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ABSTRACT

Presented is a detailed study of National Science Foundation programs in pre-college science education. The development of policies and operational procedures were traced over the past quarter of a century and their impact on management practice was analyzed. The report is presented in two parts: Volume 1, the findings and recommendations, and Volume 2, to include basic documents related to Volume 1. Volume 1, this volume, summarizes the extensive work of the review team. It presents the general findings of the study, along with the principal observations of the team, and highlights the major policy issues that formed the basis of discussion for a special meeting of the Advisory Committee for Science Education. Recommendations of this committee are included. Finally, recommendations made by the chairman of the review team are presented. Many areas of administrative practice that could be improved are pointed out--specifically, the need for better definition of interval documentation, more explicit criteria for selecting reviewers, and clarification of procedure, followed in the modification of proposals in response to reviewer comments. (Author/EB)

Pre-College Science Curriculum Activities of the National Science Foundation

REPORT OF SCIENCE CURRICULUM REVIEW TEAM

MAY 1975

Volume I—Findings and Recommendations

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FOREWORD

A special review team was appointed by the Director of the National Science Foundation, H. Guyford Stever, for the purpose of reviewing the NSF program in pre-college science education.

The review team, as directed, completed a detailed study of pre-college science curriculum development and implementation activities. The development of policies and operational procedures were traced over the past quarter-of-a-century and their impacts on management practice were analyzed. A carefully delimited study of all curriculum development projects was carried out and five representative projects were examined in depth. Background studies by outside consultants were commissioned and a substantial body of data was collected for use in preparation of the report.

The report of the review team is presented in two parts—Vol. I.—*Findings and Recommendations* and Vol II.—*Appendix*. Vol. I summarizes the extensive work of the review team. It presents the general findings of the study, along with the principal observations of the team, and highlights the major policy issues that formed the basis of discussion for a special meeting of the Advisory Committee for Science Education. Recommendations of this Committee as submitted to the Director, NSF, are included. Finally, recommendations made by the chairman of the review team are presented for consideration by the Director and the National Science Board.

As might be expected in any detailed review of a complex judgmental process, the review team identified many areas of administrative practice that could be improved. These include, but are not confined to, the need for better definition of internal documentation, more explicit criteria for selecting reviewers, and clarification of procedure followed in the modification of proposals in response to reviewer comments. While all are of importance to proper program performance, they can and should be addressed satisfactorily through normal administrative action, and, therefore, have not been taken up in detail in the report.

Vol. II—*Appendix* will include many of the basic documents used to arrive at the findings and recommendations of Vol. I. They include an historical overview of the factors impacting on NSF policies and programs in pre-college curriculum development and implemention, detailed summary case studies of five major projects, publication policy and financial arrangements, a summary audit and curriculum development financial arrangements. Attention is invited to the two contracted background papers which address important issues of curriculum implementation and commercial curriculum development activity.

In my opinion, the report is straightforward, factual and speaks directly to important issues. It is remarkably comprehensive considering the relatively short time available to the research team and supporting staff. Under the direction of Dr. Joel Snow, the team remained objective throughout and provided a balanced analysis that honestly addresses both strengths and weaknesses of the program.

I want to express my appreciation to the review team members and to the other members of the staff who contributed much time, thought, and effort to the development of this report, often with considerable personal sacrifice.

Robert E. Hughes
Assistant Director/National and International Programs
Chairman, Science Curriculum Review Team

EXECUTIVE SUMMARY

On April 7, 1975 the Director, National Science Foundation appointed a review team to undertake a detailed study of the pre-college science curriculum activities of the NSF. The team has completed its study and has submitted its report in two volumes; Volume I, *Findings and Recommendations*. and Volume II, *Appendix*.

After extensive investigation and development and analysis of a substantial body of data, the review team has made the following observations:

- The program has been instrumental in bringing about a major change in the content of science teaching materials at the pre-college level
- No comprehensive review of future needs for pre-college curricula has been carried out, although there has been extensive change in the national situation with respect to these curricula
- There is a need for substantial reexamination of the policy framework of this program
- Project management decisions conformed adequately with policies, procedures, and practices in effect at the time decisions were made
- General NSF management practices were consistent with policies in effect at the time
- While there has been steady improvement in operational and management practices, additional improvements can be made.

Five general policy issues were identified. These are:

- Redefinition of the NSF role in curriculum development
- Determination of future needs
- Open competitive process for selection of awardees
- Strengthened proposal review and project evaluation processes
- Redefinition of the NSF role in curriculum implementation.

These observations and issues were discussed in detail on May 9-10, 1975, among members of the team and the Advisory Committee on Science Education. The Committee then made the following recommendations:

- NSF has a continuing role in science curriculum development at the pre-college level; NSF should not avoid controversy at the expense of educational and scientific value;
- NSF should take an active and continuing role in determining needs for improvement of pre-college science education
- NSF should use a broad range of granting mechanisms, including expanded use of "program solicitation" procedures
- All large scale projects should have detailed evaluation plans and make provision for external summative evaluation
- Developers should be encouraged to make arrangements for publication, manufacturing, and marketing without a requirement for NSF funds.

The chairman of the review team, after consideration of the results of the study and discussion with members of the NSB, made the following procedural and policy recommendations.

PROCEDURAL

- A needs assessment program should be initiated to develop and establish priorities for curriculum development
- Procedures should be developed to guarantee broad dissemination of needs, competitive proposal procedures, review by qualified professionals and, when appropriate, pilot testing of competing courses
- Formal in-depth review of completed curriculum development programs should be carried out
- More formal, structured procedures should be established for periodic review of ongoing major curriculum development programs
- Barriers to broad diffusion of new curriculum materials should be researched and results broadly disseminated to allow and encourage State and local authorities to exercise their total responsibility for adoption of curriculum materials
- The NSF should ensure, by legally binding agreements, that all curriculum development grants include the NSF disclaimer clause.

POLICY

- The National Science Board should develop a definitive policy statement on the purposes and objectives of NSF curriculum development activities. This statement should delineate the extent to which future activities in both the natural and social sciences should be directed toward the objectives of supporting science training specifically for individuals embarking on science careers, and science education for *all* students to illuminate the underlying nature of our technological world.
- The National Science Board should formulate a clear policy statement on the role of the NSF in natural and social science curricula implementation. Since curriculum implementation activities are designed to disseminate materials that are sometimes regarded as controversial or political in nature, a clear policy is needed for the guidance of future activities.
- Mechanisms for administering curriculum implementation that allow NSF to remain at "arm's length" from the process are needed. New approaches should involve State and local authorities, private institutions and academies.

CONTENTS

I. Purpose and Design of the Study

Dr. H. Guyford Stever, Director of the National Science Foundation established a special Science Curriculum Review Team to undertake a detailed study of all pre-college science curriculum activities of the NSF. The review team was charged with developing an analysis of the policies, procedures, and practices of the program from its inception to the present. Further, the team was to determine whether NSF procedure was adequate to ensure that:

- proposed subject matter fits within reasonable limits or norms with respect to educational value;
- scientific content is accurate;
- course developers are responsible and competent persons;
- institutional and contractual arrangements are sound.

Additionally, Dr. Stever stressed that:

- the study and analysis should be in all respects independent and objective,
- the examination of cases and experience should be complete and unbiased by our previous practices,
- scrutiny of the fiscal and management approach should be thorough and unhindered by past commitments,
- potential or real conflicts of interest must be carefully addressed,
- NSF policies and practices are to be carefully scrutinized to ensure that the appropriate role of NSF in curriculum development is being followed.

Dr. Stever further directed that the study team ensure that:

- a thorough examination of past practices is undertaken,
- a rigorous analysis of business and contractual relationships is developed, and
- positive recommendations for improving the program's practices are developed.

"A fully effective analysis of these issues is essential to honest examination of the integrity of our curriculum programs.

"As you know, I am committed to reporting our conclusions to the Congress after appropriate discussion with the Advisory Committee for Science Education and the National Science Board. Your work is a crucial element in formulating this report. Let me urge you to require that in every respect that this study will be a model of objective and professional analysis."

In his letter of April 1, 1975, to Congressman Olin E. Teague, Chairman of the House Committee on Science and Technology, Dr. Stever outlined the structure of the analysis to be undertaken.

"In my NSF review I plan to have investigated the pre-college curriculum development activities in a broad sense, including MACOS particularly and also the program more generally. To do this, some procedural questions will be studied; for example, the distribution rights and royalty arrangements. In addition to a general survey of all of the curricula that have been developed, I shall have the review team make a detailed study of several cases as well as MACOS to see what they illustrate about the procedures that NSF has used in the support of curriculum development. The review will examine the following:

(A) Curriculum Development Program

(1) History

(2) Case Studies

a. CHEM Study (Chemistry curriculum), 1959-1972
b. Science Curriculum Improvement Study, (SCIS) 1962-Present
c. Man: A Course of Study (MACOS) 1963-1970
d. Comparing Political Experiences (CPE) 1972-Present
e. Individualized Science Instructional System (ISIS) 1972-Present

(B) NSF Distribution Policy and Royalty Arrangements

(1) History
(2) National Science Board Policy (1969)

(C) Curriculum Implementation Procedures

(1) History
(2) Research Studies Regarding Implementation
(3) Current Practices

(D) Evaluation Procedures for Establishing Content and Utilization

(E) Practices and Procedures in Science Curriculum Developed by Other Organizations

(F) Recommendations

Designated members of the team included:

Dr. Robert E. Hughes, Assistant Director for National and International Programs (Chairman of the Review Team)
Dr. Grover E. Murray, Member, National Science Board, and President, Texas Tech University and Texas Tech University School of Medicine
Dr. L. Donald Shields, Member, National Science Board, and President, California State University at Fullerton
Mr. Robert B. Boyden, Audit Officer
Dr. Eloise E. Clark, Director, Division of Biological and Medical Sciences
Dr. James D. Cowhig, Deputy Director for Public Sector Productivity
Mr. Walton M. Hudson, Budget Officer
Dr. J. Arthur Jones, Program Analyst, Office of Planning and Resources Management
Mrs. Maryann B. Lloyd, Deputy General Counsel
Mr. Leonard A. Redecke, Contracts Administrator
Dr. Joel A. Snow, Director, Office of Planning and Resources Management (Executive Secretary of the Review Team)

Many other members of the NSF staff with scientific, grant and contract, financial management, and research management experience were called upon to contribute to the study. Members of the Education Directorate staff provided source material and assisted in the development of factual data. It is important to note that none of the members of the review team had worked in the programs being investigated.

A major effort was undertaken to analyze practice and procedure in five curriculum development projects. The five examples were chosen to represent a wide range of fields of science and are at differing stages of program development; one is totally completed and "closed out," two have completed the development phase and are being implemented; and two are still under development. It is believed these examples provide a representative view of the evolution of NSF procedures for curriculum development and implementation.

Project case studies were carried out by review team task groups which also included experienced NSF officials with professional backgrounds in both science and business practice. Each task group was instructed to examine the grant records over the lifetime of the project and to document how each significant project decision was made.

In the examination of project files the review and monitoring history of each project and the decision making process were analyzed.

The results of this detailed analysis were transmitted in writing and with full documentation as internal working papers, to the Executive Secretary of the review team. After completion and critique of this analysis, each task group prepared a summary report describing the curriculum project and developed recommendations for possible improvement of program practice or policies. Appendix 4 comprises the summary case study reports.

A general survey covering a sampling of all 53 NSF curriculum development projects was also undertaken to determine whether the issues raised in the course of the case studies were isolated instances or were more widespread. In addition to the above analyses, working documents were developed which related to each of the items identified in the outline (page 2). Particular attention was paid to the business and financial elements of the projects. The distribution policy and fiscal history were reviewed and audit reports were prepared on each of the case study projects. A summary of these audit reports is found in Appendix 5; the individual audit reports are on file.

The roles of NSB, the Congress and the Executive Office of the President in developing NSF policy in the pre-college curriculum area were examined. In addition, background studies were commissioned on the practices of the publishing industry and its relationship to government funded projects and on the extensive research literature relating to curriculum implementation. The Office of Education and the National Institutes of Education provided information about their practices, and finally, an analysis of evaluation and oversight procedures was prepared. These working documents and the case studies provide the basis for the analysis presented in this report; many of the documents can be found as appendices to this report, Volume II.

The final report was prepared by a group assembled by, and under the direction of the Executive Secretary of the review team.

II. Findings, Observations, and Policy Issues

This section contains a general survey of curriculum projects and synopses of five case studies chosen for detailed analysis by the review team. Also presented are observations that represent a consensus of the review team. Policy issues that were identified during the study are organized to reflect the flow of activities in curriculum development projects and were discussed jointly by the members of the review team and the Science Education Advisory Committee in meetings held May 9 and 10, 1975.

Director Stever charged the review team and Committee with ensuring that:

- the proposed subject matter fits within reasonable limits or norms with respect to educational value
- the scientific concept is accurate
- the course developers are responsible and competent persons
- the institutional and contractual arrangements are sound.

The list of 53 curriculum projects follows. More than half were reviewed in some depth by the team. Detailed case study summaries from which the synopses were drawn are to be found in Volume II, Appendix 4.

LIST OF CURRICULUM PROJECTS

	Curriculum Project	*Current Status*
**1.	Physical Science Study Committee (PSSC)	Completed
**2.	School Mathematics Study Group (SMSG)	Completed
3.	Chemical Bond Approach (CBA)	Completed
**4.	BSCS Biology	Completed
*5.	CHEM Study	Completed
6.	Elementary School Science Project—University of California	Completed
7.	Elementary School Science Project—University of Illinois (Atkin)	Completed
8.	TV Program for Mathematics Teachers	Completed
9.	Syracuse Webster Mathematics Projects (Madison)	Completed
**10.	Elementary Science Study (ESS)	Completed
**11.	Anthropology Curriculum Study Project (ACSP)	Completed
**12.	Science-A Process Approach	Completed
13.	University of Illinois Committee on School Mathematics	Active
14.	MINNEMAST	Terminated

*15.	Science Curriculum Improvement Study (SCIS)	Completed
**16.	Earth Science Curriculum Project (ESCP)	Completed
17.	School Science Curriculum Project—University of Illinois (Sallinger)	Terminated
*18.	Man: A Course of Study (MACOS)	Completed
19.	Elementary School Science Improvement Project—University of Utah (Wood)	Terminated
20.	Secondary School Science Project (Time, Space, Matter)	Completed
**21.	Introductory Physical Science (IPS and PS II)	Completed
22.	Films for In-Service Education of Teachers of Elementary School Mathematics	Completed
23.	Quantitative Approach in Elementary School Science	Completed
24.	High School Course in Modern Coordinate Geometry	Completed
25.	High School Geography Project (HSGP)	Completed
26.	Sociological Resources for the Secondary Schools (SRSS)	Completed
27.	Engineering Concepts Curriculum Project-Man Made World	Completed
28.	Elementary Mathematics Projects (Arithmetic Project)	Completed
29.	Harvard Project Physics (PP)	Completed
30.	Portland Interdisciplinary Science Project	Completed
**31.	Intermediate Science Curriculum Study (ISCS)	Completed
32.	Improvement Project in Mathematics for Subcultural Groups (Gibb)	Completed
33.	Secondary School Mathematics Curriculum Improvement Study (SSMCIS)	Completed
34.	Computer Based Self-Instructional Course for Supplementary Training of Secondary School Teachers of Physics	Completed
35.	Environmental Studies for Urban Youth (ES)	Completed
*36.	Comparing Political Experiences (CPE)	Active
37.	Biomedical Interdisciplinary Curriculum Project (BICP)	Active
38.	Demonstration and Experimentation in Computer Training and Use in Secondary Schools (Dartmouth)	Completed
39.	Boston University Mathematics Program	Active
40.	Development of Computer Simulation Material (Huntington II)	Completed
41.	Development of Teacher Training Materials in Math (HCTH)	Completed
42.	Experimental Teaching of Mathematics in Elementary School (Suppes)	Terminated
43.	Exploring Human Nature (EDC)	Active
44.	First Year Algebra with Application Project	Active
45.	Human Behavior Curriculum Project (APA)	Active
46.	Human Science Program (HSP)	Active
*47.	Individualized Science Instructional System (ISIS)	Active
48.	Mathematics Problem Solving Project	Active
49.	Mathematical Resources Project (Hoffer)	Active
50.	Outdoor Biology Instructional Strategies (OBIS)	Active
51.	Project for the Mathematical Development of Children	Active
52.	Technology-People-Environment (TPE)	Active
53.	Unified Science and Mathematics for Elementary Schools (USMES)	Active

* 5 Case Studies

** 9 projects selected for relatively intensive review

FINDINGS

Findings of the review team members are summarized in the General Survey of Curriculum Projects and synopses of the five case studies.

It must be strongly stressed that the material presented here is structured to identify and highlight problem areas and does not reflect the overwhelming extent to which the procedures and administrative activities represented good judgment and sound management.

GENERAL SURVEY OF CURRICULUM PROJECTS

To fulfill the Director's charge, the review team sought to identify any problems—past, present or future—of possible public concern. More than half of the 53 projects were screened for indications of procedural ineffectiveness and to determine the degree of compliance with established policies. Six procedural areas were considered in the survey: (a) needs assessment, (b) proposal generation, (c) proposal evaluation, (d) development monitoring, (e) evaluation of materials and processes, and (f) arrangements for production and distribution.

Nine sample projects, in addition to the case studies mentioned, were selected for a relatively intensive review. They were chosen because they represent a significant fraction of the total NSF obligations in the field—an aggregate obligation of $95 million—which, along with the $30 million obligated for the five case studies, covers 76 percent of the total amount obligated for curriculum development and implementation.

NEEDS ASSESSMENT

Strengthened external review procedures will be required if effective mechanisms are to be created for the determination of needs for new curricula. This is illustrated by some of the following problems identified in the course of the study.

Typically, a needs assessment related to a particular field is performed by a conference of scholars and educators in that field. Experience has shown that it is commonly assumed by conferees that a need in *fact* exists, and that the question of *how* to improve a curriculum is to be addressed. This assumption of need during development of certain projects has resulted in a less than clear definition of goals. Lack of specificity in early development stages, reliance on conclusions of study groups on other topics, and the modeling of projects on existing examples has at times created doubts concerning the need for a new course.

In some instances, projects have been spin-offs, initiated in fields not previously taught as separate disciplines; others have been initiated primarily because they complement existing projects; and yet others are

open to question because of their sheer number, e.g., twenty projects in the field of mathematics. Heavy expenditures for preparation of texts in one project drew criticism because it was argued that private enterprise was meeting the need.

Procedures requiring a systematic and independent assessment of the need for projects are less than adequate. Clearer statements of needs would improve NSF's ability to generate a broader base of interest in potential development projects, provide a framework upon which competitive proposals could be evaluated, and could enhance the basis for monitoring development and evaluating results.

PROPOSAL GENERATION

Ordinarily a proposal to undertake curriculum development is submitted in response to informal encouragement by the Foundation of a source whose credentials have been established and who is perceived as responding to a potential need. In this survey no case was found where competitive proposals for the same project exist. Further, the Foundation has taken no explicit position on competitive solicitation.

Criticism could be directed at certain proposal generation practices which may have led to questionable results. Examples include the charge that formation of a corporation was a direct result of one project grant; that some proposals have been developed in direct consultation with the Foundation; that other projects have been transferred from one institution to another along with the project director; and that there have sometimes been no records to indicate how the transfer or acquisition of a particular project was effected by a grantee.

A more normal competitive solicitation procedure, if instituted, could result in more focused delineation of specific needs, more definitive short- and long-term planning and should elicit more detailed, and in some instances, more realistic cost estimates.

PROPOSAL EVALUATION

The need for outside review prior to initial funding becomes evident when it is realized that an award in seven figures for a continuation of work has occasionally been granted after review by one individual, albeit subject to approval by higher management. Initial funding, it appears, has in some instances been granted without benefit of more than cursory staff review.

Proposals to initiate major phases of a project are ordinarily subject to mail and NSF divisional committee review. Mail reviewers' complaints that some proposals were too extensive or complex to be given more than a global appraisal are supported by many of the reviews examined by the team.

Often, in current practice, evaluation is performed by a single project director which has led to his "owning" it and becoming the ultimate authori-

ty on its nature, success and value. While this procedure is of merit in a research program, it is less felicitous in these costly projects that are designed to meet specific public needs, and which would benefit from expanded outside review.

As in other procedural matters, judicious proposal evaluation would encourage development of explicitly stated goals, well formulated plans, and a realistic budget clearly related to the project plan.

MONITORING OF DEVELOPMENT

While the Foundation's monitorship of most projects appears to have been broad, vigorous and responsible, it appears to have lacked a systematic approach. The files examined reveal extensive but occasionally incomplete records on administrative, financial, and technical matters, and it appears that most contacts with NSF staff were initiated by grantees. Few progress reports were found, and those on file were normally submitted with a request for renewal of support.

Advisory groups are not required by NSF but are usually formed by grantees to monitor projects under development. If the Foundation relies on these groups, it runs the risk of becoming captive to the grantee whose creature the advisory group almost inevitably is. True neutrality in such an autonomous arrangement is difficult, and the deliberations of these groups would appear to merit more stringent monitoring.

Generally, a policy of neutrality has been maintained on substantive matters, but where the Foundation has been the sole source of support for a large grantee organization, it has usually accepted responsibility for the grantee's salary and employment practices. In a few cases, this practice may have resulted in excessive disbursements or an inappropriate degree of Foundation intervention in fiscal practices of the grantee.

There is further evidence that suggests the need for increased monitoring. Major awards have sometimes been deemed necessary to continue efforts on certain projects in order to glean useful materials from earlier disappointing performances. Lack of monitorship has resulted in continued support of some projects where the aims of the Foundation and the grantee have, over time, diverged; where tangential activities have been pursued to the detriment of the goal; and where empire building tendencies on the part of the grantee have become evident. Weaknesses could be corrected by more active monitoring and by clarification of policy on Foundation support of revision costs and by setting maximum personnel per capita costs.

A model or detailed plan is needed to provide a framework for evaluating status information. Such a model should include a basis for evaluating the acceptability of subject matter, accuracy of its content, the competency and responsibility of potential course developers, and the soundness of institutional arrangements.

EVALUATION OF MATERIALS AND PROCESS

The question here is to determine whether materials and processes under development respond to the needs, goals and specific objectives originally addressed in the project plan. This differs from the "formative" monitoring and evaluation described above. An effective example of this type of evaluation is demonstrated by *The National Longitudinal Study of Mathematical Abilities* in which students were followed for five years to determine effects of conventional, SMSG, and other new course sequences on performance in mathematics and science.

Lack of a systematic procedure for evaluating project results has left the Foundation vulnerable to such criticisms as sponsorship of materials development beyond its legitimate sphere, or support of courses which touch upon value-charged matters in a possibly insensitive or ineffective way. Materials cited have included those which apparently treat evolution as a fact rather than a theory; deal, however obliquely, with religious institutions, ethnicity, human behavior, birth control, and reproduction; and those using living materials. It is not claimed that science related to these subjects should be excluded from support, but rather that NSF lacks a systematic procedure that would ensure monitoring of the use of potentially controversial materials and that would also ensure careful decision-making.

Elitism is yet another charge that has been leveled at some projects—those which lead to the benefit of but a few—while the content of others has been judged too difficult for the average student targeted. Following the adoption of some courses, the level of enrollments has actually dropped. Random reactions to implemented courses on the part of evaluators have run the gamut from "too highly structured," "of limited usefulness," "too vigorous," to the expression of belief that teachers are not always adequately prepared to handle the new course material. Another reason given for lack of widespread adoption of some courses is simply that they cost too much.

A more systematic procedure for the evaluation of projects after implementation should be viewed as a high priority need in science curriculum development.

ARRANGEMENTS FOR PRODUCTION AND DISTRIBUTION

Such arrangements are usually made by the developer, but are normally subject to Foundation approval of subcontracts and disposition of income. Some evidence of procedural inadequacy was found in this area where Foundation approval was either not sought, or informally given, perhaps because most action is between grantees and subcontractors. However, free and effective competition seems to have been a normal practice, with contracts awarded to the lowest fully qualified bidders.

Authors paid from grant funds were commonly permitted to publish their work commerically, provided their royalties were paid over to the grantee.

Records indicate that income from development projects has been closely controlled by the Foundation. Typically, it is deposited in a special account and disbursed only with Foundation approval. Nearly $12 million have been returned to the Foundation by sixteen of the projects. Revolving funds were set up to finance publication in a number of the projects surveyed.

A recurrent issue appears to have been whether income could be used to finance the revision of curriculum materials. It is clear from the records examined that NSF has not adopted an unequivocal position on this question.

Recognizing that the selection of subject matter is a responsibility of school authorities, the Foundation, has, as a rule, limited the use of grant funds to the development of new materials and the dissemination of information about them. It has left publication and distribution arrangements to private enterprise. While it relied on its grantees to manage these processes, the Foundation has maintained ultimate control over them and is therefore indirectly accountable for the widespread distribution of experimental textbooks. Produced as paperbacks, these trial textbooks may have competed during the test phase with regular published editions. This suggests another area requiring policy definition by the Foundation.

SYNOPSES OF CASE STUDIES

The five case studies used were chosen for extensive examination because they are at different stages in the total process, because they represent different disciplines and reflect ways in which methods of development may have varied over the years. Again, the aim was to identify program procedures and potential problems, thus most findings relate to administrative practices rather than general policy.

Administrative decisions are necessarily contingent upon a policy framework. The foregoing survey and the case studies, synopses of which follow, served as an aid in staff and Committee development of the Observations and Policy Issues presented in this section.

SYNOPSIS OF CHEM STUDY REVIEW

The CHEM Study project which was initiated in 1960 and continued until 1972, had as its goal "organization of a chemical educational materials study to prepare, through research and study, textual and experimental material to aid in development of a modern chemistry teaching program for U.S. high schools."

The published material developed in the CHEM Study program includes a textbook, laboratory manual, teacher's guide, a series of achievement examinations, other supplementary programs and 29 films. Additional reading lists, wall charts and lab equipment items were developed.

Dr. Glenn T. Seaborg, University of California, Berkeley, was asked to assume leadership for the proposed revisions. A steering committee of experts was established to develop a detailed plan for content; compile lists of contributors, writing groups, and trial teachers; set target dates and develop an outline for initial testing in high schools. Following endorsement from NSF and after review by the NSB, an award to initiate the project was made.

By 1965, in addition to its widespread use in the U.S., the material had been adopted in many parts of Canada, India, New Zealand and Australia, and by 1968 the material had been translated for use in 13 foreign countries.

In the U.S. the materials were widely and quickly adopted and their use persists to the present, with minimal use estimated to be 25% of all high school students. CHEM Study materials, including revisions and derivations run well over 60% usage.

Review and Oversight History

These mechanisms reflect traditional practices of the Foundation. By definition this requires acquaintance and communication with scientists carrying out the work.

The CHEM Study proposal received staff review and review by experts outside NSF prior to that of the NSB. The steering committee remained as the advisory and policy group and gave overall direction to the project. NSF closely monitored developments and participated in meetings with the Steering Committee throughout the development, revision and evaluation stages and thus was able to represent its viewpoint.

Monitoring History

NSF staff followed the development of the project closely. Fiscal reports and annual reports of progress were required in the terms of the award. At a managerial level, the NSF staff was essentially in continuous contact with the progress of the project. Informal reports were frequent, advice and confirmation of proposed directions were given prior to undertaking the activity. Questions involving selection of publishers and distributors, royalty income, etc., were forwarded to NSF legal counsel for verification of compliance with NSF and Federal policy. The pattern of advance planning with NSF feedback and subsequent action was firmly established in the CHEM Study project. The project directors, in turn, made conscientious efforts to keep NSF fully and currently apprised of progress and solicited advice on anticipated directions and problems.

NSF staff made frequent site visits to the central project office at Berkeley and to regional centers after they were established. They attended planning and writing sessions and meetings of the Steering Committee. A CHEM Study newsletter was developed and formal descriptions of the course were published in a wide variety of educational journals.

In 1966, accounts were audited by NSF, and required minor changes concerning indirect costs; no improprieties in the use of funds were found.

The evaluation of content was built into the project from the outset. The first draft of the text was written and put to use in classrooms within three months. Reactions of teachers and students were fed back to the project director after use of each section, thus, modification and revision of the text was a continuous process. Periodic meetings with participating teachers were held to exchange ideas.

By the second year, the text was virtually complete. The teacher's guide was developed almost entirely from teachers' suggestions. In subsequent years heaviest effort was devoted to supplementary material, specialized aids and teacher training, again using the mechanism of testing, evaluation, feedback and revision.

Suggestions for revision, identified problem areas, and student and teacher evaluations were assimilated and acted upon under the advisement of the Steering Committee and NSF. Deadlines were met, and copies of material were available for testing by the end of the first summer's work.

Contractual Arrangements

In December 1960 the CHEM Study staff solicited proposals from those interested in servicing, printing and distributing the materials. After review, the staff and Steering Committee recommended W. H. Freeman and Co. be awarded the contract—which was satisfactory to NSF in all respects. Subsequent film arrangements were equally satisfactory.

Based on information contained in the Foundation's files, it appears that the CHEM Study project was managed in accordance with NSF's and NSB's policies on distribution, royalties, and copyrights and that good business practices were followed.

A complete and detailed study of all financial arrangements is found in the case study, Appendix 4.

Implementation/Dissemination History

It was determined that the materials produced should be competitive with current texts, and that the packaging should be flexible in order to allow selective utilization and easy adaptation of both equipment and supplementary materials. Participants in policy discussions at NSF, with advisory committees and project personnel recognized that "product acceptance" and utilization were the ultimate goal for this effort. At the same time, NSF repeatedly reiterated its position that its funds could not be used for promotion and distribution of the materials and that selection of materials for use in schools resided with State and local authorities. Funds could, however, be used for the dissemination of information about the project, and indeed the grantee was obligated to publish reports on the project in national journals.

Early in the study, inadequate teacher preparation in the sciences was recognized to be as much a problem as poor curricula. Gradually, the summer institutes adopted CHEM Study materials, and as teachers became acquainted with them, materials were adopted for use in classrooms around the country. The newsletter and publications generated many requests for consultant assistance in adopting the materials in schools as well as privately sponsored institutes. In addition, a series of conferences were initiated for key personnel. Except for this initiative, no other formal implementation mechanisms were considered for the CHEM Study Program.

SYNOPSIS OF SCIENCE CURRICULUM IMPROVEMENT STUDY (SCIS) REVIEW

The SCIS project currently under way at the University of California at Berkeley, begun in 1962 and scheduled to continue until 1977, is focused on developing a framework of fundamental science concepts related to students' own experience with natural phenomena. To date, SCIS has developed several ungraded, sequential physical and life science programs. There are six units for a physical science sequence, and six for a life science sequence for elementary grades and one unit designed especially for kindergarten. Each has been carefully evaluated by SCIS staff during development and all were tested throughout the Nation prior to publication.

The six basic physical science units are designed to introduce and develop concepts leading to science literacy; the life science sequence focuses on organism environment interaction. Either may be used independently, but units within each are designed to be sequentially presented.

Class materials are in the form of a kit for a teacher and 32 children containing all materials save standard classroom supplies and certain fresh water organisms sent separately on request. Each complete kit costs between $125 and $280; refills cost between $8.00 and $60.00. A complete set of the K-6 SCIS kits would cost approximately $2,700.

The SCIS program is designed to foster laboratory-type experiences in which students deal directly with live animals and real objects. Objectives for each activity are well specified in the teacher's guide, but are not presented in student texts to avoid hindering the explorational and experimental aspects of learning.

To teach SCIS programs effectively, the developers recommend that the teacher have sufficient background in science and the program to profit from its inherent flexibility. The developers have therefore maintained a strong emphasis on in-service training for teachers at SCIS headquarters in Berkeley and at the other SCIS trial centers. Other conferences and courses have been made available through the publishers, developers and other colleges and universities.

SCIS units and materials are presently being used to some extent in almost all states. Sales estimates by the publisher (Rand McNally & Co.) in-

dicate that more than 3% or approximately 1 million students in the elementary grades are now using SCIS, and it is projected that by 1977 a minimum of 15% of the school aged population will have been exposed to the program. The program has been modified for use by blind children.

Its continued use will depend on whether school personnel are willing to spend a larger share of their limited funds on elementary school science, and on effective training of teachers.

Review and Oversight History

From inception of the project through December 1970, formative evaluation was conducted by project staff. Evaluation generally moved from discussion and testing of the exploratory version to classroom trials, revision and retrial. In the spring of 1970, NSF supported an evaluation workshop, and in spring 1971 development of evaluation supplements was begun to serve teachers who needed external assistance to evaluate student performance. These were completed in 1974. Plans for a summative evaluation are being developed by NSF staff.

Monitoring History

Monitoring of the SCIS project by NSF personnel appears to have been minimal, and at best appears to have been in the form of reactions to stimuli from the SCIS project director. Major interactions between NSF and SCIS staff appear to have taken place only directly following NSF receipt of annual SCIS proposals or when SCIS personnel suggested budget changes.

Contractual Arrangements

NSF personnel approved the selection of all publishers/distributors for SCIS materials and agreed to all contractual arrangements between SCIS (U.C., Berkeley) and the publishers/distributors. Sound legal and business practices appear to have been followed.

Dissemination/Implementation

Characteristics of SCIS implementation followed the following pattern:

1. School leaders obtain funds, arrange training.
2. Pilot run of programs.
3. Key people are chosen, attend program at Berkeley involving training, observation, conferences.
4. Key personnel train local teachers.

A newsletter is published quarterly which reaches more than 25,000 readers. In the summer of 1974 NSF funded implementation projects

nationwide with 1600 participants involved extensively with SCIS materials, concepts, philosophy and teaching methods.

The summary case study of the SCIS project is found in Appendix 4 and is accompanied by a list of perceived problems.

SYNOPSIS OF MAN: A COURSE OF STUDY (MACOS) PROJECT REVIEW

As described to the National Science Board on August 8, 1963, "This project is part of a comprehensive plan for developing a carefully integrated sequential social science-humanities program for elementary and secondary schools." A primary emphasis was on producing ethnographic film studies to deal with the questions: What is human about human beings? How did we get that way? How can we be made more so? The curriculum was designed to introduce organizing ideas early and restate them frequently by the use of films of people in other, and apparently quite different cultures. Students were to be encouraged to learn to use anthropological and ethnographic methods and materials.

During June 9-23, 1962, prior to any NSF support, Educational Services, Inc. (ESI) sponsored an Endicott House Conference in Dedham, Massachusetts, ". . . to develop an overall unifying approach that would provide guidelines for structuring of a humanities and social studies curriculum running through the entire elementary and secondary sequence." Participants included some 61 persons representing social science disciplines plus those of law, history, physics, and education.

A report on the conference, *A Narrative Report 1962-1964 Social Studies Curriculum Program*, November 1964 concluded that, ". . . the teaching of the general field of social studies and the humanities is desperately in need of improvement in the elementary and secondary schools of this country."

Proposals from Educational Services, Inc., and the American Council of Learned Societies (ACLS) received by the National Science Foundation on January 3, 1963, described a review of 250 existing social science films conducted in August-September 1962 by ESI and ACLS staff which resulted in criticisms regarding the minimal involvement of social scientists. New projects were proposed which would deal with these shortcomings by having films made by social scientists and reviewed by experts; by developing films that could be used for children at all grade levels and would be edited for viewing by a general audience. The films would provide a flexible format and would be limited to that data which could be best represented on film leaving much to the student to be interpreted, and which would also experiment with film innovations.

In addition, two conferences supported by the Office of Education and NSF were sponsored by the President's Scientific Advisory Committee (PSAC). Results reinforced the conclusion that there was an urgent need for course improvement in the social sciences and led to recommendations that the NSF support social science curriculum development projects.

Today, MACOS materials are estimated to be in use in about 1,700 schools in 47 states. Estimates of students affected range from about 200,000 to 328,000. The materials are also being used in five Canadian provinces and in England, Scotland, North Ireland, and New Zealand. One report estimates that in 1970 the MACOS materials were being used by about 200,000 children and that the number of schools using the materials had increased from approximately 375 in 1967 to nearly 1,700 in 1970.

Materials on community response are mainly newspaper accounts, reports of very small-scale mail surveys, or anecdotal information. These materials do indicate that MACOS was a subject of controversy as early as 1971 and that NSF social science projects received cautionary Congressional comment in the mid-sixties.

Review and Oversight History

Prior to its support of MACOS-related projects, NSF supported development of secondary curricula in anthropology. Each major MACOS-related award was subject to staff review and/or peer review, and was submitted, as revised on the basis of those reviews, to the National Science Board for approval. It appears, then, that in the judgment of scientific peer reviewers, representatives of the educational community, staff of the Education Directorate, and the National Science Board that the proposed subject matter did fit within reasonable limits or norms with respect to educational value. Further, there appeared to be no questions on accuracy of content nor doubt about competence and experience of the developers.

The proposals that led to the development of the MACOS curriculum in 1963 requested $284,200 for the preparation of anthropological films. All four proposals were submitted to peer review. Awards were made for two projects; the other two proposals were withdrawn in August 1963. The awards did not involve either policy issues or levels of funds requiring NSB approval.

On the advice of NSF staff, the same grantee organization submitted a consolidated proposal requesting $618,315 for additional work on the two projects that had been supported and for incorporating work described in the two proposals that had been withdrawn. This consolidated proposal was not submitted to peer review; NSF staff recommendations for support were based on results of evaluations of the separate proposals that had received peer review earlier. The staff recommendation for support, at a reduced budget level, was submitted to and approved by the National Science Board.

All subsequent proposals for continued substantive work received peer review and or review by NSF program staff. In each instance, the program staff summarized the major issues raised by reviewers and made recommendations for support to senior staff of the Education Directorate. In each instance, the recommendation was for a lower level of effort than had been proposed and was submitted to and approved by the National Science Board.

Monitoring History

The primary means of monitoring the MACOS projects appears to have been peer review and staff review of the proposals submitted for specific work elements. These reviews resulted in modifications in the budgets requested and occasionally resulted in modifications in the scope of work. There appear to have been only two site visits conducted during the course of the MACOS curriculum development. Major responsibility for the conduct of the work was with the principal investigators and a planning committee of social scientists and educators that was assembled by the grantee.

Review suggests that monitoring of the project has been a comparatively weak point in management of the MACOS project.

Contractual Arrangements

Because of the unusual nature of the MACOS project and the teacher training requirements which Educational Development Center (EDC) insisted on being written into the contract, the task of locating a suitable publisher was very difficult. The contractual arrangements between EDC and Curriculum Development Associates (CDA) which finally evolved, though somewhat at variance from the norm, appear to be fiscally sound and adequate for the purposes intended.

Dissemination/Implementation Plan

Major difficulties were encountered by EDC in developing and carrying out dissemination and implementation of MACOS curriculum. The publishers believed the program had four major liabilities that made marketing it a risk of capital, time, and personnel.

- Unconventional concepts of the course;
- The need for special teacher education;
- The interrelatedness of media with function;
- The cost of the program.

In 1969 and 1970 (prior to EDC obtaining the services of a publisher) NSF supported a small number of regional centers strategically located in universities and colleges in Florida, Oregon, Colorado, Connecticut, New York, and other states. The purpose of these centers was to furnish information concerning the MACOS curriculum in the school districts in the region. When schools expressed the wish to utilize MACOS curriculum, appropriate teacher training was provided by the centers. These centers were supported by the Course Content Improvement Program for three years beginning in FY 1969 and were discontinued shortly after CDA contracted to publish and disseminate MACOS curriculum.

Because of the innovative nature and unconventional concepts of the course, EDC felt strongly that teachers should receive specific training prior to teaching MACOS in the school systems. As a result, EDC made this a requirement for publishing the course. CDA officials stated that they would "be insistent on a method and program of dissemination which provides the teachers who use the Course with full exposure to the use potentials conceived of by those who have developed it;" and would "seek a financial arrangement which provides maximum opportunity for further development by the Center (EDC) of this and other teaching-learning courses."

CDA was given full responsibility by EDC to develop the production and dissemination program. The Price Information Sheet for materials developed for MACOS contains the following statement: "All orders for classroom or film materials are subject to verification by CDA that the purchaser has complied with teacher education requirement necessary for proper implementation of the Course." NSF provided support for teacher training for MACOS through its Summer Institutes Program, its Course Content Improvement Program, and its Cooperative College School Program. A multiplier effect is considered to be highly desirable by EDC, and trained personnel are expected to return to their school districts and train other teachers in the effective teaching of the MACOS course, as is the case with many implementation projects supported by NSF.

At the present time NSF does not fund any regional centers for dissemination/implementation and NSF staff have repeatedly asked EDC to delete reference to NSF support of "regional centers" from its publications.

Detailed discussions of financial arrangements, implementation, and diffusion methods are found in the MACOS case study, Appendix 4, along with staff comments on procedures to date and perceived problem areas.

SYNOPSIS OF COMPARING POLITICAL EXPERIENCES (CPE) REVIEW

The American Political Science Association proposed to establish a Political Science Course Content Improvement Project for elementary and secondary schools to design and develop new instruction materials for teaching government and politics in elementary and secondary schools. The Political Science Course Content Improvement Project was to consist of two components. One, the High School Political Science Curriculum Project, to develop instructional materials for use in senior high school civics and government courses; the other, the Elementary School Political Science Curriculum Study Project, has undertaken a study of political science education in elementary schools and, on the basis of this study, developed a set of guidelines for the production of new instructional materials and media for grades kindergarten through six. They were designed to be used either in conjunction with existing curricula or as new programs in political science education. However, in winter 1975, the decision was made not to support the elementary school project after the first year.

The high school project material was in tryout in 1974 and the second semester material is in preparation. The exact nature of publication is not yet determined. It may be one hard cover textbook or a series of separate units.

Presently there are twenty-five pilot schools using the course material. There are also fifty affiliate schools which receive the materials but are only informally involved in pilot testing.

Review and Oversight History

The determination was made by NSF that political science is an appropriate subject material for the Foundation. Verification as to the accuracy of the scientific content was a responsibility of APSA in its activities in monitoring the curriculum development. At later stages, some portions of the material were distributed to reviewers or summarized in renewal proposals and comment was obtained regarding scientific content. Based on the comments of the reviewers, co-project directors were found to be highly qualified professionals and there were no questions as to their competency.

Monitoring History

No site visit was made prior to the award of the grant on March 13, 1972. A site visit was later made to Indiana University, a subcontractor to APSA.

Possibly, because this project is in its early stages, there has been continuity on the part of the NSF program office personnel and reasonable attention to monitoring of the program. Not unlike other grants, the major reviews occur annually when requests for additional funds are received. No specific oversight committee was appointed by the Foundation. The fact that the American Political Science Association was the named grantee, with responsibility for the overall coordination of the effort, appears to have led to the conclusion by NSF staff that the need for such a function was met.

Contractual Arrangements

Indiana University held a publishers conference in July of 1974 to present four Social Studies Development Center projects to potential publishers. The University was furnished with a copy of the Foundation's publication policy, which required approval of the plan to announce the availability of materials to all qualified distributors; selection of a particular publisher; and finally the proposed contract between the publisher and the grantee. A second conference is planned for fall 1975 to present more definitive material, and then to invite specific proposals.

Dissemination/Implementation Plan

The dissemination and implementation plan has not been fully developed at this point, but it appears that it will conform to NSF requirements.

SYNOPSIS OF INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM (ISIS) REVIEW

The ISIS project is focused on developing a flexible, open-ended, interdisciplinary curriculum that will facilitate individualization of science instruction at the high school level.

ISIS will consist of approximately 80 short, essentially independent modules or minicourses, each requiring 2-3 weeks of classroom time. Each module will deal with a specific topic by presenting, in an interdisciplinary manner, the appropriate concepts from biology, chemistry and physics. Pertinent information from the social sciences will be incorporated in units that deal with the social implications of science and technology. Mathematics will be included when necessary. For all modules, "excursions" will be developed which will permit the student to probe into some of the more complex aspects of the topic. In an effort to keep down the equipment costs for schools adopting ISIS, the laboratory work will make use of materials and apparatus normally available in high school science labs. Guidance in implementing ISIS under a variety of situations will be provided by an instructional management scheme. Twenty-nine minicourses are now in the trial stage of development and are being field tested in several high schools throughout the United States.

According to the project director the ISIS minicourses will not simply be a set of plans, but rather will be complete learning packages containing everything the teacher needs to provide students with individualized science instruction. The ISIS developers feel that such a complete package will free the teacher from much of the routine of a classroom and allow the necessary time for interaction with individuals or small groups. A few of the topics to be included are: buying and selling, people pressure, seeing colors, ways we learn, heart attack, house plants, home electrical appliances, fire and explosion, and energy supply and demand. Other courses are proposed and are being readied. Two trial minicourses, "Human Reproduction" and "Birth and Growth" have in one case (Dallas, Texas) been refused by a trial center.

ISIS trial materials are currently being used by more than 10,000 high school students attending the ISIS trial center schools located throughout the U.S. It is still too early to assess the actual impact of the ISIS program since no final versions of minicourses have been developed. According to the ISIS developers there is already a high demand for ISIS materials, and they plan to release minicourses as they are completed.

Review and Oversight History

In a grant dated June 23, 1971, NSF provided support for a conference held in October 1971 at Callaway Gardens, Georgia, which brought together 34 experts to explore the feasibility of a new approach to high school science. The persons attending the conference represented a very wide range of experience in science and school instructional materials development. Every branch of the teaching profession was represented including classroom

teachers, science supervisors, school administrators, professors of science education and learning theorists. There were also representatives from various professional organizations. The conference participants cited what they felt was considerable evidence for the inability of the then current science programs to meet the needs of today's society, today's schools, and today's students.

Criteria for reviewers included that they represent a cross-section of disciplines, be prominent in their field, and required that they have experience in pre-college education. They were asked to base their evaluations on the merit of the idea, the feasibility and effectiveness of the procedures, the qualifications of project leaders and on budget factors.

Two oversight committees were initially set up, but have been replaced by an advisory board that seldom meets as a unit, but in subgroups which concentrate on the areas of their expertise. Board members are listed in the case study, Appendix 4.

The principal investigator has expressed the opinion that a summative evaluation could not be made for at least seven years to determine what happens to children as a result of being exposed to a fully developed product. Further, criterion referenced testing is recommended rather than normative testing. The object is to determine how many children meet some specific criteria rather than to see if they achieve a given score on a test. Step-by-step details of the evaluation process are found in Appendix 4.

In the course of the detailed examination of ISIS the internal documentation leading to the award decision was reviewed. In particular, it was observed that, as is often the case, the written peer reviews formed only a part of the process. After analysis of the reviews, the program staff made the essence of these reviews available to the ISIS project team. The ISIS team then responded at some length to the critical views raised by the reviewers. In addition, the ISIS staff met with NSF staff to further clarify various points. The program staff recommendations reflected these discussions in detail and indicated a staff decision that these interactions dealt effectively with the critical reviewer comments. The recommendation for an initial trial phase with a subsequent decision-to-continue being contingent on an adequate indication of progress, is fully consistent with the review consensus.

Awards to continue the project were based primarily on staff evaluation of progress which included site visits, review of progress reports, and other oversight procedures.

Although the review and oversight is judged to be adequate, it is noted that the material provided to the NSB did not fully describe the interactions with ISIS staff which dealt with negative comments of reviewers. It was also observed that panel review of the initial and subsequent proposals might have had advantages over the mail review process. The observations are documented in the case study report, Appendix 4.

Monitoring History

The Foundation has monitored progress of the ISIS project through site visits, telephone conversations and correspondence. Results from a team of three outside reviewers will be used by NSF staff. Staff members have attended meetings of the ISIS Advisory Board and have reviewed all recommendations and actions of the group.

Contractual Arrangements

The commercial version of the program will be published by Ginn and Co. who will retain exclusive rights until December 31, 1984, after which the exclusive publication rights expire. All arrangements are reported to be satisfactory.

Dissemination/Implementation Plan

Current plans call for release of completed minicourses in groups of 15 to 20 over the next five years. The first lot of 10 will be released this year. With the release of subsequent minicourses, the possibilities for clustering them to build several varieties of courses for students of all abilities will increase and ultimately there will be many disciplinary as well as multidisciplinary course possibilities. By 1979 the ISIS developers expect to have published enough minicourses to allow schools who wish to do so to totally replace their high school science programs with one of many locally determined alternatives.

OBSERVATIONS

These observations stem from consideration of materials prepared in the course of the study, and relate this information to our understanding of the practices in program management and program development in this and other Federal agencies. Practices of the school systems of the Nation and of the industries that supply them with material were reviewed and views of the scholarly community were also noted. Specifically, the detailed case studies undertaken provided the opportunity to examine the nature and character of NSF program procedures as they have evolved and have been applied in the course of curriculum development activities.

Observation 1: It is widely believed that this program has been instrumental in bringing about a major change in the content of science teaching materials at the pre-college level. This has stimulated related creative efforts in development of teaching materials in other Federal agencies, in the industry, and in the school systems themselves.

Observation 2: There have been extensive changes in the national situation with respect to pre-college curricula over the lifetime of this program which began, essentially, in 1958. Program guidelines and policy have been

revised as the climate changed and as NSF staff and the National Science Board became increasingly aware of the very complex issues associated with the dissemination and implementation of course materials. The policy framework has evolved in a manner that reflects changes in the external situation, However, no comprehensive review of future needs for pre-college curriculum seems to have been carried out in any breadth and depth. Current program emphasis is on completing and implementing the array of courses already under development; very little attention is being given to initiation of new courses during this present period of stocktaking.

Observation 3: NSF program staff has conformed with acceptable and current procedures and policies since the inception of these programs. However, climate in the Federal Government with regard to program accountability, openness and the involvement of outside affected parties implies a need to consider a substantial reexamination of the policy framework for this program and of the management procedures which are in use.

Observation 4: Operational management decisions made by the NSF pre-college science educatio program staff reflected acceptable practices, procedures and policies that existed at the time the decisions were made. During examination of project files and documentation only minor uncertainties in project management decisions could be found, and these were few.

Observation 5: General management practices as applied by NSF offices external to the pre-college science education programs were essentially consistent with existing policy framework and procedures. There are, however, alternatives which could be considered to improve the effectiveness of NSF programs and which, in some cases, are contingent upon changes in policy. Other improvements can be effected by internal strengthening of current practices.

Observation 6: The operational and management practices of the pre-college curriculum program reflect steady and consistent improvement over the past decade. Nevertheless, further improvements in program management practices are still desirable and should be considered. Some of these are:

- strengthened monitoring of projects through site visits, telephone contact, and other techniques
- improved attention to the determination and definition of run-out costs
- strengthened evaluation procedures
- more extensive and detailed review of legal and business matters
- more clearly established criteria for general program practice.

POLICY ISSUES

Although the foregoing observations indicated that the management and decision processes in this program have been adequate in the context of existing policy and practice, there are questions both of policy and of management practice that require increased attention. In retrospect, as with any judgmental process, there were errors both of individual judgment and of administrative practice of a type which can be reduced by diligence but never eliminated. More serious are major policy issues which have been considered at times in the past but which have not been fully resolved or which now require reexamination.

The review team has identified five general policy issues which should be addressed in determining the future course of this program. These are:

1. Redefinition of the NSF role in science curriculum development
2. Determination of future needs
3. Awards process
4. Proposal review
5. Curriculum implementation

These policy issues were identified in the course of the study, and reflect the flow of activities in curriculum development and implementation. They were presented to and discussed in detail with the Advisory Committee on Science Education. The Committee's recommendations along with those of the review team are found in Section III.

Policy Issue 1.

REDEFINITION OF THE NSF ROLE IN SCIENCE CURRICULUM DEVELOPMENT

For both the natural sciences and social sciences, present and future goals and objectives require examination and a statement is needed to define more clearly whether the program should be directed toward education of future scientists, science education for all citizens, or both.

BACKGROUND

The pre-college science curriculum development and implementation programs arose out of the perceived need in the late 1950's for major improvement in the science content of public education. This was stimulated, in part, by the advent of Sputnik and also by the view of most scientists and educators that the scientific training of students entering college was weak and that the

content of pre-college courses and texts was out of date. As a result, the initial courses supported by NSF were proposed by, and came to be directed by, scientists with extensive research experience and established scientific reputations but with relatively little experience in the elementary and secondary classroom environment. This early trend led to some major successes but also created certain problems. Some of the early courses developed with NSF support were judged by schools to be too esoteric for a great number of students. Others were able to receive only limited distribution; local school systems were reluctant to adopt them because of their novel features, difficult content and the need for extensive teacher training or retraining.

Examination of early projects shows that review of the content and intent of the program was performed almost entirely by research scientists whose principal concern was for the substantive content of the course rather than for its teachability, and who lacked familiarity with the milieu in which it would be used. By contrast, many of the reviewers of recent projects are classroom oriented teaching professionals from local school systems and teacher's colleges.

There seems to be adequate evidence that a major shift in pre-college science curricula has taken place. A key question, however, is the extent to which further Federal support is, in fact, needed. Therefore, it is suggested that a redefinition of NSF goals and objectives in pre-college programs is in order.

One of the crucial issues is whether projects should be oriented toward providing the base of experience in science methodology, attitudes and content primarily for those students who will be the future scientists of the Nation, or whether they should be oriented towards science education for the general citizen. It must be noted that many individuals who will receive advanced scientific training in college will not themselves become research scientists but will work in a wide variety of science-related jobs. It appears that the scientific pre-college needs of these students may not have been adequately met, and it is felt this need merits more extensive evaluation. Still, these two groups are surely outnumbered by those individuals who will not study advanced science intensively or at all.

The question of who should receive intensive pre-college scientific training is particularly germane in the natural sciences where an early start toward scientific creativity is often considered to be exceedingly important for future scientists. Conversely, such an intensive introduction to the substance and method of science might not be appropriate for the individual who is unable to perceive a need for scientific education.

In addition to the question of which students should receive such scientific training, course content must be considered carefully as well as the proper grade level for introduction.

Development of social sciences curricula demands particular awareness of the ways society views values that may be associated with the subject matter. This can substantially affect acceptance of courses, or at least public perception of them.

It is to be hoped that a redefinition of the NSF role in these programs involving participant representative of all disciplines, from both academe and the classroom, will aid in determining what NSF should do as well as what it should not.

Policy Issue 2:

DETERMINATION OF FUTURE NEEDS

Establishment of broadly-based review groups would allow assessment of pre-college curricula through integrated studies; new starts could be deferred pending this review of needs. Other systematic approaches to needs assessment could be explored.

BACKGROUND

It would appear desirable to carry out broad based analyses of future needs for science curriculum development at the pre-college level. This could be done in a variety of ways; for example, contracted studies and surveys could be undertaken which would examine the attitudes of special groups—teachers, school administrators, scientists, and others. Alternatively, conferences or symposia could be planned for each discipline; or congressional hearings could be held where expert testimony is presented by all interested parties. Possibly NSF could charter a special commission to examine needs in science curriculum development, or the Advisory Committee for Science Education or other outside groups could be organized into task groups to specifically examine these needs.

At this stage it is proposed that a very broad needs assessment be undertaken that would cover the spectrum of science disciplines for students of all ages at the pre-college level. Such an assessment could then be followed by individual discipline assessments or other specific assessments after a need is identified in the broader scope. This would narrow the range of anticipated teacher-curriculum development projects to a relatively manageable number. The process could be designed to tap the experience of scientists, educators, and citizens otherwise involved in the educational process and would allow them to work toward a mutually agreed upon assessment of needs and requirements.

Policy Issue 3.

AWARDS PROCESS

Contingent on the systematic assessment of needs, an NSF program decision to proceed in a given area could be broadly disseminated to allow an open competitive process for selection of awardees as compared with the customary NSF practice of responding to unsolicited proposals.

BACKGROUND

The process by which NSF makes grants for curriculum development is patterned rather closely after the traditional NSF approach for research grants; however the tasks undertaken are very different. Research projects are tailored to suit the individual investigator and his innovative ideas, while a curriculum development project requires a team effort over a number of years to ultimately produce an educationally useful and commerically viable product. The present NSF approach of responding to unsolicited proposals from interested parties in the community may today be inappropriate.

From another viewpoint, the use of the full machinery of Federal procurement contract regulations for the development of curricula might be equally as inappropriate. These procedures require arm's length competitive processes which would make it quite difficult for NSF staff or advisors to work with those submitting proposals to aid in defining and improving programs, and would limit the degree to which subsequent changes in the program could be effected without exhaustive and detailed review.

There are, however, intermediate procedures. For example, based upon a broad general needs assessment and subsequent specific assessments, the technique of program annoucement or program solicitation could be employed wherein areas of interest and general requirements for programs are identified, leaving proposing institutions or consortia free to propose or not propose after needs have been identified. Most often in the past, those who have identified the needs through a conference or other process have become the agents in constructing a large proposal and there has been little opportunity for direct competition.

A phased, step-by-step process, in which two or three or more projects for program definition would be supported might yield a variety of different approaches to a given problem. A restricted proposal competition could then follow in which the small number of groups who had defined the problem would be invited to develop a full-fledged proposal and would receive support for this purpose. From these, one awardee might be chosen. This process could conceivably produce a more highly developed plan for each project; one which would result in an improved structure to permit evaluation and oversight. Similar techniques have been used by other agencies of the Federal Government and by the RANN program at NSF.

Policy Issue 4.

PROPOSAL REVIEW AND PROJECT EVALUATION

Procedures for external, independent evaluation of project progress and content at all stages of development are important to ensure their accuracy and usefulness. These procedures could be strengthened and might include participation of practitioners and other "users." Such evaluations could take into account problems, needs and perceptions at the local level.

BACKGROUND

Evaluation of curriculum proposals has customarily taken place in a manner analogous to basic research proposals, that is, individual proposals are usually sent to mail reviewers, and these and other reviewers are sometimes used as consultants on proposal site visits. Evaluation of the content of ongoing projects is often carried out by an advisory board or steering committee that works with the director of the project. A major project may undergo three or more external peer evaluations in various stages of its funding over a period of seven or eight years. Curriculum development proposals might better lend themselves to panel review than to mail review—particularly if well defined review criteria are in use. However, this method might raise the question of cost effectiveness.

There has been an increase in participation of practicing educational professionals in NSF evaluation processes, but by and large, the evaluation of content has been left to the project team. Although material is subject to peer review, the question is whether it might not be desirable to have an independent third party advisory board or panel check on the content and progress of major projects, particularly of courses that may have value-laden content. At the end of the development process, independent third party evaluation might be particularly useful.

Policy Issue 5.

CURRICULUM IMPLEMENTATION

One approach is for implementation to be supported only after an independent, impartial external review has been undertaken covering need, content and potential benefit. If NSF is to continue to support implementation, the following elements are worthy of consideration:

- well defined review mechanisms for judgment of content,
- a more clearly defined process for dissemination/implementation,

- more definitive policies on rights, royalties, exclusivity, and fiscal arrangements,
- mechanisms for NSF review of decision to proceed with implementation including periodic review by NSF.

BACKGROUND

An analytical study of research on curriculum implementation carried out as part of this study[1] has shown that "the successful implementation of innovations is generally considered to require a degree of change, capability and motivation not typically found in schools." It indicates that "early and meaningful involvement of those who will implement change" is essential, frequent communication with the users of materials is necessary and that training or involvement of all levels of the user system, teachers, administrators and field of study specialists is essential. NSF has used many mechanisms to deal with these matters, including special institutes for administrators and teachers and the regular program of teacher training institutes.

The issue of curriculum implementation is not clearly faced in the present program, but is dealt with *ad hoc* when each curriculum approaches the implementation stage. It is customarily assumed that implementation is an essential goal. However, there has not generally been a conscious, carefully designed evaluation of the product prior to the decision to proceed with implementation of the program.

Because implementation involves precisely that phase of the program that might be labeled "promotion" or "marketing", an explicit policy statement on the extent of implementation appears to be needed. It is probably desirable to have a much more carefully delineated stage of, first, the decision to implement and second, the plan or scheme by which implementation is carried out.

One approach worthy of consideration would be to undertake implementation or dissemination review jointly with the Office of Education and the National Institute of Education. It should be recognized that implementation has long been a matter of serious concern both to the NSF staff and to the National Science Board and that most of the possibilities that have appeared reasonable have long been subject to trial and error and have often met with success.

Of particular importance is the refinement of business policies in order to ensure that NSF practice is fair and equitable, including development of greater consistency with practices in other Federal agencies.

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[1] Sikorsky, Linda A., An Analytical Summary of Knowledge About Curricula Implementation in U.S. Schools, April 29, 1975.

III. Recommendations

ADVISORY COMMITTEE FOR SCIENCE EDUCATION RECOMMENDATIONS

On May 9-10, 1975 the Advisory Committee for Science Education met for the prime purpose of reviewing the findings and observations of the science curriculum review team. The Advisory Committee focused its efforts on the policy issues raised by the review team and its recommendations are structured in response to those issues. The report of the Advisory Committee as made to the Director, NSF, is included in its entirety.

ADVISORY COMMITTEE FOR SCIENCE EDUCATION REPORT

At the request of Dr. H. Guyford Stever, Director, National Science Foundation, the Advisory Committee for Science Education met May 9-10 to hear and consider the draft report of the NSF science curriculum review team. This *ad hoc* study team, headed by Assistant Director Robert E. Hughes, provided an extensive report to the Advisory Committee. In order to have an outside opinion, as requested by Dr. Stever, the Advisory Committee considered the five major policy issues raised in the report. The Advisory Committee has submitted the following recommendations to the Director.

1. **The NSF has a continuing role in science curriculum development in the mathematical, physical, medical, biological, engineering, social, and other sciences at the pre-college level, insofar as these subjects can be addressed appropriately at that level.** In view of the NSF's contacts with the scientific community in research and education, the Foundation can make a unique contribution by bringing new, intellectually challenging science content, and teaching methods to elementary and secondary school students and their teachers. The program should be broadly aimed toward encouraging future scientists and technicians as well as preparing all citizens who will face increasing demands for informed decisionmaking with regard to the impact of science and technology on their lives. In pursuing this role, the Foundation should be mindful of the fact that the final decision regarding the use of instructional materials and curricula is made locally. In other words, the schools must have genuine options from among which they may select the approaches most suitable to address local needs and circumstances.

   It should be recognized that much educational innovation is, by its nature, controversial. It therefore follows from the Foundation's educational mandate that the Foundation cannot and should not attempt to avoid controversy at the expense of educational or scientific values in the creation or development of new materials.

2. **The NSF should take an active and continuing role in determining needs for improvement of pre-college science education.** The needs analysis will include

solicitation of suggestions from the scientific research community in traditional and interdisciplinary areas, elementary and secondary school teachers, school administrators, science educators, students, and parents. While comprehensive needs analyses are in progress, the Foundation should continue to consider proposals and make grant awards where the need has been clearly identified. The results of the needs analyses should receive wide distribution to the public and will provide a basis for future program development.

3. **The NSF should avail itself of a broad range of granting mechanisms.** They should continue to accept unsolicited proposals and should expand the use of "program solicitation" procedures. Program announcements should specify the criteria for evaluation and selection.

   Curriculum development projects cannot always be judged by the usual "peer group" used in research project review. When appropriate, reviewers should include experts in the subject matter, in the process of teaching that material, in project evaluation, and in the administration and management of such long term efforts in school systems.

   The NSF should be alert for unsolicited proposals that may be of high quality, but limited applicability (e.g., excellent curricula dealing with local ecological systems). The individual who works out such curricula may not be aware of NSF procedures and may need special help to become involved in the granting process.

4. **All large scale project proposals should include a detailed plan for evaluating the progress of the project at specified times during the course of the work. The NSF should provide for external summative evaluations of all major projects.**

   Criteria of evaluation should include factual data, estimates of levels of performance and educational significance, cost effectiveness, and degree of non-NSF support provided.

   One technique for external evaluation which should be considered by NSF is the use of third parties to engage in a debate of the merits and weaknesses of the project. These debates could be used to identify not only weaknesses of factual content, but possible questions of "propriety of content" in the anticipated use of the material. This debate might be carried out before any widespread dissemination of the curriculum is undertaken and a summary of the pros and cons might accompany the materials as they are disseminated.

   Students who have actually participated in these programs could be interviewed to include their reactions to the program.

5. **To assure availability to the public of Foundation supported curricula and teaching materials, the developer should be strongly encouraged to make arrangements for the publication, manufacturing, and marketing of these curricula or materials without the requirement of Foundation funds for these programs.**

   To improve teaching practice in science, the Foundation should support outstanding projects for teacher education and resource personnel development. These may concern the use of innovative curricula or material whose development was supported by the Foundation, but shall not be restricted to such materials.

CHAIRMAN, SCIENCE CURRICULUM REVIEW TEAM RECOMMENDATIONS

The following recommendations were submitted to the National Science Board and the Director by the chairman of the special review team Assistant Director, Robert E. Hughes. They represent the conclusions of the chairman after due consideration of the results of the study conducted by the review team. The chairman also consulted with two members of the National Science Board who were associated with the review team for oversight purposes and with the Advisory Committee for Science Education.

Procedural Recommendations

The following recommendations are procedural in nature. They are intended to strengthen ongoing practices and to develop a somewhat more formal, structured approach to curriculum development and curriculum implementation activities of the National Science Foundation. They can be implemented through normal administrative action, but this, of course, does not preclude the possibility that the National Science Board might wish to speak to these or related issues in a general policy statement.

1. **It is recommended that a continuing program be instituted to develop and establish priorities for curriculum development activities.**

This needs assessment program should utilize a variety of mechanisms such as panels, conferences, symposia, workshops, etc., to develop priorities within and among prospective disciplinary and interdisciplinary areas. These activities should include representatives with professional experience in education, curriculum development, and in the disciplinary fields of interest. Active participation should also be solicited from school administrators, teachers and the interested public.

2. **It is recommended that procedures be developed to guarantee: (a) that information is widely disseminated about needs for curriculum development activities that have been identified in certain specific or broad areas (b) that proposals received in response to such announcements are reviewed by appropriate panels in a competitive mode; (c) that the review panels are carefully constructed to provide a sound intellectual base and reasonably broad representation; (d) that, when appropriate, several of the best proposals be funded as pilot programs for approximately two years, after which time another competitive review should be conducted to determine whether one or more of these should be continued.**

Many innovative and important ideas and programs arise from unsolicited proposals from individual investigators. It is vitally important that neither the needs assessment program nor the competitive review procedures

be structured so as to discourage or preclude the submission of independent ideas to the National Science Foundation.

3. **It is recommended that more formal, structured procedures be established for periodic review of major curriculum development programs.**

These reviews are not to be confused with "formative evaluation" or "summative evaluation" activities that are undertaken by the grantee as a normal part of the curriculum development activity itself. The reviews should be structured by NSF to include appropriate professional and public representation and should be directed toward an assessment of the merits of the total development activity. The review activity should involve an interactive panel and, whenever appropriate, an on-site visit with the grantee. Special care should be taken to ensure that the review panels, while free to express their views, do not stifle freedom of intellectual inquiry and innovativeness on the part of the investigators.

4. **It is recommended that a formal mechanism be established for conducting an in-depth review of completed curriculum development programs.**

The review panels should be carefully structured to provide balanced professional oversight and appropriate public representation. Such a review should be mandatory before curriculum implementation activities are considered. This should not preclude normal testing activities within selected school communities for the purpose of developing and revising elements of the curriculum programs.

5. **It is recommended that a research program be developed to carefully explore existing barriers to diffusion of new curriculum materials in science education.**

The program should be structured to provide basic information about the total system. The information should be made available to the Congress, Federal agencies, State and local authorities, the educational community, and the curriculum development community.

Total responsibility for adoption of curriculum materials in school systems rests with local and State authorities. There appears to be widespread concern among many professional and public groups about the complicated process of introducing new curricula into local school systems. It is important that all interested parties fully understand every aspect of the curriculum implementation process in order to ensure that Federal activity in this area does not infringe upon local and State responsibilities.

6. **It is recommended that a legally binding codicil be added to every curriculum development grant to ensure that the grantees comply with the existing provision that a disclaimer of NSF endorsement be prominently displayed on all materials developed under the grant.**

Although such a disclaimer is called for in the NSF Grants Administration Manual, it appears that the requirement has been ignored in some cases. This is an important issue and the disclaimer should be made mandatory with legally binding agreements.

Policy Recommendations

1. **It is recommended that the National Science Board develop a definitive policy statement that speaks to the purposes and the objectives of curriculum development activity at the National Science Foundation.**

The fundamental objectives of curriculum development activities at the NSF have gradually changed over the years. At first, the primary objective was to design curricula to attract the best minds and to improve the educational attainments of those students in secondary and primary school systems who were likely to embark upon careers as professional scientists. Gradually, another objective gained widespread acceptance. This involved a deliberate concern with providing a deeper understanding of the impact of science and scientific thinking on modern society to *all* students at every educational level. The first approach is directed toward developing competence in specific intellectual disciplines; the second toward illuminating the underlying nature of our technological world. The policy statement should delineate the extent to which future science curriculum activities at NSF should be directed toward these goals for both the natural and the social sciences.

2. **It is recommended that the National Science Board formulate a clear policy statement on the role of the National Science Foundation in the implementation of science curricula.**

In the public at large, in Congress and in the local and State educational communities there are widespread convictions that the role of the social sciences in school programs differs in some fundamental way from the role of the natural sciences. Traditionally, in many quarters, the social sciences have been regarded as a key element in introducing young students to the social and political environment in which they will live and work. Indeed, courses in local, State and Federal government—civics, history, and geography—have often been directed to that end. From this point of view, attempts to introduce alternative approaches to the social studies are sometimes regarded as having political implications.

Concern over new and controversial ideas is, of course, not limited to the social sciences; possible impacts of new developments in the physical and natural sciences have long been debated. In both cases, such concern is heightened whenever the Federal Government appears to be using its resources to deliberately disseminate or promulgate controversial material.

Since curriculum implementation activities are designed to disseminate materials that are sometimes regarded as controversial or even inherently political in nature, it is important that a clear NSF policy be developed for the guidance of future activities in this field.

3. **It is recommended that the National Science Board initiate a study to develop new mechanisms for administering curriculum implementation activities that will allow the National Science Foundation to remain at "arm's length" from the process.**

Analyses of the overall impact of NSF sponsored curriculum developments in the sciences suggest that there has been widespread acceptance of many of the programs in the Nation's school systems. The national educational establishment is not only huge, it is remarkably diverse and highly decentralized. It is generally accepted that organized curriculum implementation activities are necessary if new developments are to be brought to the attention of local authorities for their consideration. Thought should be given to new approaches that might directly involve State and local authorities, private institutes or academies in curriculum implementation.