are transferable.

Hispanics. The term "Hispanic" is almost useless in designing intervention efforts, since it is related only to Spanish-English language considerations that may need to be taken into account in dealing with students, and especially with their parents. Aside from this, programs dealt with specific groups of Spanish origin and the problems they were likely to encounter. For example, mainland Puerto Ricans most often have educational problems related to their minority status in a majority culture in urban settings — poverty, low expectations of teachers, language differences. Island Puerto Ricans do not share this problem of being a minority, but have other educational problems related to the socioeconomic conditions of the island, education in Spanish in

science, engineering, and mathematics, where participation is English-dominated and so on.

Mexican Americans have a largely rural background and in some ways share with American Indians the difficulties of receiving education in science, mathematics, and technology in isolated and rural settings. Combined with this are differences in language from the dominant culture and low expectations by teachers of their abilities to perform in academic areas perceived to be very difficult. Exemplary programs for Mexican American populations take such factors into account. There is likely to be an emphasis on family involvement; role models of successful Mexican American scientists and engineers are shown to students and family alike; academic programs focus on mathematics (especially applied mathematics, probability and statistics, computers), science (applied science, science projects, solving problems, building models), and development of English language competence in science and technology (while not downgrading the value of Spanish language competence). Exemplary programs often draw on historical examples from early Hispanic peoples in an attempt to show that mathematics, science, and technology have always been a part of the Spanish culture of the Americas.

American Indians. There are hundreds of tribes and therefore hundreds of separate cultural experiences represented by the term American Indian. According to 1980 census figures, there were more than 1.4 million persons in the United States identified as American Indian and Alaskan Native. Although small numerically, Native peoples are a significant part of the diverse populations that comprise the United States because they are the first Americans and because of the unique relationship between the tribes and the government. This relationship alone affects questions of support for programs, control of schools, and delivery systems for intervention efforts.

In the face of such heterogeneity, such a small population, and such overwhelming social, economic, and health problems, someone looking at the problem of science, mathematics, and technology education for all Americans might be tempted to dismiss the need to give special attention to these groups. An advocate arguing for such attention would probably respond that they, as much as any other group, have a special need for such literacy and a special right to it. For many tribal groups scientific and technological literacy means the survival of the tribe, reasoned development of its reservations, protection of its vast natural resources, and health of its people. These are the needs, and they are the driving forces behind the intervention programs aimed at Indian students. The programs are aimed at developing college-bound students (or at least technical-level personnel) in areas of direct application and relevance to the needs of Native peoples: engineering, natural resource management, agriculture, and health.

With such a focus on group survival rather than personal development, one can imagine the intensity of the program motivation. Most of these students are being prepared not only for science and technical competence but also for leadership. Norbert Hill, a participant in the project directors' meeting, director of the American Indian program at the University of Colorado, Boulder, and incoming executive director of the American Indian Science and Engineering Society, stated that the following elements are essential for exemplary programs for American Indians: academic intensity; parental involvement; clear expectations on the part of staff and students; cultural activities that are integrated; academic year follow-up for summer programs; integrated, activity-based curricula that provide ample opportunities for hands-on experience and situational problem solving; competent and culture-sensitive counseling; leadership training; exposure to Indian scientists and engineers as role models; committed staff; and

community support. Not given on his list, but implied (and reinforced by contact with other Indian programs), are the ideas that student participants should be carefully selected (for ability, commitment, motivation) and that intervention is needed at an early enough point, before major educational deficiencies accumulate and otherwise able students drop out, or are pushed out of the system.

Blacks. Programs aimed at Black Americans have had to deal realistically with the academic deficiencies which many such students bring with them. The generally lower socioeconomic levels of Black America have been translated into poorer housing, poorer schools, little informal exposure to community resources in science and technology, and so on. The history of race relations in this country cannot be ignored, and the legacy of past discrimination lingers. For years, the schools that educated most Black Americans received less money, had poorer facilities in science, and stressed vocational over academic programs. The attitudes of teachers, counselors, and other school officials who have never seen a Black scientist or engineer have had to be dealt with and community support developed for programs designed to educate and produce Black leadership in science, engineering, medicine, and related fields.

Programs have clearly been career-directed, oriented to employment skills and to raising the social and economic levels of Black Americans. Scientific literacy is a need, but it has seldom been the focus of programs at the precollege level. When viewed in the context of the problems of Blacks that need to be addressed, this is not surprising. Thus, the majority of efforts have incorporated career information with academic preparation. Students have been exposed to extensive use of role models, both "in the flesh" and through the use of print and video materials showing historical and contemporary figures in science, engineering, medicine, and invention. A number of corporations have developed posters that are distributed free to classrooms and/or students. In addition to highly successful professionals, students are exposed to role models at other levels -- graduate students, teachers, undergraduate students, or peers who are working and excelling at some level in science and engineering. This factor was mentioned by most of the directors of programs for minorities, women, and disabled students. Project directors stress that, in a sea of impossibilities, Black students, their parents, and others must see science, engineering, and medicine as real possibilities.

Science fairs, science projects, and early involvement in scientific research are hallmarks of many programs, with suitable recognition and awards for outstanding performance by students.

The potential of the Black colleges in developing and offering enrichment programs for students is high, but uncertainties of funding have invariably been the biggest continuing problem. A group of institutions with serious problems in attracting resources for their own operations may find it hard to raise support for outreach efforts.

Pacific Islanders and Asian Americans. Even with the data currently collected, we still do not have good information on Asian American or Pacific Island populations. In the past, programs have not concentrated on these groups because of their apparent overrepresentation in the pool of scientists and engineers compared to their proportions in the population as a whole (from which it may be inferred that their precollege preparation in mathematics, science, and technology is adequate). Following our survey and analysis, we are uncomfortable with this conclusion.

The lumping of Pacific Islanders with Asian Americans obscures the plight of groups such as Samoans, Guamanians, Native Hawaiians, and Micronesians, whose overall socioeconomic levels are more similar to those of underrepresented groups. The lumping

together of all Asian Americans obscures real cultural differences that may or may not be supportive of education in science, mathematics, and technology for different groups such as Japanese, Chinese, Filipino, Korean, Thai, or Cambodian Americans.

Data are not uniformly available on the citizenship status or country of precollege education of distinct Asian populations. We do know that in 1981, of the 2,704 doctorates awarded to Asians, only 17% were to U.S. citizens.[11] The state of precollege education in mathematics, science, and technology is not known for second and third generation (and beyond) Asian Americans whose exposure to the American precollege educational system has been complete.

Multiple jeopardies. When any of the factors that have limited the education and aspirations of segments of the population are combined, they are at least additive in their effects. For example, being both minority and female or both minority and handicapped disadvantages one several times over in receiving quality education in mathematics, science, and technology. Even though most of the precollege minority science and engineering programs have at least 50% representation of females, minority women do not receive 50% of science and engineering degrees, and representation of minority females becomes smaller with advancing degree levels. At the same time, many precollege minority programs (especially those targeted at Blacks or American Indians) have an extremely difficult time identifying qualified males to participate, which reflects at least in part their earlier loss from the educational system. Both kinds of problems must be addressed. For such students, gaining entrance to science and engineering is like negotiating a giant slalom — miss an early gate and you're out.

Patterns of female representation differ for different racial and ethnic groups. It is extremely difficult to involve Mexican American females in science, mathematics, and technology programs because these fields are identified with males. At the project directors' meeting Dr. Diana Marinez, a Chicana biologist, stressed the need to involve the family when attempting to draw females into such programs. Programs that have been successful in attracting Mexican American females have included both early and sustained contact with parents.

THE NEXT STEP

Spin-offs and Transferables

During our study, we found a number of cases in which efforts originally undertaken for women and/or minorities had been institutionalized and adopted for general use. These illustrate the transferability of what has been learned and developed in the targeted situation to the general situation.

The following are three examples.

1. A 7th and 8th grade science curriculum developed for the PRIS²M program (Rochester, N.Y., minorities in engineering effort) is being adopted for all of the Rochester schools.

2. A series of notes developed for a junior high school computer education program in an adopt-a-school program for PRIME (Philadelphia Region Introduction to Minorities in Engineering) is now commercially available

(I Speak Basic to My Atari, . . . to My TRS-80, . . .to My VIC, etc., by Aubrey Jones).

3. A mathematics program for all students sponsored by the Mathematics Association of America has been based on the WAM (Women and Mathematics) and BAM (Blacks and Mathematics) models developed earlier.

Certain academic intervention programs for minorities in science which had "disappeared" were found to have been institutionalized and to have become standard operating procedure. This suggests that programs that are valid for minorities and/or females are valid for all. Our project directors were quick to point out, however, that the opposite has not necessarily been true. Without specific attention to populations "at risk," the concerns of these populations become obscured. It may not matter to white males whether a computer specialist or engineer who comes to speak to their class about her or his job is female or minority, but it may matter a great deal to the females and minorities in the class. Besides, in the words of Dr. Iris Weiss, a participant in the project directors' meeting, "there is also virtue in showing white males that science careers are appropriate pursuits for women and minorities."

Elements of programs that have been part of the women in science intervention program experience may be particularly instructive in teacher retraining. For example, a number of programs have been developed to deal with "mathematics anxiety," and elements of these programs may be particularly useful in raising the confidence and competence in mathematics of teachers in self-contained classrooms who are uncomfortable in teaching mathematics.

Causes for Concern

Several concerns were expressed by the project directors who provided input into this study. For example, in special science high schools the early opportunity for students to do research is seen as a real plus for their education in the sciences. Directors of exemplary science programs for women and minorities stress the value of a horizontally integrated curriculum approach, the very characteristic of independent research that makes it special. Students must analyze problems, work in the library, draw on information from several different subject matter areas (the science and mathematics applied to it), build apparatus, write up results, prepare graphics, and present results. Yet education in the sciences and mathematics in most high schools is in subject matter areas where in many cases (notably even in our site visits to "good" schools) science and mathematics faculty have little or no interaction. Computer courses are offered (where computers are available), but their value as a tool in science is seldom noted.

Many of the minority students who were identified as scientifically and mathematically able by intervention projects were found to have whole content areas missing from their background. In moving from one grade to another it was assumed that students had been taught all that was supposed to have been covered. The next grade started where the student was supposed to be rather than where the student was, thus leaving large gaps in understanding. Project directors stressed the need for a curriculum that is integrated longitudinally (kindergarten to 12th grade).

Program approaches that stress working alone or competitively may be incompatible with personal styles of females and some minorities. Many of the exemplary projects (especially engineering projects) stressed a team approach, which is, the project directors stressed, also more reflective of the way engineering is actually done.

A number of federal programs have been established and directed at special populations and/or special problems. There is a great tendency, when a new problem emerges, to declare the old problem solved or unsolvable, less urgent or too highly focused on a narrow interest group (even if that interest group comprises the majority of the population) and to redirect the funds. Careful consideration must be given to the role these programs have played in educational equity in science, mathematics, and technology as well as to the role they might play in the future. For example, the Women's Educational Equity Act program has supported the production of valuable materials and models for science and mathematics. The improvement in the National Assessment seen especially for Black and Hispanic 9- and 13-year-olds has occurred in areas affected by Title I, showing the effect of compensatory education programs.[12] Project directors were concerned that such targeted programs might be eliminated without regard to evidence of their success or usefulness. Any other efforts to support the science and mathematics education of minority, female, or handicapped youth must be augmentative.

The project directors were concerned that new programs would be established at local levels to address precollege education in science, mathematics, and technology even where exemplary programs with a similar mission already existed, and that these programs would be ignored largely because they had been developed for women or minorities. They were particularly concerned that programs would fail to draw on past experience and thus be wasteful of the limited funds available for intervention.

RECOMMENDATIONS

Federal Government

1. Federal support for programs to improve the quality of precollege education in science, mathematics, and technology should require that proposals specifically address themselves to plans for serving women, minority, and disabled student populations.

2. Federally supported programs for teacher training and retraining should require that teaching methods and career and equity aspects be included, along with a rigorous focus on improving competence in subject content.

3. The federal government should support dissemination of models previously shown to be effective in improving science and mathematics education for women and minorities, including technical assistance on management and evaluation systems. These models should be reviewed for possible adaptation to rural school systems.

4. Data should be collected by the National Science Foundation on the numbers of qualified precollege science and mathematics teachers by sex and race. Data should be collected in such a way as to determine relative teacher shortage in inner city, urban, suburban, and rural areas.

5. Rather than create totally new federal efforts, previously supported programs that had a strong positive educational impact on women and minorities should be reexamined for possible reinstitution. Of particular interest in this regard are the Resource Centers for Science and Engineering and the Student Science Training Program.

6. The federal government should seek to determine the state of precollege education in science, mathematics, and technology for Asians and Pacific Island populations, disaggregated to the degree possible and with citizenship status specified. Such research is necessary to determine whether program interventions are required.

State and Local Governments

1. Guidelines for in-service training of science and mathematics teachers should specify that programs include not only content, but also activities, methods, careers, and equity aspects.

2. As a first step, the establishment of special science or magnet schools provides an alternative education for students with particular interest in these fields. Enrollments and recruitment practices should be carefully monitored to ensure sex equity and race equity in these programs.

3. State and local proposals and plans for the improvement of precollege science and mathematics education should indicate how programs will be tailored to the specific needs of female, disabled, and various racial/ethnic minority students.

4. Enrollments in vocational and technical programs should be monitored to determine whether quantitatively based programs are accessible to women and minorities and whether patterns of occupational segregation are being perpetuated within science-related programs.

5. Effective state and local programs should be publicized as possible models for adoption.

Colleges and Universities

1. Colleges and universities should continue to support precollege intervention programs for minority and female students with interest and ability in science, engineering, and related fields.

2. The institutions should develop cooperative relationships with industry-, school-, and museum-based programs for women and minorities to expand the base of resources in science, mathematics, and technology available to such special programs.

3. In considering tenure and promotions for faculty, colleges and universities should include community service and participation in programs aimed at increasing scientific and technological literacy among females, minorities, and disabled persons.

Business and Industry

1. Business and industry should support the full range of science, mathematics, and engineering intervention programs for minorities and women — for example, by encouraging employee participaton in adopt-a-school programs, career days, and museum and school visits.

2. Where possible, business and industry are encouraged to indicate long-term financial commitments to proven programs rather than year-by-year support.

3. Business and industry should join with schools, civic groups, and colleges and universities in consortial arrangements, to orchestrate the flow of effective programming and resources to improve the quality of science education for minorities and females.

Community Organizations and Professional Societies

1. Parent/teacher organizations should explore sponsoring Family Math or Family Science programs as a means of involving parents in the learning process. This extension of the educational experience is particularly important for female, minority and disabled students.

2. Parent/teacher organizations should investigate science and mathematics course enrollments by minorities, females and disabled students in their schools.

3. Professional societies should encourage local science enrichment programming by chapters and members and give extensive visibility in their journals to successful efforts.

4. Professional societies should support the preparation of career information materials for precollege students which include gender- and race-sensitive language and prominently picture minority, female and disabled professionals.

5. National meetings of professional societies should include workshops, demonstrations, and other features on precollege programming for women, minorities and disabled students (e.g., youth days, teacher workshops).

Program Implementers

1. Program directors are encouraged to carefully review information contained in this report regarding program design and implementation.

2. Especially important are recommendations on documenting populations served and program effectiveness.

3. In recruiting students, the family must be involved.

4. Minority newspapers, Spanish-language radio stations, churches, clubs and word-of-mouth are often effective ways of reaching minority communities.

5. For women's projects special efforts should be made to recruit minority women.

6. For both women's and minority projects special efforts should be made to involve disabled youth.

Survey Form

Precollege Programs in Science, Mathematics and Engineering for Minorities and Women

Please use one form for each separate project; copy the form if you have more than one project to describe. Continue answers on additional sheets if needed. Write "N.A." if a question does not apply to your project. We would appreciate return of the completed from within two weeks of receipt to ensure we stay on schedule.

1. Title of project: ____________________

2. Location: Institution: ____________________

   City: ____________ State: ________ Zip: ________.

3. Dates of project: Started ____________. Is the project still running?

   ___Yes ___No. If completed, month ____________ year ______.

4. Scientific fields covered: Please check as many as apply.

   Mathematics __ Physics __ Biol./Med. Sci. __ Engineering __
   Earth Sci. __ Chemistry __ Soc./Behav. Sci. __ Other (specify) __

   Did participants use computers in the project? __Yes __ No.
   Did they have other "hands on" experience? __Yes __No. If yes, describe in #9.

5. Educational level targeted: Please mark as many as apply.

   Elementary: ____ Grades covered: ____ through ____
   Junior High: ____ Grades covered: ____ through ____
   High School: ____ Grades covered: ____ through ____

   Teacher or counselor training ____ Precollege administrators ___ Parents ___
   Other (specify) ____________________

6. Who participated in the project? Number of:

	Students		Adults	
	Females	Male	Female	Males
American Indians				
Black Americans				
Mexican Americans				
Puerto Ricans				
White (non-Hispanic)				
Pacific Islander, Asian Americans				
Other: specify ethnicity				

7. Did you have any physically disabled participants? ____Yes ____No
If yes, how many and with what disabilities? ______________________________

____

8. How were the participants for this project obtained? Please describe any special strategies used to recruit any particular segment of your participant population.

9. Please compose a narrative description of your project, covering goals, methods, results, and unexpected benefits. Did you use role models, special curricula, hands-on experience, etc.? Include any insights you would share with others who might wish to conduct a similar project. Feel free to continue to an additional page.

10. Project costs: Direct funds: $____________ Estimate of in-kind costs borne by the institution: $______________. Who funded the project (student fees, names of granting agencies, etc.)______________________________________

____

Have the sources of funds changed over time? ____Yes ____No.

11. Have parts or your project become "mainstreamed" or "institutionalized" into the regular programs of your sponsor over time? ____Yes ____No.

12. What aspects of your project could be beneficial for students?

13. Did the project complete a videotape, film, slide show, or audiotape? ____Yes ____No. If yes, give title, date completed, medium and length in minutes.

14. Did the project result in a report, journal article, evaluation, or other publication? ____Yes ____No. If yes, please give author, title, publisher, year, and length (better still, please send us a reprint!).

15. Person to contact for additional information: ______________________________
Address: ____
____ Telephone: ( ) -

Please return form to: Office of Opportunities in Science
American Association for the Advancement of Science
1776 Massachusetts Avenue, N.W., Suite 620-B
Washington, D.C. 20036

APPENDICES

Appendix A, the Detailed Plan of Work, was submitted with the proposal to the National Science Foundation. This work plan outlines the study methods used to prepare the report for the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology.

Appendix B reports the results of surveys received from science camps and computer camps. The programs are described as well as the participation of minority, female and disabled youth in them.

Appendix C lists the programs that responded to our survey of intervention efforts by target group. Within each group programs are listed by alphabetical order of the state where each program was located.

Appendix D lists the precollege programs in science, mathematics, and engineering that were visited by external consultants and staff.

Appendix E gives the agenda and list of participants in the meeting of directors of exemplary programs.

Appendix F provides more detailed information on a few of the specific intervention efforts mentioned or listed elsewhere in the report. Especially highlighted are a few of those which provided documentation of their effectiveness from external evaluations.

APPENDIX A

DETAILED PLAN OF WORK

I. Use the materials already available in the AAAS Office of Opportunities in Science accumulated in connection with the preparation and publication of Programs in Science for Minority Students: 1960-1975 and Programs in Science, Mathematics and Engineering for Women in the United States: 1966-1978 (hereafter referred to as the minority inventory and women's inventory, respectively).

II. Examine the AAAS publications that inventory programs for minorities and women for projects that include students at the target level, kindergarten through 12th grade. When originally surveyed, all projects were asked to provide specific detail on: the target level(s) of the program; goals; objectives; racial/ethnic group(s) served; specific activities undertaken; program cost; contact person, etc.

III. Consult archives and copy original materials submitted for the entries in question. Also consult Office of Opportunities in Science (OOS) working files for programs undertaken since the publication of these reference books. The conduct of an in-depth analysis of intervention programs was a part of the original plan for the minority inventory proposed to the National Science Foundation. Although the proposed assessment of programs was not supported at that time, OOS staff continued to keep up the files of intervention programs, hoping to update the inventory and/or find support for the assessment of programs. In a subsequent OOS project, intervention efforts supported by minority professional societies were collected and documented. Another project involved preparing a sourcebook of programs supported by the Minority Institutions Science Improvement Program, a number of these directed at precollege students. For the women's inventory, we inquired specifically whether an evaluation was done and asked for copies of evaluation reports, which are preserved in AAAS files. All of these sources were tapped for relevant program information.

IV. Survey the contact persons and/or sponsoring organizations for an update of their material—goals, objectives, impact, etc. We were especially looking for additional reports of evaluation studies. We wanted to find out what had happened to the programs since our last contact. We sent letters to the contact persons asking for updated information which stressed the time factor involved in completing the project. Letter and telephone follow-ups were also undertaken as necessary to ensure a prompt and complete response.

V. Develop a matrix of programs based on type of intervention, sponsoring organization, group or groups served, grade level, target discipline(s), etc. Using this matrix, programs have been categorized, described, and updated. Most of the intervention programs can be placed in different categories based on a number of criteria. The programs address some particular barrier or barriers to participation in science and engineering. In the case of women's intervention programs, a substantial body of educational research usually accompanies the identification of barriers and the development of specific strategies to address them. The research base for minority intervention programs has traditionally been much smaller than that for women, although many groups have come to recognize the importance of research in developing effective intervention strategies. Familiarity with a range of program strategies permits us to make generalizations across seemingly unrelated efforts.

VI. Use external consultants to examine supporting data from the programs and determine those with greatest evidence of success. Analyze evaluation reports. When looking at intervention programs that have been undertaken, we attempted to determine what barriers the programs attempted to address and the extent to which they were successful in doing this. "Success," initially, was assumed for any program that met its primary goal as measured by staff, participant or external evaluation. Formal program evaluation, where relevant and where well done, was the preferred criterion. Where a formal evaluation had not been conducted, anecdotal evidence was used first, buttressed by such additional measures as length of time program has been in operation, ease in attracting external program support, ratio of project applicants to project participants, and reputation of the program with area scientists from the affected groups. Program transferability, cost effectiveness, and impact in removing a significant barrier were also considered in determining program success. Based on this supporting evidence, a partial list of exemplary programs was developed by staff and external consultants.

VII. Conduct site visits to some representative sample of these exemplary programs and institutions in order to talk with project staff, faculty, students, administrators, parents, and others connected with the program. A final list of critical program elements was developed from these visits. The visits allowed us to assess the immeasurables that often contribute as much as measurables to the success of any effort. Written reports of what was done and how and its impact on participants do not always mention critical elements such as neighborhood or parental support or zeal of the program director and staff. On-site visitation by project staff and consultants and the preparation of detailed reports have provided further data on these programs that cannot be garnered otherwise.

VIII. Hold a two-day meeting with ten directors of programs (five that were site-visited, five that were not) to probe in depth the elements of effective programming in science and mathematics for minorities and females, K-12. This meeting was necessary to validate the tentative conclusions drawn from previous activities. Program developers and implementers were thus involved in the development of recommendations on intervention programs. Staff and consultants met with these persons in a two-day intensive session.

IX. Prepare final report based on the above activities as outlined in the Request For Proposals.

Due to the tight time schedule, we canvassed existing networks to identify and solicit information on programs not already known to staff and consultants, especially where needed to fill a broad intervention category. Also in the interest of the time schedule, we relied on survey instruments already developed and tested for use in the more recent survey of programs for women. In all our efforts we attended to the issue of how strategies may differ for different groups and for males and females in those groups, as well as for white females.

Because education in science and computing is increasingly available in camps, we obtained the list of accredited camps from the American Camping Association and surveyed them to determine the nature and availability of their programs to minority, female, and disabled youth.

APPENDIX B

SCIENCE CAMPS AND COMPUTER CAMPS

Introduction

For decades, camps have provided nature study for children, imparting a form of out-of-school "science education" that may interest the Commission. Recently, computer camps have sprung up as well. The AAAS investigated science and computer instruction at camps as part of this report, including their accessibility to female and minority campers. Camps have long been available to girls through the Girl Scouts and to minority children through the Y's camps. The data below suggest that camps open to the general population now enroll these groups as well.

PIRP Inc., the public relations firm for the American Camping Association (ACA), generously provided us with a copy of the ACA's book describing accredited camps, with supplementary material on accredited computer camps. We wrote to 78 science and computer camps listed in these materials and received 19 replies, a response rate of 24.4%. A copy of the questionnaire follows this appendix.

The camps that responded seem reasonably open to a diverse population. At least half offered "camperships" to defray part or all of the fees for low-income children (fees ranged from $70 to over $2,500). One camp was for boys only, one for girls only, and the rest coeducational or with separate sessions for boys and girls. Fourteen of the nineteen (73.7%) said they admitted physically disabled campers, although a couple of these mentioned that the terrain of the camp was not well adapted for wheelchairs or that the camp lacked facilities for chronic medical problems. Five skipped the question on the number of minority campers enrolled during 1982, but all of the remaining fourteen did have at least some campers who were Black (12 of the 14), Hispanic (9 of the 14), American Indian (2 of the 14), or Asian American (6 of the 14). The minority students accounted for 2% to over 50% of the campers at these fourteen sites. In terms of role models, eight computer or science instructors were women and seventeen were men.

Seven of the respondents were computer camps, six others conducted a camp that combined science and computer instruction, and the remaining six dealt with science only. The director of Saguaro Camp Cherith in Arizona remarked that science camps in rustic settings such as hers would have a hard time adding computers to the curriculum because of the vagaries of rural electrical systems.

Computers and Camps

All of the thirteen computer camps or computer/science camps used microcomputers rather than a mini with terminals. All but one taught programming, ten of them BASIC, four LOGO, two PASCAL, two FORTRAN, and one COBOL. Eight said they taught advanced programming. Eight offered games and seven taught word processing. Eight used computer-assisted instruction. One each dealt with spread sheets, database management, graphics, game design, and problem solving in science. Computers are a recent phenomenon among them: the oldest program dates back to 1979, with two started in 1980, three in 1981, four in 1982, and three in 1983. Eleven used texts, but no two camps used the same one. The written material ranged from books on computers written specifically for children to technical manuals and software

documentation written for adults. A few manufacturers dominated the hardware choices, with most camps offering more than one brand of computer. The kinds of computers used at the camps were:

Commodore PET and Apple
Apple II plus
Apple IIe
Apple II plus and TRS 80 Model III and IV
Sinclair and Commodore PET
Commodore PET and TRS 80
Apple IIe and Apple II plus
Apple IIe and Commodore PET
Apple and IBM
VIC 20 and Commodore 64
TRS 80 (color)
Commodore and Texas Instruments
Commodore PET, VIC 20, and Timex/Sinclair

The campers spent 4 to 30 hours a week on computers, with virtually all the time at terminals: whether practicing, playing games, or receiving instruction. The camps let the students work at terminals from 45 minutes to 6 hours per day, but only one camp reported letting the children stay at a terminal for more than 2 hours at a stretch.

Eight of the camps sketched in the credentials of the personnel who taught computers. The range of training and experience is a microcosm of the computer field generally:

- Summer school in computer languages, experience in teaching computers in school classrooms
- College major in computer science
- One computer science major and one schoolteacher with a specialty in computer education
- Experienced programmer
- College computer courses and programming experience
- College instructor in computers (MA in computer science)
- Systems analyst for 20 years
- College undergraduate with computer science/electronics major

Science Camps

As noted above, six camps combined science with computers and six taught science without computers added. Children spend one to five hours per day in science activities at these camps, nearly all of it in hands-on experiences. All 12 camps

included field trips to nature sites. Eleven also had the campers doing small group projects and eight asked them to do individual science-related projects. Only five had lectures on science and four ran laboratories. Seven used written materials in the science work, mostly as reference material (field guides to birds and the like). As might be expected, the "outdoors" sciences dominated the disciplines offered at these 12 camps. The science specialities offered (with the number of camps offering each specialty given in parentheses) were:

Environmental science (10)
Biological or medical science (10)
Earth or astronomical science (8)
Agricultural science (4)
Social or behavioral science (4)
Chemistry (3)
Engineering (3)
Mathematics (2)
Physics (1)
Rocketry (1)

The camps had more experience with science than with computers. One program dated back to 1928, one began in the 1940s, one in the 1950s, four in the 1960s, three in the 1970s, and one in the 1980s. The training and experience of science instructors were less eclectic than those of the computer teachers:

- Bachelor's degree in biology plus 60 hours graduate work in sciences
- Certified by the state to teach sciences
- High school biology teacher with 15 years teaching experience
- Working toward biology degree
- Bachelor's and two or more years education/natural science background
- Science teacher during school year
- One Ph.D in zoology/physiology and one Master's in biology
- Junior high school science teacher
- Bachelor of science degree
- Biology teacher during school year
- College science courses

SURVEY FORM:
SURVEY OF CAMPS PROVIDING PROGRAMS IN SCIENCE AND COMPUTING

1. Name of Camp ____________________
2. Permanent Mailing Address ____________________
____________________ Telephone ( ) ____
3. Location of Camp ____________________ Telephone ( ) ____
Name of Contact Person ____________ Address ____________
____________________ Telephone ( ) ____
4. Sponsoring Organization(s) ____________________

5. **COMPUTERS:** If computing is offered, please complete this entire section.

(a) How many hours per week per student are devoted to instruction, projects, labs, etc. on computers?____. How many hours per week do students actually spend at the terminal?______. How is this time apportioned during the week (e.g., one-half hour each day; 2 ½ hours once a week)?

(b) Number of terminals available to students ______. Type/Brand(s) of computing hardware used by students.

(c) What is the nature of computing activities? Check as many as apply: Beginning Programming (please specify language(s)____________ ____________Games_____Word Processing_____Computer Assisted Instruction_______Advanced Programming_______Other(please specify)
____

(d) Is any text material used? Yes___No___. If yes, name of author and title of text

(e) Name of Teacher of Computer Class ____________________
Briefly summarize the computer background of the person(s) providing this instruction.

(f) When was the program in computing started? Year ____________

6. **SCIENCE:** If science is offered please complete this entire section.

(a) How many hours per week per student are spent on instruction, projects, labs, field trips, etc., in science________. Which sciences are taught? Mathematics____ Physics____ Biol./Med. Sci.____ Engineering___ Earth Sci.___ Chemistry___ Soc./Behav. Sci.__ Envir. Sci.__ Agriculture______ Other (specify)________________________________

(b) What activities are included in the Science Program? Lectures____ small group projects_____ individual projects____ laboratory instruction____ field trips____ Other (please specify)______________________

(c) How many hours per week are spent in laboratory, field or other hands-on activities (exclusive of computing time reported in 5(a))?____________

(d) Is any text or other written instructional material used in connection with the science program? Yes____ No____. If yes, name of author and title of material.

(e) Name of Science Instructor ________________ ________________. Briefly summarize the science background of the person(s) providing this instruction.

(f) When was the science program started? Year ____________.

7. Cost of camp to each student ______________. Are there any additional charges associated with computing and/or science components? Yes___ No___. If yes, what is the additional cost?______________ Do you provide camperships? Yes___ No___.

8. Characteristics of Camp: Day___ Residential___ Coeducational___ All Boys_____ All Girls______ Size of Camp______

Are physically handicapped students admitted to your program? Yes_____ No_____. If yes, how many of such students do you average per year?_________ Approximate minority student enrollment during 1982: American Indian______ Asian American_____ Black_____ Hispanic_____ Other (specify)________________

Thank you for completing this questionnaire. Please return to:

AAAS
Office of Opportunities in Science
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036

APPENDIX C

PRECOLLEGE SCIENCE, MATHEMATICS, AND ENGINEERING PROGRAMS BY TARGET AUDIENCE

The list is divided into four categories: programs for minority women, for minority and female students or for a general population, for women, and for minorities. In each category, projects are listed by states (states appear in alphabetical order); under each state, there is no particular order. For each project, the title, sponsor, and duration are given.

For Minority Women

Pre-Freshman Summer Science Program, Spelman College, Georgia, 1972-.

Factors Affecting the Persistence of Minority High School and College Women in Science/Health Careers Programs, Morris Brown College, Georgia, 1979-1982.

Math Component of Quest, Alverno College, Wisconsin, 1981-.

For Both Women and Minorities, or for the General Population

(Projects listed here for general population are included because they did special recruitment or had special features relevant for women and minority students.)

Professional Development Program, University of California, Berkeley, 1975-.

Family Math, Lawrence Hall of Science, California, 1980-.

Microcomputer and Video-Based Mathematics Modules for High School Women and Minority Students, University of California, Santa Cruz, 1981-1983.

Nuclear Energy, Connecticut Yankee Information Center, 19??-.

Mathematics at Work in Society, Mathematics Association of America, Washington, D.C., 1982-.

Scientific Tools and Techniques, Fernbank Science Center, Georgia, 1981-.

Junior Curators Project, Bishop Museum, Honolulu, 1981-.

Science Anxiety Clinic, Loyola University, Chicago, 1977-.

Summer Engineering Seminar, Purdue University, West Lafayette, Indiana, 1971-.

Gifted Science Project, Montgomery County Public Schools, Maryland, 1977-1981.

ASSET (Air and Space Science for Elementary Teachers), Northeast Missouri State University, 1979-.

Work in Technology and Society (WITS), Massachusetts Institute of Technology, 1976-1980.

USEP (Upsala Summer Enrichment Program), Upsala College, New Jersey, 1973-.

Careers in Engineering, Bell System Telephone Companies, New Jersey, 1973-.

Computer Experience Van Program, International Space Hall of Fame and New Mexico State University 1983-.

Bridging Year Program, Clarkson College of Technology, New York, 1978-.

Project City Science, New York University, 1974-1979.

Science Careers Program, Research Triangle Institute, North Carolina, 1979-.

Women & Minorities Scholarship Program, University of Cincinnati, Ohio, 1969-.

Engineering, Science and Computer Orientation Program (ESCORT), University of Dayton, Ohio, 1982-.

Why Take More Math? University of Washington, Seattle, 1977.

For Women

Math-Science Sex Desegregation Project, Novato Unified School District, California, 1978-1981.

Math/Science Network, Math Science Resource Center, Mills College, California, 1974-.

"Expanding Your Horizons in Science and Mathematics" Conferences for Young Women, Math Science Resource Center, Mills College, California, 1976-.

Investment in Women, Math Science Resource Center, Mills College, California, 1983-.

Women in Engineering, University of Santa Clara, California, 1978-.

Role Models in Math, Science and Engineering, UCLA, 1979-1980.

SPACES-Solving Problems of Access to Careers in Engineering and Science, Lawrence Hall of Science, University of California, 1979-1982.

EQUALS, Lawrence Hall of Science, University of California, 1977-.

GEMS-Gender Equality in Math and Science, Santa Cruz County Office of Education, California, 1981-1982.

Math/Science Interchange: "Expanding Your Horizons," Loyola Marymount University, Los Angeles, 1983.

Expanding Your Horizons, Colorado State University, 1982.

Multiply Your Options, Wesleyan University, Connecticut, 1982-.

Women in Engineering, University of Idaho-Moscow, 1973-1981.

AWIS-CAC Bibliography of Career Pamphlets, AWIS-Chicago, 1981-.

Speakers' Bureau, AWIS-Chicago, 1978-.

Math for Mothers and Daughters and Math Anxiety, Museum of Science and Industry, Chicago, 1981-.

"Ala Kazam" Girl Scout Evening, Museum of Science and Industry, Chicago, 1980-1983.

Engineering Career Workshop for Women, Northwestern University, Illinois, 1971-.

Michiana Mathematics Contest for High School Women, St. Mary's College, Indiana, 1977-.

Women in Science, Tri State University, Indiana, 1977-.

Women in Engineering, Tri State University, Indiana, 1974-.

Factors Affecting Retention of Girls in Science Courses and Careers: Case Studies of Selected Secondary Schools, National Association of Biology Teachers and Purdue University, West Lafayette, Indiana, 1983-.

Future Focus on Women in Engineering, Purdue University, West Lafayette, Indiana, 1977-.

Engineering Career Information Brochure-Poster, Purdue University, West Lafayette, Indiana, 1974-.

Women in Engineering Career Day, Purdue University, West Lafayette, Indiana, 1975-.

Science Center Camp-Ins, Des Moines Center of Science and Industry, Iowa, 1977-.

Promoting the Exploration of Personally Relevant Career Options in Science and Technology, American College Testing, Iowa, 1975-1976.

COMETS: Career Oriented Modules to Explore Topics in Science, University of Kansas, 1979-.

Careers in Science and Mathematics Workshops for Women, Maryland Academy of Science, Baltimore, 1977-.

The Gifted Girl: Helping Her Be the Best She Can Be, Equity Institute, Maryland, 1983.

Hey What Are Your Plans for the Next Sixty Years (Project Open Door), Equity Institute, Maryland, 1977-1978.

From Here to There: Exploring the Apprentice-to-Journeyworker Career Ladder with Girls and Boys in Grades 1-9: A Multi-Media Approach, Equity Institute, Maryland, 1980-1983.

Summer Math, Mt. Holyoke College, Massachusetts, 1982-.

Women in Medicine, Harvard Medical School, Massachusetts, 1982.

Radcliffe Summer Program in Science, Radcliffe College, Massachusetts, 1981-.

WAM (Women and Mathematics), Mathematics Association of America and University of Michigan, Flint, 197ɔ-.

Women in Science Videotape Series, University of Michigan, Ann Arbor, 1981-1984.

"Yes You Can": A Project to Encourage Girls to Get Serious about Science and Math, Cranbrook Institute of Science, Michigan, 1982-.

People 'n Science, Cranbrook Institute of Science, Michigan, 1982-.

Women in Engineering Workshops, Michigan Institute of Technology, 1973-.

Science Career Workshop, Gustavus Adolphus College, Minnesota, 1979-1980.

Visiting Women Scientists Program, 3M Center, Minnesota, 1979-.

Short Course for Women, University of Minnesota Institute of Technology, 1975-.

Women in Science Career Exploration, Jersey City State College, New Jersey, 1980-.

POWER: Production of Women's Educational Resources, School District Eleven, New York City Board of Education, 1978-1979.

World of Today and Tomorrow, Girl Scouts of America, New York City, 19??-.

Physics in Your Future, American Physical Society, New York, 1983.

Visiting Women Scientists Program, Research Triangle Institute, North Carolina, 1978-1979.

Math and Science Day, Meredith College, North Carolina, 1979.

Engineering Institute for High School Students, University of North Dakota, 1971-.

Women in Engineering Seminar/Institute, University of Dayton, Ohio, 1983.

Women in Natural Science, Academy of Natural Sciences, Philadelphia, 1982-.

Pre-College Chemistry, Gwynedd-Mercy College, Pennsylvania, 1978.

Female Access to Careers in Engineering/Industrial Technology, Trident Technical College, South Carolina, 1978-.

ENTRYS, Greenville Technical College, South Carolina, 1978-1979.

Careers for Women in Science, Pacific Science Center, Washington, 1981.

Multiplying Options and Subtracting Bias, University of Wisconsin, Madison, 1977-1979.

Expanding Your Horizons, University of Wisconsin, Madison, 1980-.

Geology Field Camp for Girls, Association of Women Geoscientists, Wyoming, 1984.

For Minority Students

Science Discovery Day, Alabama Network of Minority Women in Science, Selma University, Alabama, 1982.

Research Apprenticeship Program for Minority High School Students, Alabama A&M University, 1981-1982.

Hopi Health Manpower Development Program, Hopi Indian Reservation, Arizona, 1973-.

Secondary School Science Project and Student Support Program, California Institute of Technology, 1968-.

Explainer Program, Exploratorium, San Francisco, California, 1969-.

Ecology Workbooks, Oakland Museum, California, 1982-.

Cooperative College Preparatory Program, Lawrence Hall of Science, California, 1980-.

MESA (Mathematics, Engineering, Science Achievement), Lawrence Hall of Science, California, 1970-.

Motivating Urban Science Education, Lawrence Hall of Science, California, 1971-1972.

Engineering Summer Residence Program for Minority/Disadvantaged High School Students, University of California, Davis, 1975-.

STEP (Special Transitional Enrichment Program), University of California, Davis, 1976.

ACCESS (Affective and Cognitive Concepts for Excellence in Science Studies), California State University, Fullerton, 1980-1981.

U.S. Fish and Wildlife Service Summer Fisheries Program, Humboldt State University, California, 1981-.

Integration of Reading, Math and Science, California State University-Los Angeles, 1981-1982.

LESSON (Lawrence Livermore El[illegible]ntary Science Study of Nature), Lawrence Livermore National Laboratory, Calif[illegible]nia, 1969-.

Minority Participation in the Earth Sciences Elementary School Program, U.S. Geological Survey-Menlo Park, California, 1981-.

Minority Participation in the Earth Sciences Teacher Workshop, U.S. Geological Survey-Menlo Park, California, 1982-.

MITE (Minority Introduction to Engineering), University of California, Irvine, 1975-.

SUMMET (Summer Minority Mining and Engineering Training), Colorado School of Mines, 1974-.

TRIBES (Tribal Institute in Business, Engineering and Science), Colorado College, 1981-.

Colorado Minority Engineering Association's MESA Program, University of Colorado-Denver, 1978-.

Science Motivation Program, Colorado State University, 1974-.

FAME (Forum to Advance Minorities in Engineering), Delaware, 1978-.

Project YES: Youth in Engineering and Science, University of the District of Columbia, 1982-.

Science Teachers Workshop, D.C. Area Network of Minority Women in Science, Washington, DC, 1981-.

Science Discovery Day, D.C. Area Network of Minority Women in Science, Washington, D.C., 1980-1982.

Science Discovery Day, University of the District of Columbia and D.C. Area Network of Minority Women in Science, Washington, D.C., 1983.

High School Intern Program, Smithsonian Institution, Washington, D.C., 1983-.

Career Awareness Program, Smithsonian Institution, Washington, D.C., 1983 (pilot; being evaluated for continuation).

Satellite Summer Enrichment Program for Gifted/Talented Students and Satellite Saturday Enrichment Program, Howard University, Washington, D.C., 1979-.

ALPS (Advanced Learning Program for High School Students), Howard University, Washington, D.C., 19??-.

BAM (Blacks and Mathematics), Mathematics Association of America, Washington, D.C., 1977-.

Project SEED, American Chemical Society, Washington, D.C., 1968-.

Rowland Scholar Program, Clark College, Georgia, 1976-.

SECME (Southeastern Consortium for Minorities in Engineering), Georgia Institute of Technology, 1976-.

Ho'ike Akeakamai (Introduction to Science), Bishop Museum, Hawaii, 1982-.

Hall of Discovery, Bishop Museum, Hawaii, 1979-.

Greater Chicago Area (Engineering) Program, University of Illinois-Chicago, 1978-.

Principals' Scholars Program, University of Illinois, Urbana, 1975-.

Minority Introduction to Engineering, University of Illinois, Urbana, 1969-.

INROADS/Chicago Pre-Collegiate, Illinois Institute of Technology, 1975-.

Pre-University of Minority Programs, Illinois Institute of Technology, 1973-.

Minority Engineering Opportunity Program, Northwestern University, Illinois, 1978-.

Black Contributors to Science and Industry, Museum of Science and Technology, Illinois, 19??-.

Science Awareness: A National Demonstration Project, East St. Louis Campus of Southern Illinois University, 1975-.

Science and Engineering Challenge, US Naval Avionics and Indiana Children's Museum, 1983-.

Science and Engineering Exhibition, Indiana Children's Museum, 1978-.

MEAP (Minority Engineering Advancement Program), Purdue University, Indianapolis, 1976-.

Minority Engineering Programs, Purdue University, West Lafayette, 1974-.

An Investigation of Instructional Strategies Which Enhance Biology Meaningful Learning, Purdue University, West Lafayette and Gary Community Schools, Indiana, 1981-1984.

Science Literacy Program, Des Moines Center of Science and Industry, Iowa, 1983-.

Project SOAR (Stress on Analytical Reasoning), Xavier University, Louisiana, 1977-.

Summer Science Program for High School Students/Health Careers Opportunity Program for High School Students, Southern University, Louisiana, 1967-1981.

LEAP (Louisiana Engineering Advancement Program), Xavier University, 1980-.

Medical Education Reinforcement and Enrichment Program, Tulane University, Louisiana, 1969-.

Engineering Pipeline/MESA, Baltimore Public Schools, Maryland, 1976-.

Interest and Involvement in Science Program, National Organization of Black Chemists and Chemical Engineers, Maryland, 1980-.

Minority Engineering Programs for Precollege Students, University of Maryland, College Park, 1976-.

Massachusetts Pre-Engineering Program for Minority Students, Wentworth Institute of Technology, 1979-.

Summer Institute for Minority High School Students, Northeastern University, Massachusetts, 1982.

ECO (Engineering Career Orientation), University of Massachusetts, Amherst, 1974-.

MEFO (Minority Engineering Freshman Orientation), University of Massachusetts, Amherst, 1981-.

Mathematics and Science for Minority Students, Phillips Academy, Massachusetts, 1976-.

Science Training Program for Blacks and Minorities, Western Michigan University, 1980-.

Detroit Area Pre-College Engineering Program, Michigan, 1976-.

Project Technology Power, University of Minnesota, 1976-.

Health Careers Opportunity Program (Preliminary Education), University of Missouri-Kansas City, 1981-.

Minorities in Engineering Project, Union County College, New Jersey, 1979-.

STEP (Stevens Technical Enrichment Program), Stevens Institute of Technology, New Jersey, 1968-.

RCA Minorities in Engineering Program, New Jersey, 1975-.

High School Scholars Program, New Jersey Institute of Technology, 1972-.

Native American Mineral Engineering and Science Program, New Mexico Institute of Mining and Technology, 1979-.

NAPCOE Summer Institute, University of New Mexico, 19??-.

Saturday Science Academy, University of New Mexico, 1979-.

Research Apprenticeship for Minority High School Students, University of New Mexico, 1980.

Travelling Science Show, University of New Mexico, 1981-1983.

Saturday Science Academies, New Mexico State University, 1981-.

Microgrant (for Precollege Science Teachers), New Mexico State University, 1981-.

Summer Institute for Science and Engineering, New Mexico State University, 1982-1983.

Counselor Workshop, New Mexico State University, 1982-1983.

Manhattan Center for Science and Mathematics, New York, 1982-.

Workshop on Organizing and Operating Saturday Academies, City College of New York, 1982-.

Summer Enrichment Program for High School Students, City College of New York, 1981-.

Summer Transition Program for High School Students, City College of New York, 1981-.

Teacher Training: Introductory Physical Science, City College of New York, 1982.

Teacher Training: Using Computers in Mathematics Instruction, City College of New York, 1982.

$PRIS^2M$ (Program for Rochester to Interest Students in Science and Mathematics), Rochester City School District, New York, 1978.

Xerox Science Consultant Program, New York, 1968-.

MITE (Minority Introduction to Engineering), New York, 1969-.

Minorities in Engineering Project of the National Coordinating Center for Curriculum Development, State University of New York, Stony Brook, 1977-1980.

Summer Youth in Engineering and Science Program, Central State University and Wright State University, Ohio, 1977-.

ESCORT (Engineering, Science, and Computer Orientation), University of Dayton, Ohio, 1976-.

Minority Engineering Programs, Case Western Reserve University, Ohio, 1973-.

American Indian Business and Engineering Center, University of Oklahoma, 1981-.

Mathematics Project for Teachers of Nat.ve Americans, Math Learning Center, Oregon, 1980-.

PRIME (Philadelphia Regional Introduction for Minorities to Engineering), Pennsylvania, 1973-.

Saturday Academy, Resource Center for Science and Engineering, University of Puerto Rico, 1982-.

Short Courses and Workshops for High School Teachers and Counselors, Resource Center for Science and Engineering, University of Puerto Rico, 1980-.

Workshop for Secondary School Teachers on the Supervision of High School Research, Resource Center for Science and Engineering, University of Puerto Rico, 1981-.

Math and Science Bowls, Resource Center for Science and Engineering, University of Puerto Rico, 1981 .

Experimental Chautauqua-type Workshop for High School Teachers, Resource Center for Science and Engineering, University of Puerto Rico, 1983-.

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Summer Institute for High School Students, Resource Center for Science and Engineering, University of Puerto Rico, 1981-.

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Biomedical Program, Fox Tech High School, San Antonio School District, Texas, 1981-.

Texas Alliance for Minorities in Engineering, University of Texas, Arlington, 1975-.

MESET (Minority Enrichment Seminar in Engineering Training), University of Houston, Texas, 1977-.

UHTRESS (University of Houston Transitional Engineering Summer School), Texas, 1981-.

Careers Workshop, Clemson University, South Carolina, 1978-.

REAP/Washington MESA, University of Washington, 1973-.

GEST (Gateway to Engineering, Science, and Technology), University of Wisconsin, Milwaukee, 1976-.

APPENDIX D

LIST OF PRECOLLEGE PROGRAMS IN SCIENCE, MATHEMATICS AND ENGINEERING THAT WERE VISITED

The Arizona Mathematics Project

Berkeley High School, California

Brooklyn Children's Museum, New York

California Institute of Technology Secondary School Science Program

The Comprehensive College Preparatory Program (CCPP), California

Council of Energy Resource Tribes (CERT) -- American Indian Science and Engineering Society (AISES), Connecticut

Detroit Area Pre-College Engineering Program (DAPCEP), Michigan

EQUALS, Lawrence Hall, California

Expanding Your Horizons (EYH), Mills College, California

The High School for Engineering Professions (HSEP), Texas

James Madison Memorial High School, Wisconsin

Manhattan Center for Science and Mathematics (MCSM), New York

Math and Computer Education Project (MCEP), California

The Math/Science Network, California

Mathematics/Computer Science Summer Program, University of the District of Columbia (UDC), Washington, D.C.

The Mays Academy of Science and Mathematics, Georgia

MESA Center -- California State University, Los Angeles

MESA Program -- Lawrence Hall of Science, Berkeley, California

MESA Program — Los Angeles Council of Black Professional Engineers

Native American Programs, Colorado

New Frontiers, Arizona

Northeast Resource Center for Science and Engineering, New York

Options for Excellence, Texas

Philadelphia Regional Introduction for Minorities to Engineering (PRIME), Pennsylvania

Physical Science Institute, University of the District of Columbia, Washington, D.C.

PREFACE, Arizona

Pre-University and Minority Programs, Illinois Institute of Technology, Chicago

/__/ -- Women in Science and Engineering

/__/ -- Minorities in Engineering—Early Identification

/__/ -- Health and Medical Careers Program

Professional Development Program (PDP), University of California, Berkeley

Program for Rochester to Interest Students in Science and Mathematics (PRIS^{2}M), New York

Project YES, University of the District of Columbia, Washington, D.C.

Resource Center for Science and Engineering, Atlanta

/__/ -- Saturday Academy

/__/ -- Summer Enrichment Program

/__/ -- Teacher Training

/__/ -- Counselor Training

Safford (Magnet) Junior High School, Arizona

Satellite Summer Enrichment Program for Gifted/Talented Students, Howard University, Washington, D.C.

Solving Problems of Access to Careers in Engineering and Science (SPACES), Lawrence Hall of Science, Berkeley, California

Southeastern Consortium for Minorities in Engineering (SECME), Georgia

Southwest Resource Center for Science and Engineering

Special Elementary Education for the Disadvantaged (SEED), California

Spelman College's Summer Science Bridge Program, Georgia

The Texas Alliance of Minorities in Engineering (TAME)

University High School, Arizona

University of New Mexico -- Minorities in Engineering Program

Women in Science and Engineering (WISE), Arizona

APPENDIX E

Precollege Science, Mathematics, Engineering Programs for Women and Minority Students

Agenda of Meeting of Project Directors

Monday July 25, 1983, 9:00 a.m.—5:00 p.m.: Boardroom, AAAS, 1515 Massachusetts Avenue, N.W.

Tuesday, July 26, 1983, 8:00 a.m.--11:00 a.m.: Salon E, Second Floor of the Washington Marriott (1221 22nd Street, N.W., corner of 22nd and M Streets).

I. Welcome and introduction of participants and guests.

II. Overview of the study, survey, site visits, and intended products.

III. Purposes of the study.

IV. Results of mail survey.

   A. How the survey was done.
   B. List of projects: suggestions for what needs phone canvassing.
   C. Tabulations of forms: additional ones needed and interpretation.

V. Project directors' summaries of their programs.

VI. Results of the site visits.

   A. Selection of sites.
   B. Reports of consultants and staff on site visits.

VII. Synthesis — preliminary conclusions.

VIII. Report and recommendations to the Commission.

   A. Organization and contents of the draft.
   B. Discussion of the document.

      1. Suggestions for improvement of analysis.
      2. Recommendations: revision and additions.

IX. Policy implications and findings.

APPENDIX F

DOCUMENTING CHANGE: SOME EXAMPLES

- MESA (Mathematics, Engineering, Science Achievement) -- Lawrence Hall of Science, Berkeley, California

This program has proved to be extremely portable (with adaptation, of course) and has spread from the Bay Area all over California, Colorado, New Mexico, Washington state and Baltimore, to name some examples. From its beginning in 1970 with 25 students, it has grown to a program with 16 centers, 131 high schools and almost 3,400 students in 1982-1983. The program has benefited from a clear focus and design, efficient management, and a dedicated staff. An external evaluation of the California program by the Center for the Study of Evaluation, UCLA, noted, "MESA may work because it has side-stepped much of the 'noise' in the educational system."

Results of the evaluation study indicate that:

1. Of recent MESA graduates, 90% have attended a college or university and approximately 66% have pursued a math-based field of study.

2. "MESA seniors performed significantly higher than college-bound seniors of similar racial/ethnic backgrounds across the nation."

3. "MESA seniors at sampled schools did not differ significantly on SAT performance from the total population of college-bound seniors state-wide and nationally (regardless of ethnicity), despite the fact that sampled schools were among the lowest-achieving schools in the state."

In a follow-up of former MESA participants at sampled postsecondary institutions, the majority of these students were found to be in good academic standing and progressing at an average rate.

- Summer Science Enrichment Program -- Atlanta University Resource Center

This program has provided summer instruction in mathematics, science, and communications to 338 high school juniors since its inception in 1979. This selective program draws student participants from across the United States but mostly from the Southeast. It focuses on students who have demonstrated interest and performance in science and mathematics. Of the mostly Black students who have participated in this program 100% have gone on to college, 95% of them majoring in a quantitatively based field.

- Career Days for Women

Based on a model developed out of the NSF Women in Science program, this model seems to have caught on all over the country. There is a broader base for such efforts, with reported sponsors as diverse as museums, universities, school systems, local chapters of the American Association of University Women, women's professional groups and sororities.

The power of receiving accurate information about the relationship between mathematics course-taking and future career choice for women cannot be overstated. Activity oriented toward women in science careers began in the early 1970s, with a major push occurring in 1976 with the initiation of the NSF Women in Science efforts. Though most of the NSF-supported programs were aimed at the college level, we have good indications that flow down occurred to programs at the high school level. "Expanding Your Horizons," a precollege model out of the Bay Area Math/Science Network, based at Mills College, has been transported to a number of other locations.

When one compares the degree output for women over the 1970's to the milestones for increased "women in science and engineering" activity, one sees amazing correlation. The steady upward movement in science degrees for women began around 1973. In 1980 (the expected college completion date for the high school class of 1976), the number of engineering bachelor's degrees awarded to women reached 6,072: up from 4,919 in 1979 and more than 10 times beyond 1973 figures. Engineering is a good field to look at since it was a major focus of most of the women's intervention programs. Bachelor's degrees awarded to women are outlined below.

Attribution is difficult, especially when looking at the effects of information that may be received in many ways -- through direct participation in workshops, media coverage of such programs, and direct contact with schools, programs, or women scientists. But one can surmise that these activities stimulated discussion and led to further search for information. If one compares degree data and course-taking for women from 1972 to 1980 one immediately concludes that <u>something</u> happened during that time, and this women in science movement is the only national effort that can be identified.

Field	1972	1980
Physical science	3,148	5,647
Engineering	501	6,072
Life sciences	12,694	27,606

In the 1980 study of high school seniors conducted by the National Center for Education Statistics, nearly equal percentages of females and males reported taking Algebra I, Algebra II, Geometry and Trigonometry.[13] There was a sizable difference in the reported taking of Calculus (10% of males, 6% of females). Despite these figures, a report by the College Board states that 54.4% of males and 42.9% of females reported taking 4 years or more of high school mathematics.[14] In 1972 Lucy Sells reported from the University of California-Berkeley freshman class that 57% of males but only 8% of females reported taking 4 years or more of mathematics.

- Professional Development Program of the University of California, Berkeley

This faculty-sponsored program seeks to address the problem of under-representation of minorities and women in mathematics-based fields. The overall program has distinct but interrelated activities and projects for high school, undergraduate, and pre-graduate/graduate levels. The secondary level program recruits sophomore students from 45 public and private schools in eight districts to participate in special summer academic programs followed by school-year Saturday classes. Over 60% of the students are female; 75% are Black or Hispanic. As with most academic

special programs, the selection process is rigid and requires completion of and demonstrated performance in algebra and geometry courses. Of the 421 students from 60 Bay Area high schools that have completed the program, 90% have gone on to college and a substantial number are in quantitative fields. These students maintain an average Grade Point Average of 2.8. The average SAT scores for Professional Development Program seniors in 1981-1982 were 1082: 598 in math and 485 in verbal.

- PRIME (Philadelphia Regional Introduction for Minorities to Engineering)

A consortium of more than 34 businesses, 14 government and civic organizations, and 7 area universities and public schools, PRIME is in its ninth year of operation. PRIME pioneered the concept of consortia and had at least eight other programs that replicated this model. PRIME begins in the 7th grade and takes students through high school. Since 1977 more than 820 high school seniors with 2 to 6 years of exposure to PRIME have graduated. Of these seniors more than 60% have chosen careers in engineering and/or technology. Even more significant is the increase in the participation of minority students in academic-track high school programs. In 1970 only 1,800 minority students were so enrolled; in 1980 the number had nearly tripled and approximately a third of the students are PRIME students. At a per student cost of $2.40 per week, PRIME offers the schools a mechanism that combines the talents of industry and universities and encourages academic excellence and student success.

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