DOCUMENT RESUME

ED 146 053 SE 023 272

TITLE	Models and Programs in Science Education 1959-1976. National Science Foundation Program Report, Vol. 1, No. 3.
INSTITUTION	National Science Foundation, Washington, D.C. Directorate for Science Education.
REPORT NO	NSF-77-35
PUB DATE	Jun 77
NOTE	29p.; Marginal legibility in Figures
EDRS PRICE	MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS	Curriculum; *Educational Programs; *Educational Trends; *Federal Government; Government Role; Historical Reviews; *Science Education; *Science Programs
IDENTIFIERS	*National Science Foundation

ABSTRACT

This document presents the National Science Foundation (NSF) review of science education strategies and models that have been developed and pursued via NSF support during the period 1959-1976. The review describes how federal policy and strategies on science education have changed over time and how they have affected programs and budgets. Also presented is a projected educational scenario of education in the 1980's and a discussion of major issues and options facing science education. (SL)

PROGRAM REPORT
VOL. 1 NO. 3 JUNE 1977

Models and Programs in Science Education 1959 - 1976

Presented By:
DIRECTORATE FOR SCIENCE EDUCATION

Prepared By:
OFFICE OF THE DIRECTOR;
OFFICE OF PLANNING AND RESOURCES MANAGEMENT
• PROGRAM REVIEW OFFICE

Foreword

National Science Foundation Program Reports are a port of the continuing process of review and evaluation of NSF programs and activities by the Director and NSF senior management. Reviews are presented by the responsible Program and Staff Offices. They are designed to present a candid appraisal of substantive program content, management, organization, and major trends and problems of senior management concern and interest.

Program Reports document these reviews, providing authoritative views of program objectives and accomplishments from the perspectives of the NSF Program Office having responsibility for their implementation. Publication of this report does not constitute endorsement or acceptance, in whole or in part, of the issues or changes that may be described in these reports by the Director or senior management of the Foundation. It must be kept in mind that such matters are frequently presented in the course of o review as discussion pieces, and the adoption or implementotion can only be effected through subsequent management processes or formal resource allocation procedures associated with "official" actions of the Director or, as appropriate, the National Science Board.

It should be noted that dollar and staffing information that may be cited in this report represents firm approvals of NSF management only for current year plans. Resource projections, including budget proposals, represent Program Office plans which are subject to official approval, and perhaps modification, at such time as NSF appropriations and operating plans are authorized.

Primary distribution of NSF Program Reports is intended for personnel of NSF having program/project management responsibilities. Consequently, such reports frequently have a fairly high technical orientation. They attempt, however, to provide a review of the "state-of-the-art" for NSF staff, members of the scientific community, and other persons with a speciolized interest in NSF programs and activities.

R. C. Atkinson

Richard C. Atkinson
Director

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Dr. Harvey Averch
Assistant Director for Science Education

INTRODUCTION

This review of Science Education will present the alternative strategies and models of science education that have been developed and pursued over the last 18 years. At any given time, Federal policy and strategies on science education are based on an interlocking set of beliefs and values. This review attempts to describe how those beliefs and values have changed over time and how they have affected programs and budgets. Of primary concern will be models and strategies at three critical periods in the history of NSF in science education -- 1959, 1971, and 1976. After discussing the models I will construct a reasonable educational scenario of our educational world in the 1980's. I will try to test the "goodness of fit" of our current strategies and programs against the emerging educational world. I will close with some major issues and options facing science education.

* * *

ALTERNATIVE MODELS OF SCIENCE EDUCATION

A model consists of: (a) normative values -- what ought to be; (b) beliefs about reality -- what is happening in science education; and (c) predictions of outcomes -- what will happen if this, that, or the other is done. As indicated in Figure 1, a model leads to a "strategy" by which is meant a program mix and funding level.

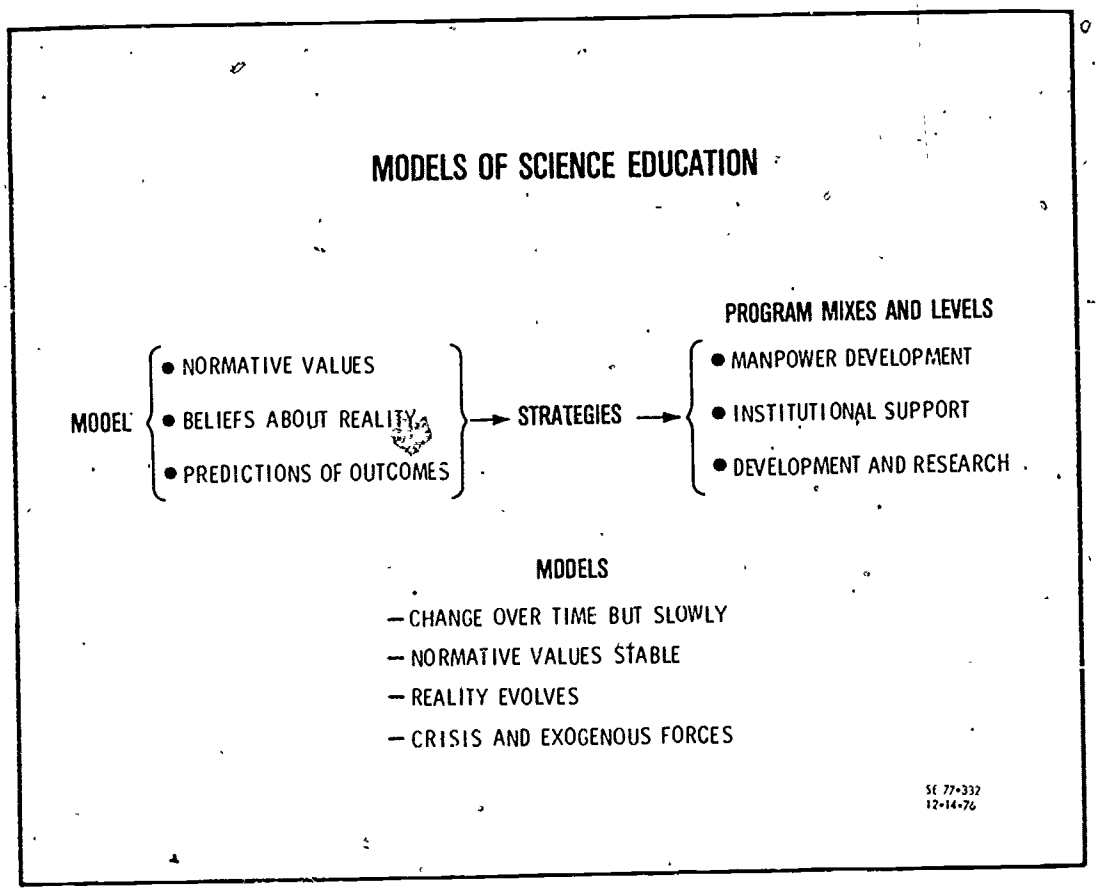


Fig. 1

I am going to use the program and budget categories that we use today -- manpower development, institutional support, and development and research. These categories do not always correspond to those used over the last 18 years, but I have tried to map the old categories into the current ones. We will concern oursevles with the level and mix of support for manpower development, institutional support, and development and research derived from the models during each of the critical periods.

Models -- as we have defined them -- change over time, but very slowly. This is because convictions about what ought to be in science education remain stable. However, the real world changes and this leads to tensions between the models, programs, and real-world requirements. It is very difficult for agencies to resolve such tensions internally because so much is invested in particular models. Such tensions are often resolved when exogenous forces are brought to bear in an agency. For example, in 1971 the Office of Management and Budget and the Office of Science and Technology became powerful actors in redirecting NSF's science education programs, as I will discuss later. Nevertheless, despite our past investments, any model should be tested. I will suggest two test criteria for educational models that I consider reasonable (Figure 2). One is whether the substantive purpose of the model fits the anticipated environment. The other is whether the model provides incentives for the system to adapt to the environment.

Before looking at particular models, it will be well to keep in mind the level of science education funding over time in relation to the Foundation's total budget (Figure 3).

Figure 3 shows the total net obligations for NSF and the net obligations for science education year-by-year since 1952. The years beyond 1976 are, of course, estimates. The dot at 1976 represents the NSF's total "program budget" for science education, that is, the direct obligations of the Directorate for Science Education plus an estimate of science education activities in the research programs -- primarily support of student assistants on research grants. The total budget then in 1976 is about $140 million. I will return to this concept of the education program budget later when strategic issues and options are discussed. I do suggest that for some science education models we must more precisely evaluate the education content of our research activities.

TESTS OF MODELS IN EDUCATION

- "GOODNESS OF FIT" BETWEEN MODEL AND EXPECTED ENVIRONMENT
  - SUBSTANTIVE PURPOSE
  - INCENTIVES FOR ADAPTATION

Fig. 2

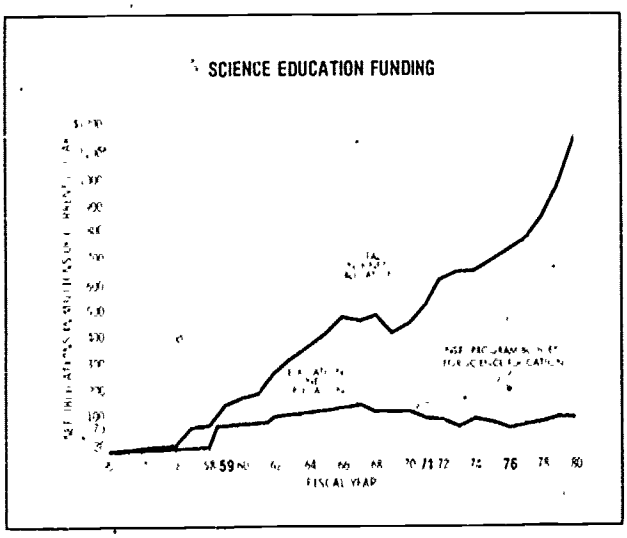


Fig. 3

Figure 4 shows science education funding as a percent of total NSF funding. The arrows indicate the three critical years that I have selected for scrutiny. The percentage of science education funding peaked in 1959, but, actually, this peak is misleading. Science education funding continued to increase beyond 1959, but funding for research increased more rapidly, causing the percentage for NSF education activities to decline. The next critical year, 1971, occurs on a true downswing. In 1976, the figure indicates that science education funding has leveled off and may even be rising.

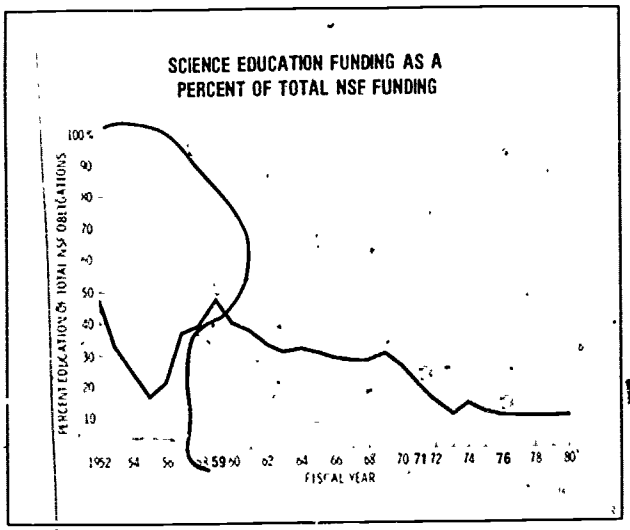


Fig. 4

The 1959 Model

Figure 5 presents the 1959 model. That year was a very bouyant time in science education.

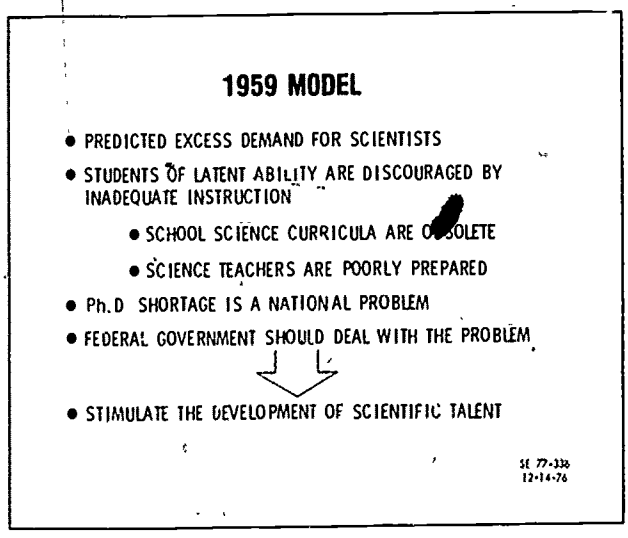


Fig. 5

Predictions of need for scientists and science teachers reflected this general buoyancy as reflected in Figures 6 and 7. They show that in 1959 the total demand for scientists and engineers predicted for 1970 was expected to be about 82 percent greater than in 1959. Physicists and mathematicians were expected to be especially in demand. While good projections of supply were not available, everyone seemed to agree that there were shortages and that the Nation was not producing enough scientific and technical manpower. Overall, the predictions in Figures 6 and 7 seem reasonably representative of the language and spirit of that time.

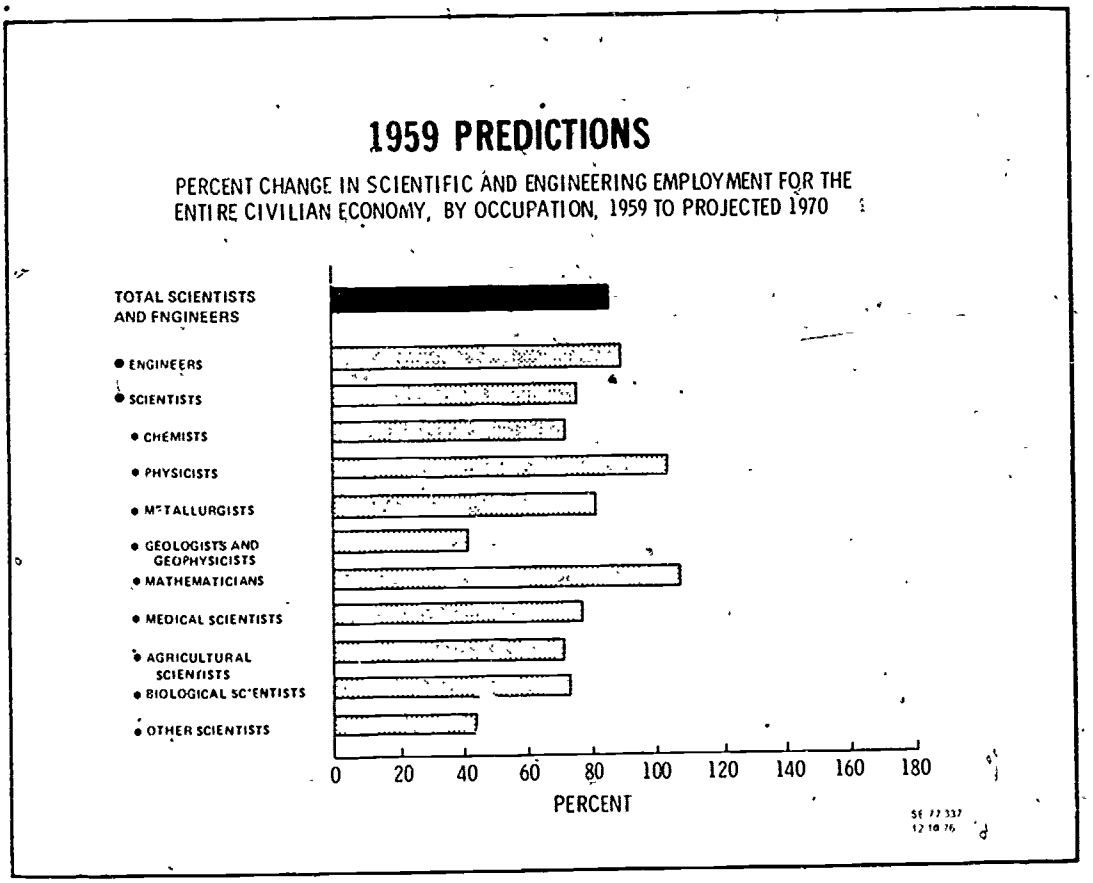


Fig. 6

In the face of these apparently sharply increasing demands for scientific and technical manpower, there was also evidence that about half of the high school students of latent ability (students with IQ's of 120 and above) were not pursuing higher education. Inadequate instruction resulting from obsolete curricula and poorly prepared teachers were believed to be significant causes.

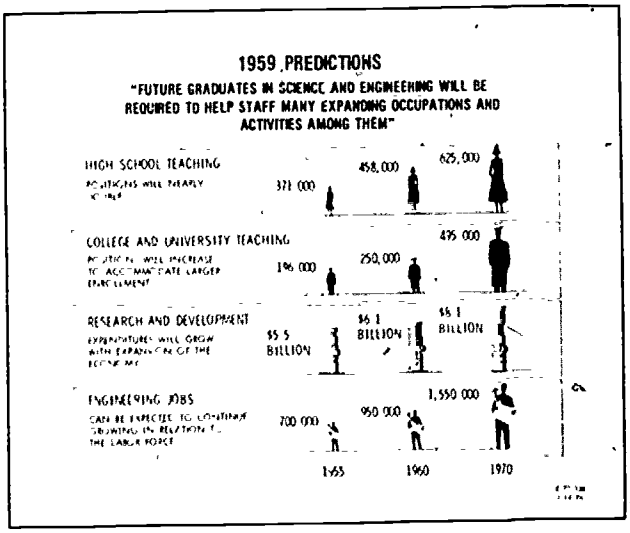


Fig. 7

These beliefs led to formulation of a strategy designed to stimulate the development of scientific talent and resulted in the program mix and funding level shown in Figure 8.

Figure 8 shows that 86 percent of the $64 million for science education in 1959 went for manpower development. This included fellowships and traineeships designed to create and increase manpower directly as well as teacher institutes to develop those who would, in turn, train our future scientists. The other 14 percent of the budget went largely for pre-college curriculum development.

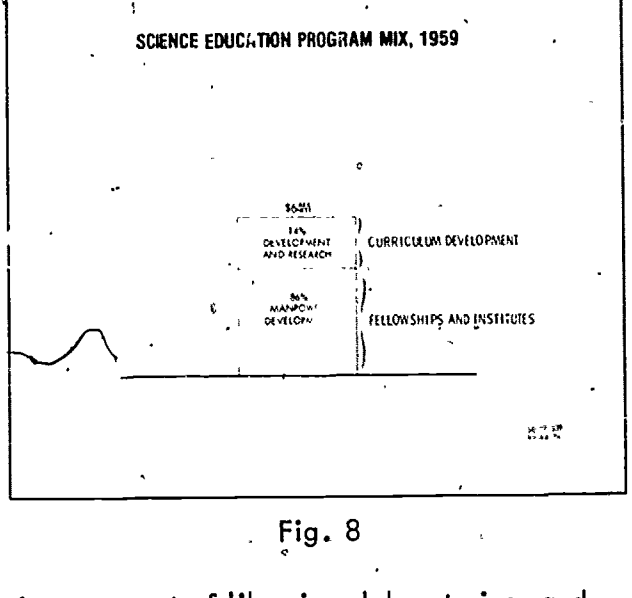


Fig. 8

As we moved from 1959 to 1971 the basic strategy remained the same, but new tactics were added. In addition to direct "human capital" formation through fellowships and teacher training institutes, some resources were earmarked for improvement of libraries, laboratories, and other facilities. That is, those engaged in forming our human capital would do so with the latest technology.

The 1971 Model

Figure 9 depicts the 1971 model and strategy drawn from it. Even though the projections shown in Figure 10 indicate an excess supply of scientists, there was a belief that the quality and variety were not adequate. This proposition about quality in our model suggest that while there may from time to time be more scientists than can be employed, one cannot identify in advance those especially talented individuals who will make the major breakthroughs. Consequently, even when supply exceeds demand, society is justified in continuing to inject a flow of new talent into the sciences. The social costs of such a policy are more than justified by the social benefits of unpredictable, but assured, scientific advances. Thus, we continued in 1971 to inject high-quality scientific talent into the science education system, although at reduced levels.

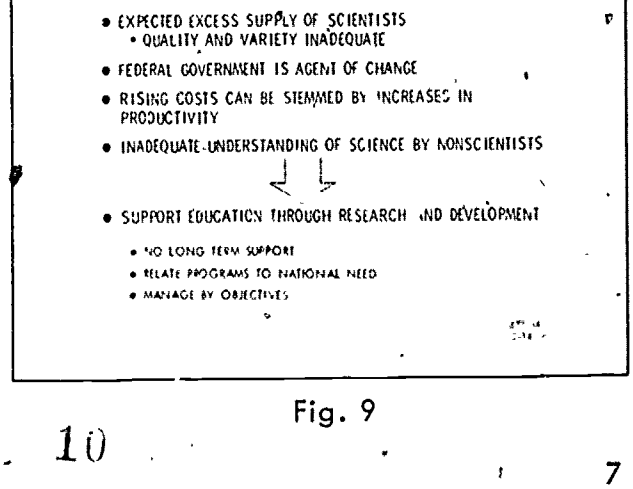


Fig. 9

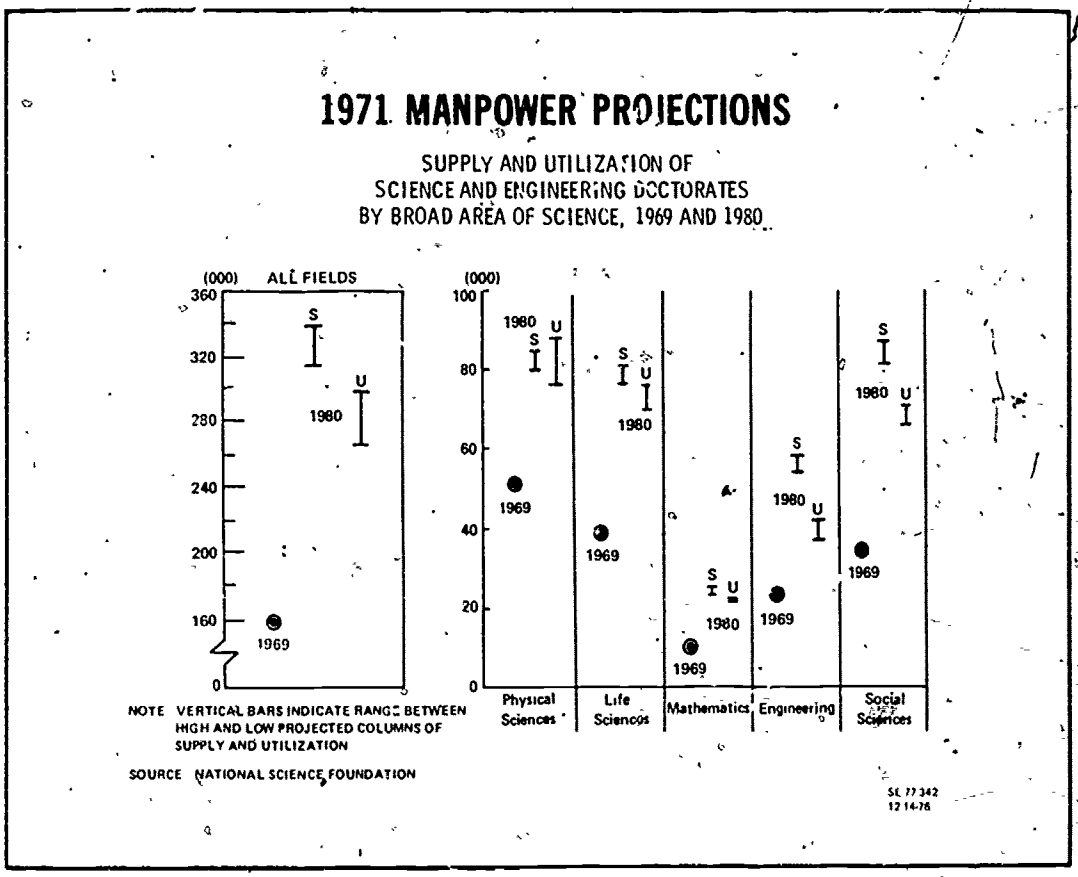


Fig. 10

Also in 1971, the Federal Government was viewed as an agent of change in the science education system. This contrasts to the 1959 view that it was an agent for developing quality and talent. One aspect of desired change related to the rising costs of education. Some relief, it was believed, could be provided by increases in productivity. But if the system did not rapidly adopt higher productivity technology and procedures, it was up to the Federal Government to provide strong incentives. Also, for the first time we find an explicit statement that nonscientists have a stake in understanding science, independent of support for education through the research system.

The strategy that emerged from this 1971 model is what might be called the RDT&E model -- research, development, testing, and evaluation. This meant that programs requiring funding indefinitely over time would give way to programs addressing specific national needs. They would be managed so that explicit objectives could be achieved within a specific time span. In sum, the Federal Government would act as an agent that would "lever" the science education system. As I noted, models often change as a result of the application of exogenous forces. This 1971 model seems to have come about as a result of a good deal of debate among NSF, the Office of Management and Budget, and the then Office of Science and Technology, along with some strenuous pulling and hauling on the overall NSF budget.

Figure 11 shows the program mix and funding level resulting from the 1971 model as compared with that for 1959.

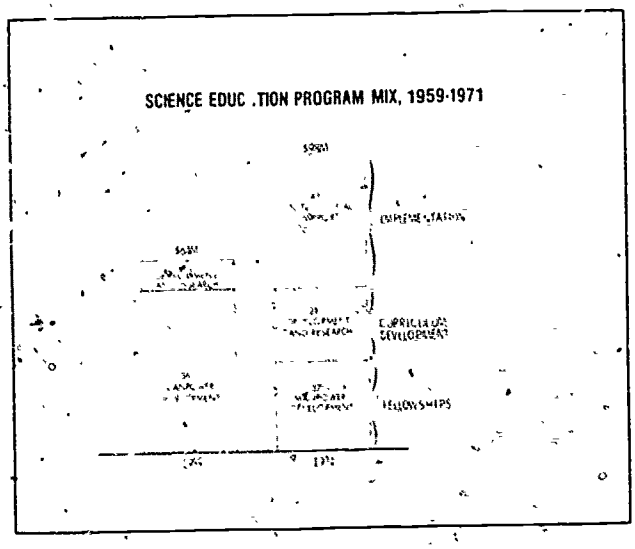


Fig. 11

Manpower development as a proportion of the budget was substantially reduced, although we still had a fellowship program. Curriculum development accounted for 21 percent of the total. Implementation, or technical assistance, became 43 percent of the total. As noted, the belief seemed to be that if the Federal Government is regarded as an agent of change and innovation, and if the science education system is perceived as recalcitrant and reluctant to change, then technical assistance to increase the rate of change and innovation becomes justified. This is exactly what happened.

Technical assistance, or implementation as it was called, extended to the point that, in order to get a grant for a teacher institute, an applicant had to agree that the material taught would be transferred to the classroom. Applicants had to sign a form to this effect. This requirement was eventually interpreted as an attempt to force school systems, teachers, and administrators to accept innovations that the NSF, or the Federal Government, believed to be appropriate.

It was natural, then, that the years from 1971 to 1976 were years of contention, debate, and criticism. The Congress, especially, expressed concern with the mode and the "R&D" strategy. The debate had three major themes: (1) the degree of Federal responsibility for general purpose support of science education versus its responsibility for stimulating innovation, particularly by supporting development of new curricula; (2) the amount of Federal dollars used to promote equity and fairness among the institutions providing science education versus the amount of dollars used for the currently most efficient delivery of education services; and (3) the value of education to improve scientific research versus education to improve science literacy among the young and the general public.

Some believed that science education support was justified only if connected to research. Others approached science education in terms of the needs of diverse clienteles and constituencies. Those holding the latter view did not regard a connection to the research system as necessary; their concern centered on delivering knowledge about science that would be useful in daily life or in participation in public affairs.

The 1976 Model

Figure 12 represents our beliefs about educational realities in the mid-1970's. It shows 1975 manpower projections for the year 1985. These projections do not suggest optimism about full utilization of our scientific and technical manpower. In 1971 it appeared that the physical sciences would fare reasonably well by 1980. But viewed from the vantage point of 1975, it appeared as though the physical sciences, too, will be in difficulty.

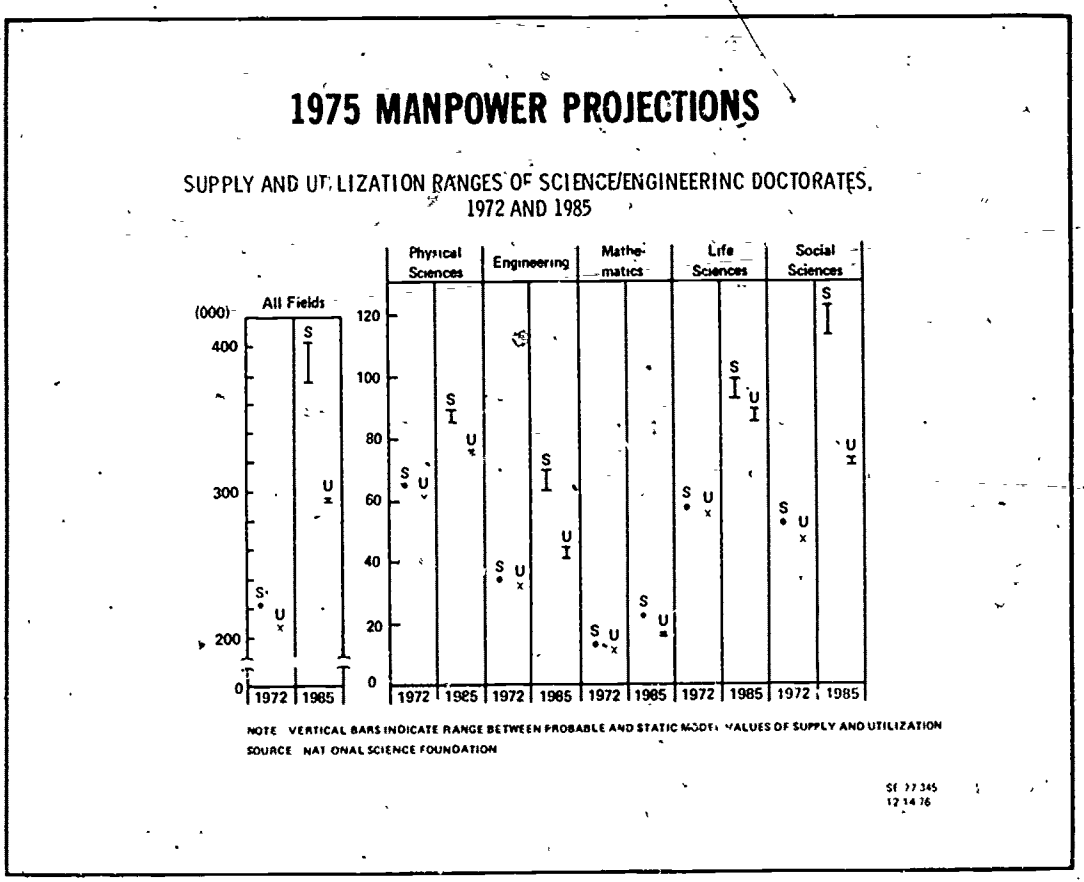


Fig. 12

Figure 13 shows the 1976 model.

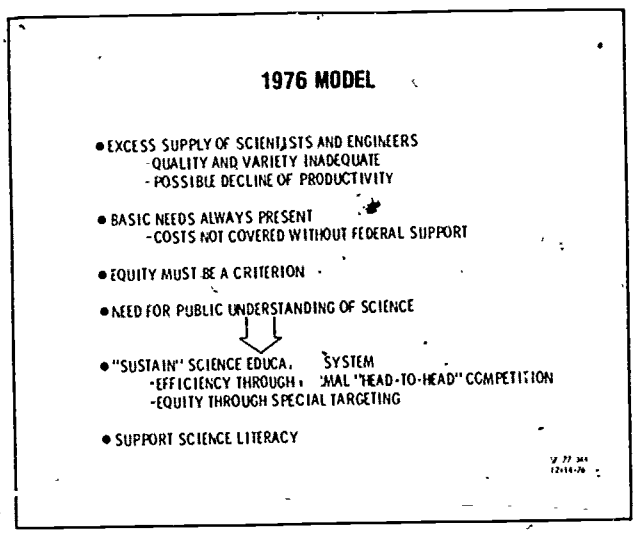


Fig. 13

We believe today that there will be an excess supply of scientists -- especially in the academic sector -- unless society decides to make large new social investments in R&D or education. The concern about quality persists. The possibility that some individuals may make significant breakthroughs is believed sufficient to justify infusion of some new talent even though the projections show excess supply.

A further concern in 1976 was the age distribution among college and university faculty. In the past, it was believed that the entry of young, technically current scientists and engineers maintained and even increased productivity in our research and education systems. However, we now envisian few new openings in our colleges and universities and this reinforces the search for new options that will allow us to maintain productivity and avoid professional obsolescence.

We also believe that the suppart we provide must be equitable as well as efficient. For equify today may manifest itself in improved performance tomorrow in both education and research. Similarly, equal opportunity must be a strong criterion in training our scientific personnel. This means that activities designed for special constituencies -- women, minorities, and the handicapped -- must become a significant part of the science education program.

Belief about the "publicness" of science now becomes stronger. We believe that there is a need for greater public understanding of science, especially concerning major issues of personal choice or public policy that have science and technology content. There appears to be a need for more interaction between scientists and nonscientists concerning maral issues connected with the impacts of science and technology. These beliefs suggest that programmatic emphasis on science -- emphasis on science museums, the media, and those who facilitate and deliver informal science education -- could respond to this need.

Figure 14 compares the program mix and funding levels for 1976 with 1971 and 1959. After five years of debate, we have returned to a mix addressed to a wide variety of audiences. We now have general purpose programs for institutional support, and programs that provide incentives for innovation. Very importantly in our Science and Society programs we are beginning to recognize science education outside our formal school and university systems as a vehicle for informed public decision-making and science literacy.

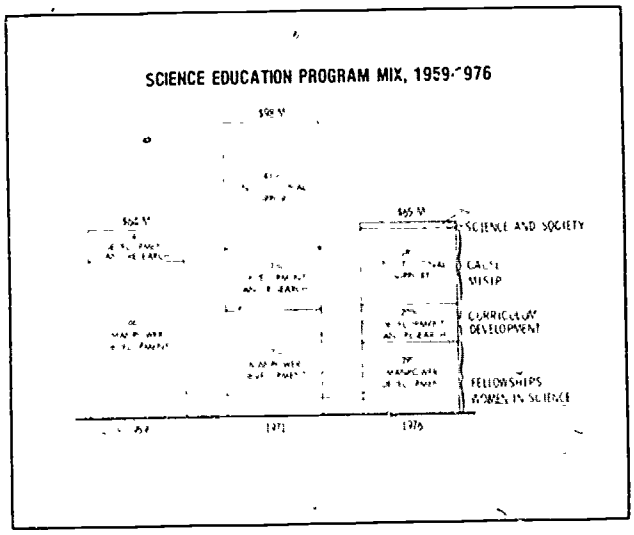


Fig. 14

For the first time in some years, we can say that our programs address science education problems at all levels. The design of these programs encourages institutions to evaluate their own performance, and to employ "self-help" measures to maintain momentum after support has run out. Such designs, I believe, provide incentives to adapt to the changing environment.

* * *

A REASONABLE SCENARIO FOR THE 1980's

Strategic beliefs need to be tested against our prospective educational world. We seem today to be heading toward a "steady-state" educational system. By a steady state, I mean we are in for a period of stability with a decreased flow of young students through our formal educational system. Because faculty-student ratios are relatively constant in our system of education, the number of new openings for teachers in our schools and colleges will be extremely limited.

We are now in a time of transition to the steady state. Colleges and universities, to maintain financial and intellectual integrity, are seeking new sources of students and are changing their offerings. Many of them face an aging faculty on the one hand and, on the other, demands for increased productivity in teaching and research. At the pre-college level the transition implies tight budgets and a continuously tight job market. We can expect further increased public demands for performance and accountability to accompany tight budgets.

Figures 15 and 16 attempt to show these and other trends. I have included what I believe will be some important changes in educational demands by those in the educational sector and by the general public.

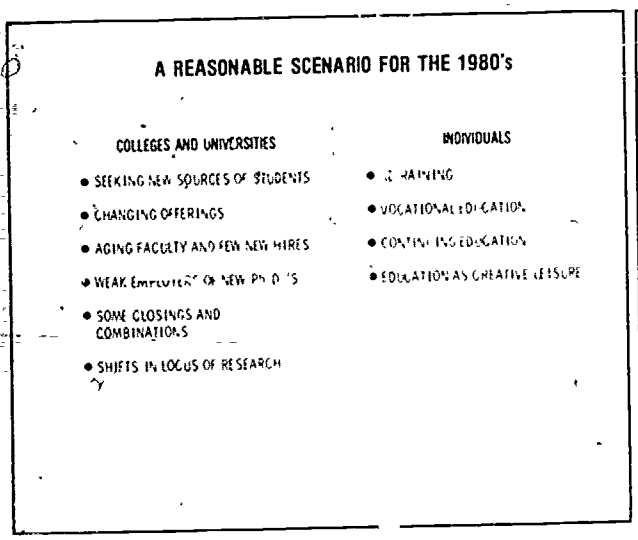


Fig. 15.

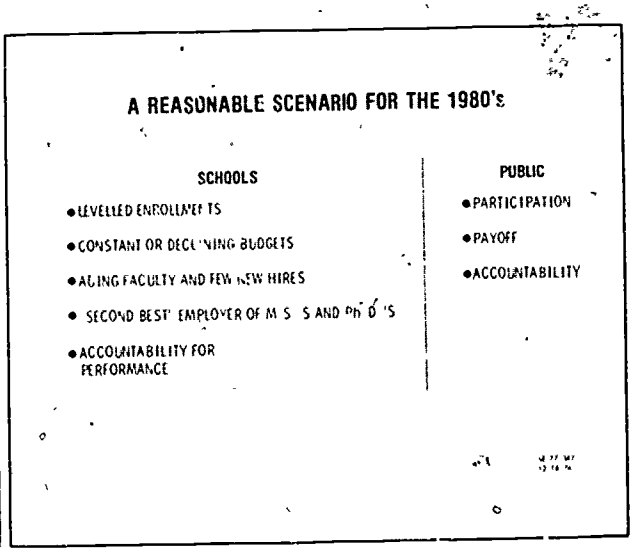


Fig. 16

If our colleges, universities, and schools were highly responsive to the changing "marketplace" for education, they might adjust to the "steady state" rapidly and without great difficulty and cost. For various reasons, they cannot be absolutely responsive, nor should they be. However, in the transition we may be facing a serious problem by having a formal system of science education that is too large, inefficient, and costly, and an informal system that is too small.

There are, in general, four Federal strategies that can be pursued with respect to this educational world (Figure 17).

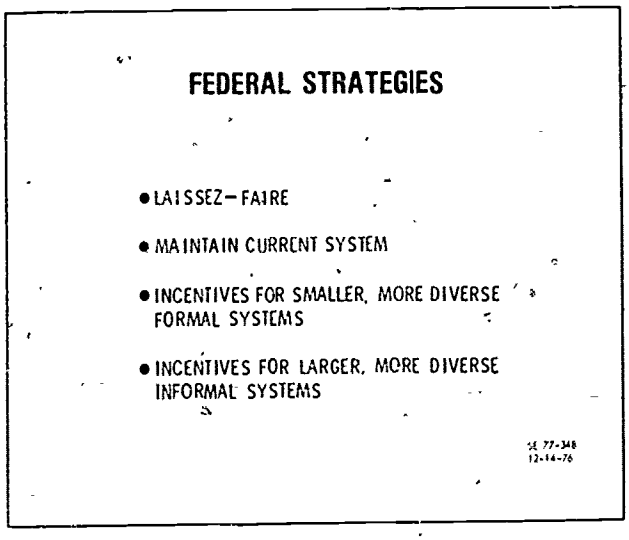


Fig. 17

We can leave our system of science education alone to sort itself out. We would then be prepared to accept the system that emerged. Alternatively, the Federal Government could try to maintain the current system. It could provide incentives for a smaller, more diverse, and more efficient formal system of education. It could also provide incentives for a larger, more diverse, informal education system.

Laissez-faire does not seem acceptable. Our science education system (or the education system proper) cannot be expected to work things out for itself without incurring very large social costs. Whether we like it or not, it does not appear feasible to maintain the current system. A reasonable Federal policy might involve some combination of the latter two options.

Science education within NSF is not immune to these general trends. I have tried to show this in Figure 18.

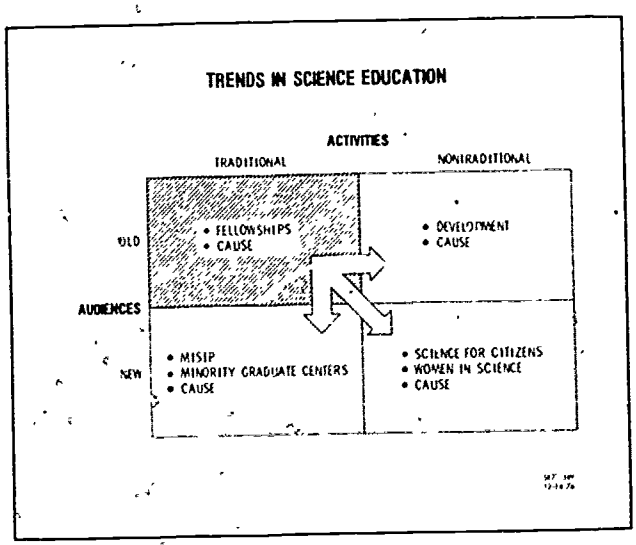


Fig. 18

In this figure "audiences" are graphed against educational "activities." Audience refers to proposers or applicants, and activity refers to those things for which audiences use grant funds. A traditional activity would be pure science for research-bound individuals. This is distinguished from nontraditional activities such as those supported, for example, in the new Science For Citizens program. The old audience comprises, for example, the top 20 research universities and the quality liberal arts colleges that feed the leading graduate schools. Members of the new audience are, for example, the set of junior and community colleges and public interest groups.

Science education at NSF has been operating during most of its history in the upper left quadrant of Figure 18. It has focused on the important, but relatively restricted, mission of fostering high-quality science education for primarily academic scientific careers. But today science education is facing demands from the new audiences that must expand. The new audiences -- minorities, women, and the handicapped -- want to participate more

fully in traditional types of science education activity. Traditional audiences such as four-year colleges want to diversify their activities and other audiences such as two-year colleges or museums envision new kinds of science education activities. I have represented these demands for participation by the arrows out of the upper left quadrant.

* * *

GOODNESS OF FIT OF THREE PROGRAMS

d at the beginning that we need to test the goodness of fit of our entire model and pro-
s. But due to limited time, instead, I will take a closer look at three programs: Fellow-
, Comprehensive Assistance to Undergraduate Science Education (CAUSE), and Develop-
and Research. The reader can extend analysis to other programs. As I noted, it is
onable to test programs for their substantive content and for the incentives they provide
daptation.

Fellowships

re 19 shows our Fellowship strategy.

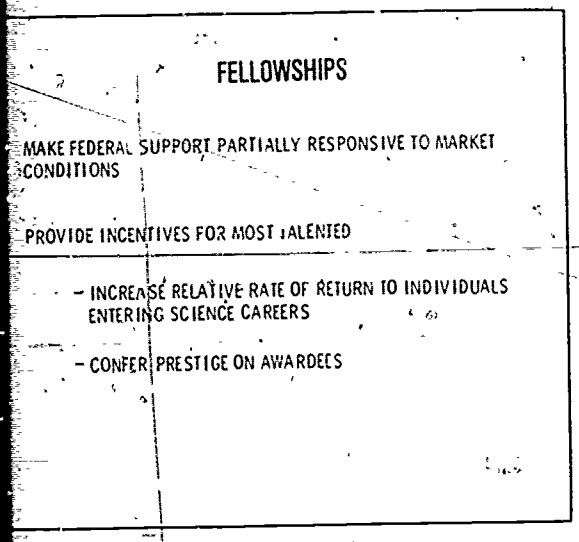


Fig. 19

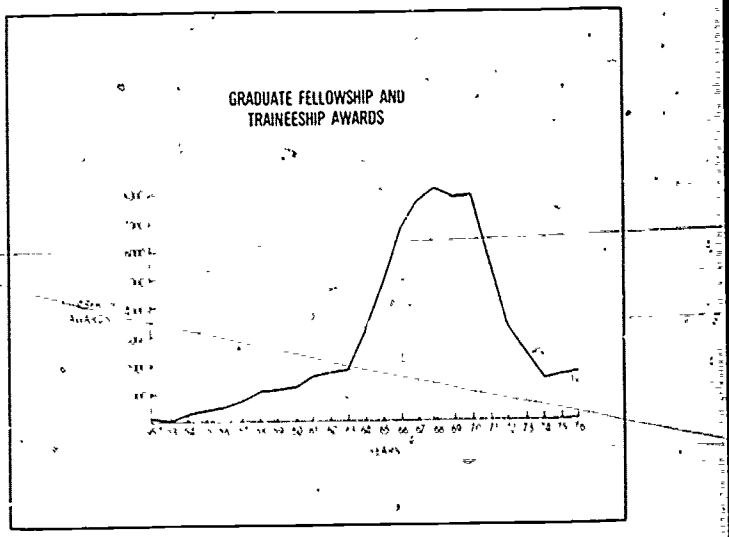


Fig. 20

e 1960's when it appeared more scientists were needed, fellowships and traineeships
greatly expanded. Figure 20 indicates how the magnitude of the program has responded
arket conditions.

The number of awards in the 1960's reflected the 1959 projections for demand, but by the early 1970's when projections began to indicate excess supply, the number of awards dropped sharply. Figure 20 suggests that the real preference of the Federal Government was to be pro-cyclical; it did not try to be a stabilizing force.

From a social perspective, fellowships provide incentives for the most talented; from an individual perspective they increase the payoff from graduate school for those receiving them and, of course, there is some prestige value attached. Unfortunately, the payoff seems to be decreasing. Some economists now calculate that the rate of return on investment in graduate education is about 11 percent.

How well has the program served its purpose? Figure 21 shows the distribution of awards in terms of graduate record examination scores. Very few applicants with scores of under 1,300 have been selected. If GRE is correlated with, or predicts scientific success, then our selection process is reasonably efficient on average. But since GRE is not a perfect predictor, we need to be concerned about equity in the process.

Figure 22 shows the citation rates for biological science fellows and that they have a higher citation rate throughout their careers than applicants who did not get awards.

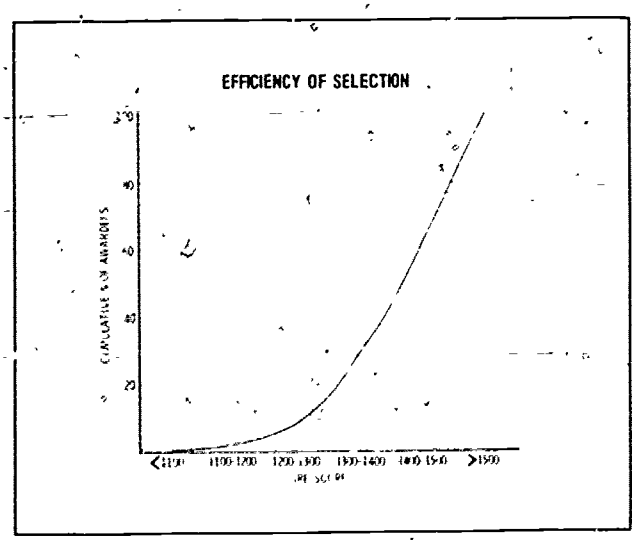


Fig. 21

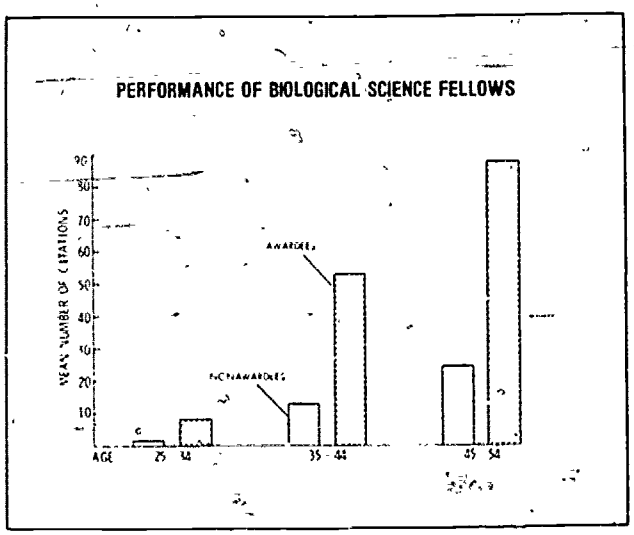


Fig. 22

Similar outcomes hold for all other fields of science and supports the belief that the most productive are being selected. However, from this data we cannot really infer that scientific success or productivity is brought about by the training received or by our efficient selection process. We can, however, acknowledge that the program does inject high-quality talent into the research system.

There are several equity problems connected with the program. Figure 23 shows the concentration of fellows in particular institutions. The closer the curve gets to the 45° line, the more even the distribution. If 50 percent of the Fellows were in 50 percent of the eligible institutions, the curve would be on the 45° line.

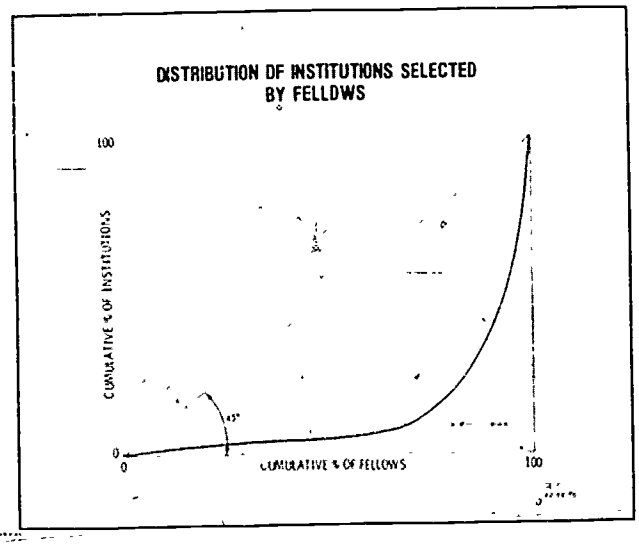


Fig. 23

In fact, the distribution is skewed. Roughly 70 percent of the Fellows are in 10 percent of eligible institutions, and this has caused some concern.

Another equity concern relates to women and minority applicants. Although the NSF has some latitude to adjust awards in relation to sex and ethnicity, the proportion of minority fellows is too low.

Figure 24 shows how the Fellowship program might be judged.

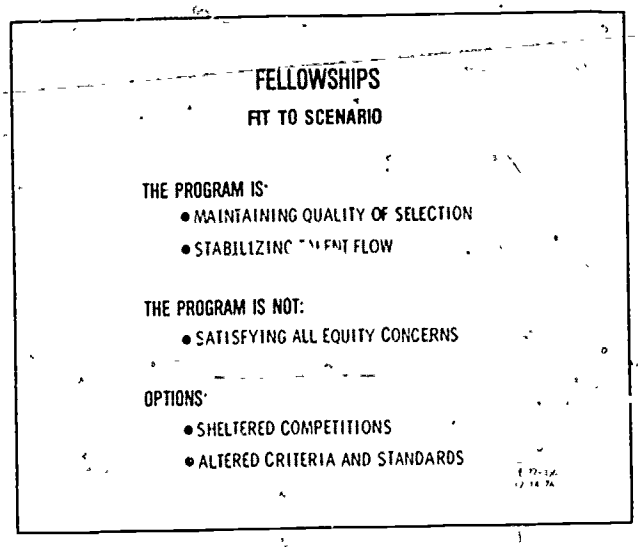


Fig. 24

It is fair to say that the program is maintaining the quality of selection and is stabilizing the flow of talent into the system. The program is not satisfying all equity concerns. These concerns take two forms: whether or not women and minorities get enough fellowships; and whether the heavy concentration of Fellows in very few institutions is fair. To address the first concern, in FY 1976 only one black student received a fellowship and women comprised 30 percent of the applicants but received 22 percent of the awards. There are at least two options that can be considered in response to the equity concerns. One is sheltered competitions, the other is alteration of criteria and standards. By law, the fellowships can be given on merit grounds only. They are awarded in terms of so-called "quality groups," Quality Group One being the highest and Six the lowest. In practice the system works as follows: Quality Group One is composed of the most outstanding applicants and all get awards. Quality Group Two consists of more individuals than there are awards remaining, and all applicants in the group are considered to be of equal merit. In selecting awards from Quality Group Two, weight is given to geographic distribution (in terms of applicants' home states), ethnicity, and sex. There are not normally enough awards available to go below Quality Group Two. It has been suggested that we reduce the size of Quality Group One, expand Quality Group Two, and give preference to women and minorities in making selections from Quality Group Two.

CAUSE

We turn now to CAUSE, an unusually complex and interesting program. All 3,000 two- and four-year institutions in the United States are eligible. The 1,200 two-year schools are a new audience for NSF. CAUSE is designed to achieve efficiency by allocating funds through a very rigorous competition. It is supposed to achieve equity or fairness through priorities in the program for two- and four-year colleges. An assumption behind these priorities is that the undergraduate programs of the Ph.D.-granting institutions have less need of outside assistance, because they are wealthier, and because there are "spillovers" from the graduate programs.

The CAUSE strategy is given in Figure 25.

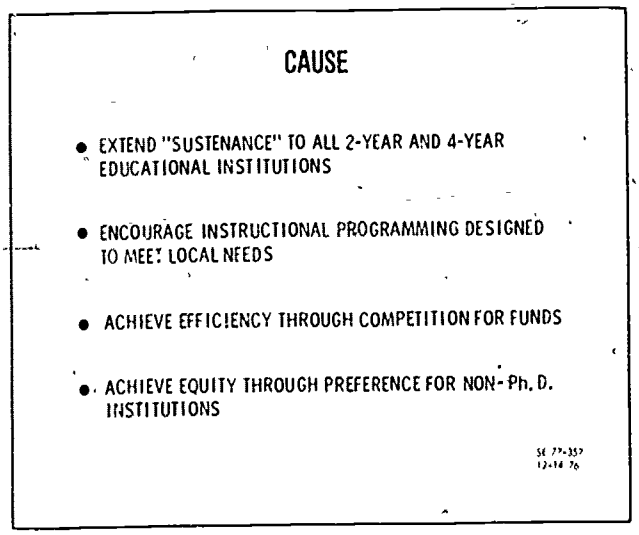
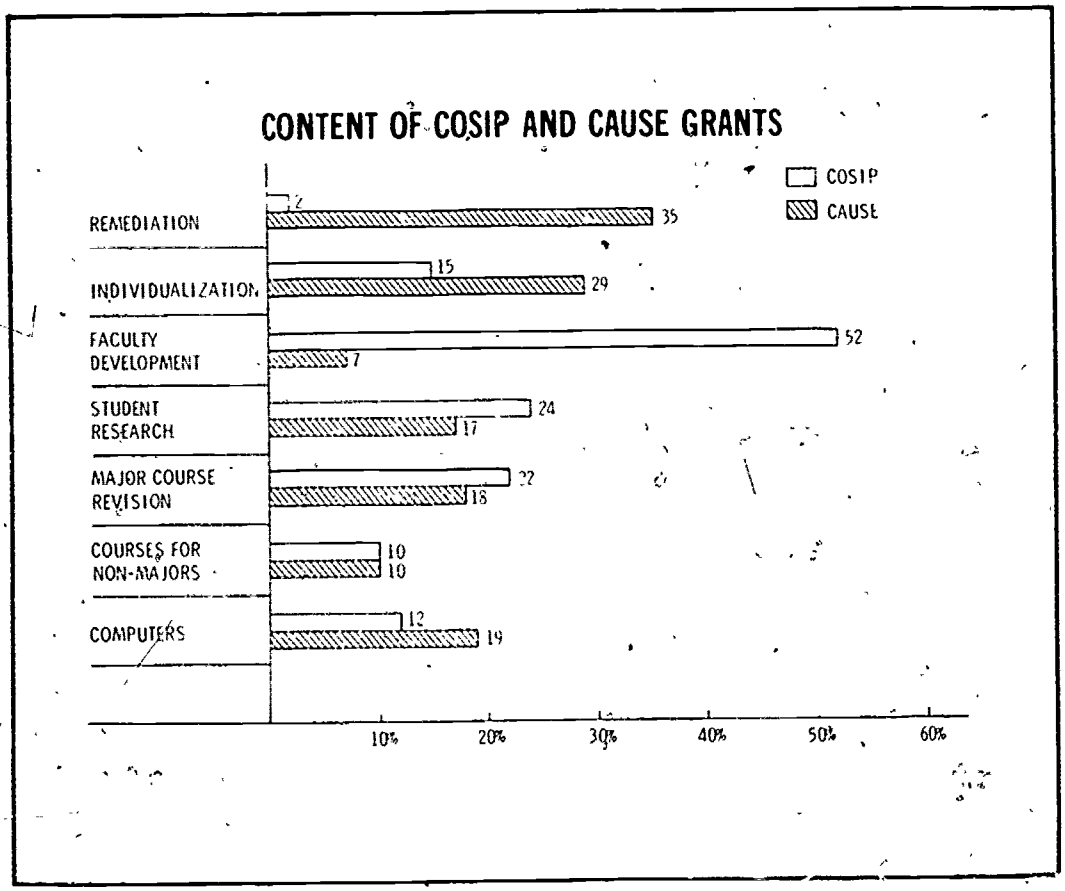


Fig. 25

ure 26 shows a comparison of CAUSE and an analogous program -- College Science
rovement Program (COSIP). COSIP supported undergraduate institutions of excellence
he early 1970's. In COSIP only two percent of the funds went to remediation; in CAUSE,
percent of the grants go for remediation. Twenty-nine percent of the CAUSE grants
olve individualized instruction, compared to fifteen percent in COSIP.



. 26

ure 27 shows the distribution of
USE and COSIP grants in terms of
audience-activities matrix
sented earlier.

nty-five percent of COSIP grants,
only 41 percent of CAUSE grants,
t to the old audience for traditional
vities.. Forty-one percent is still
reat deal, but institutions today
ear to be defining their audiences
their problems differently. Some
hese differences may arise in part
different eligibility standards.
eligibility standards reflect differences

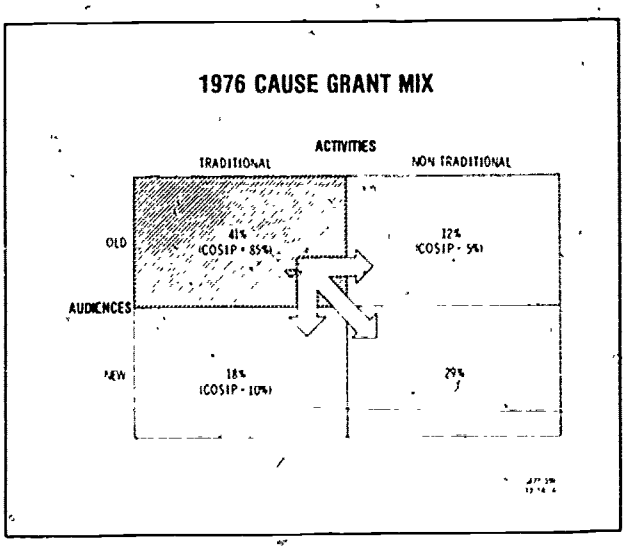


Fig. 27

in strategic models. CAUSE is broader than COSIP was, because science literacy is now an explicit part of our science education model.

The success rate for CAUSE proposals was only seven percent in 1976 -- 59 grants from 766 proposals. Figure 28 shows the projected impact of the CAUSE program at the current budget level and with a doubled budget from 1978 on. At the current level we would reach about 25 percent of the audience by 1985, but if funds were doubled we would reach 25 percent by about 1981. This year there are one-third fewer proposals which will improve the success rate. We do not yet know what has dropped out of the competititon and how this will affect the impact of the program on the system.

A qualitative evaluation of CAUSE is shown in Figure 29.

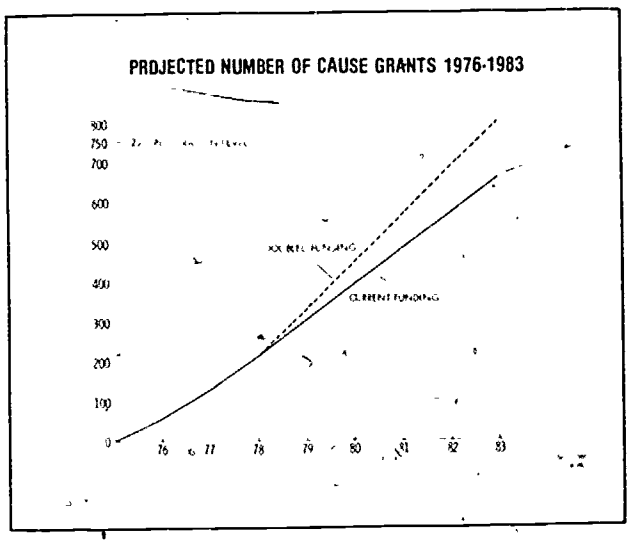


Fig. 28

CAUSE is meeting local needs and serving new audiences. It meets some equity demands by its emphasis on previously noncompetitive institutions, but it is not reaching a substantial part of the eligible population.

The options then are: (1) We could decrease the size of the grants. The current ceiling is $250,000. But we already have small grant programs for local course improvement and for instructional equipment. There may be a good argument for one large program of small grants, but there may be room for adjustment short of this. (2) We could treat CAUSE grants as natural experiments and prototypes and try to evaluate them and disseminate

CAUSE
FIT TO SCENARIO

THE PROGRAM IS
- SUPPORTING DIVERSIFICATION
- PROVIDING INCENTIVES FOR EFFICIENT INSTRUCTION
- PROVIDING INCENTIVES FOR PREVIOUSLY NON COMPETITIVE INSTITUTIONS

THE PROGRAM IS NOT
- REACHING A SUBSTANTIAL PROPORTION OF THE TOTAL ELIGIBLES

OPTIONS
- DECREASE SIZE OF GRANTS SUBSTANTIALLY
- TREAT GRANTS AS PROTOTYPES
- TARGET "MOST CRITICAL" CONCERNS
- ALLOW LOW PROBABILITY OF SUCCESS TO REDUCE APPLICATION PRESSURE
- INCREASE LEVEL OF FUNDING SUBSTANTIALLY

Fig. 29

the information gained. (3) We could try to prespecify the educational areas which would be eligible for support, i.e., specify that resources should go to remediation or individualization. But it is difficult for a central funding agency to specify how institutions should adapt to changing conditions. (4) We could increase the level of funding substantially. By this I mean a discontinuous increase in the budget.

Development and Research

Figure 30 shows the strategy for Development and Research. It is a new strategy and a much more explicit one than in the past.

Figure 31 shows that we continue to support work on materials and technologies. However, our old audience is developing nontraditional programs and courses. Also, there are new approaches to problems not explicitly addressed before, for example, the use of computer-assisted instruction for remediation in two-year colleges. In the past two years, no Development and Research projects have been specifically identified as concerned with minorities, women, and the handicapped, but it can be expected that a year from now there will be activity in this area.

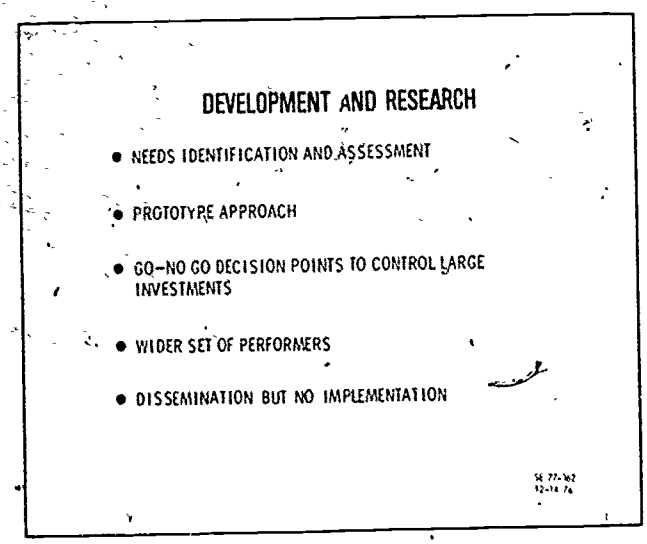


Fig. 30

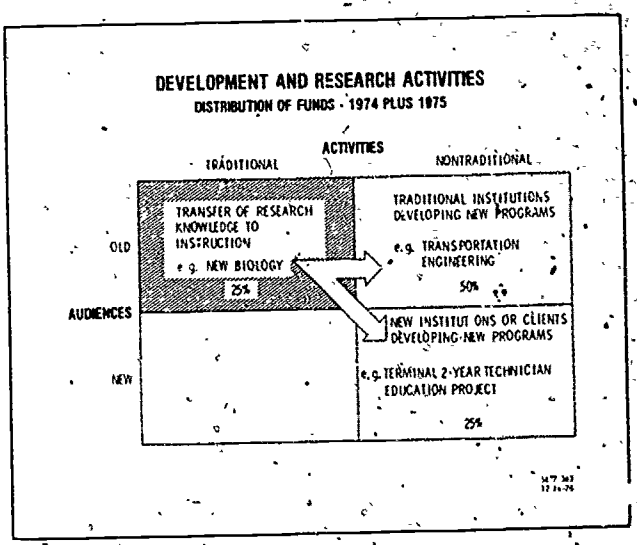


Fig. 31

Evaluation of the Development and Research program is necessarily more tentative than that for the support programs because this unified program has only recently been initiated. Figure 32 shows some interim judgments on development and research.

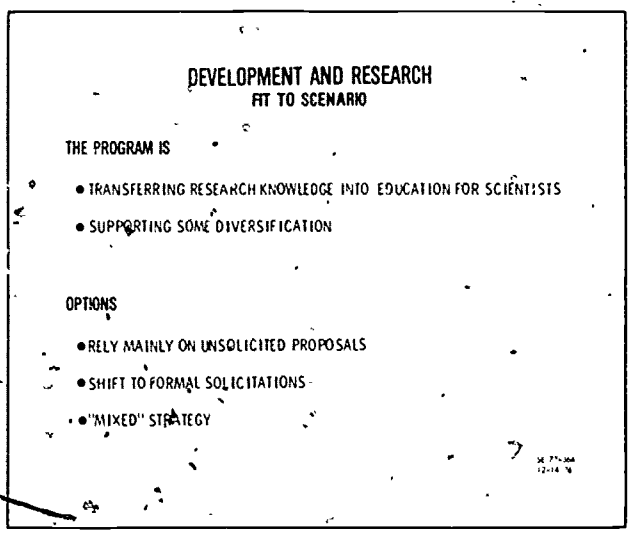


Fig. 32

The program is fostering the transfer of research knowledge into education, both of content and of modes of presentation. It is supporting innovation and diversification. We do not have a good sense of what it is not doing at the moment, but its structure should make it quite adaptable to the world of the 1980's.

In treating Development and Research, we have identified three options for the future. We can continue to rely on unsolicited proposals, use proportionately more structured program solicitations, or use some combination of the two. The difficulty with unsolicited proposals is that there is no natural process which assures that the mix of meritorious unsolicited proposals will produce an effective and balanced solution to curricular and instructional problems. On the other hand, central funding agencies have not proven to be especially good predictors either. We could identify particular needs and issue solicitations, but we should not limit ourselves exclusively to our own judgment. It will probably be best to retain both methods.

As I noted, time does not permit the qualitative evaluation of all 27 programs in Science Education. However, we do expect to extend this analysis to the other programs, and this process should give us better knowledge of our overall effectiveness.

* * *

GENERAL ISSUES AND OPTIONS

I will return now to the strategic issues I began with. Employing the audiences-activities matrix, four options for the Directorate for Science Education are outlined in Figure 33. It is clear there will probably be some activity in all four quadrants under any option chosen. What is at issue is relative emphasis.

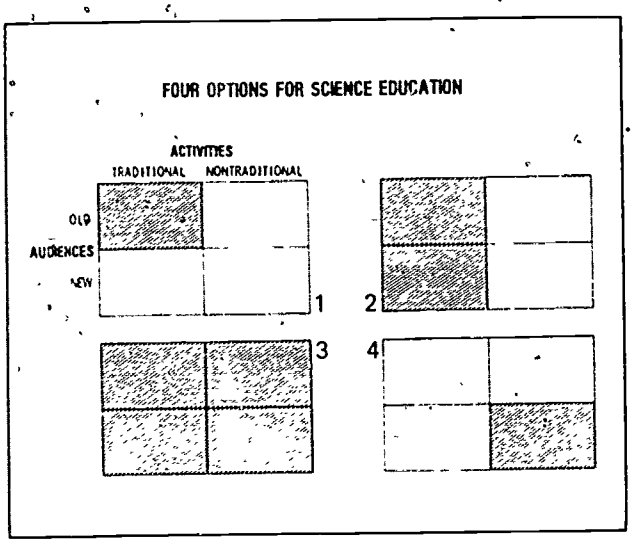


Fig. 33

1. One option would be to keep the science education funds concentrated on the traditional mission -- encouragement of the highly talented -- to sustain the research system. This approach would provide a clear definition of mission, and would reinforce the support of the science community. Internally, it would be easy to operate because it would concentrate on audiences and activities that are very familiar to the staff of the Directorate for Science Education. The disadvantages of this strategy are that it does not answer those who wish to see greater individual and institutional equity reflected in our programs, and it ignores a large proportion of the issues raised as we move toward an educational steady state.

2. A second option is to retain emphasis on activities for the scientifically talented, but encourage the broadening of participation in these activities through mechanisms such as sheltered competitions, revised criteria, and pre-award assistance. The advantages of this approach are that the mission of science education would remain well-defined, the science community would remain supportive, and greater equity would be achieved. Internally, this option would not create serious problems, given the emphasis on the talented, although we would need to continue to learn how to contact and work effectively with new audiences. The disadvantages of this approach are that it, too, would ignore emerging educational

problems, and it would create a resource problem. Because of the number of new institutions and individuals that wish to participate, we would need either to cut back substantially on resources going to the old audience, or our budget would need to be considerably increased.

3. A third approach would be to attempt to operate in all four quadrants. This strategy would have the advantage of responding to the emerging problems. However, the mission of science education would be much less defined. Continuing support by the scientific community proper might be jeopardized. Internally, operations would become more difficult, because new criteria for judging the effectiveness of activities would need to be established.

We must also face some critical questions regarding resource levels, if we are to support all activities for all audiences. To expect to have any impact, it would probably be necessary for the Science Education budget to expand discontinuously. Increasing audiences and activities would certainly spread current resources beyond the point of any impact.

4. A fourth option would be to shift the Science Education program toward new audiences and nontraditional activities. The rationale would be that basic and applied research activities of NSF provide educational support through assistantships and direct employment. Science education should thus operate in a totally different environment with relative emphasis in support of information education, e.g., science museums, the media, etc. The advantages of this approach are that many issues not currently being addressed could be included in the program, and it would offer the greatest possibility for building a general public constituency for science education. This approach, as I noted, implies that the educational content of research grants would have to be explicitly evaluated. Internally, exercising this option would be the most difficult as it would call for experience and skills not possessed by our current staff.

I do not claim to have the answer to what options the Directorate for Science Education should choose, nor would it be appropriate for us to make this decision independently of others' needs and interests. We have continuing responsibility to our old audiences as represented by the upper left quadrant of the program, but we cannot, for long, ignore the other three and we will continue to face external pressures to operate into the other quadrants. As a rough guide to decision, I believe the programs of the Directorate for Science Education need to be designed to strike a reasonable balance between our responsibility to provide the educational base for our research system and the need to be responsive to new audiences who have broader, more generalized requirements for science education.

* * *