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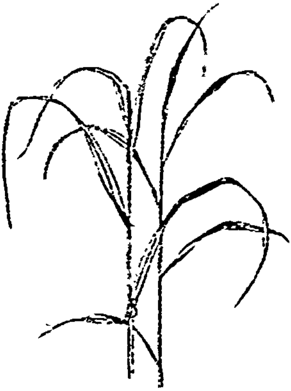
ABSTRACT

This handbook contains several suggestions for introducing and maintaining innovative science activities. It supplements the published research findings of the Harvard Study Committee ("Essentially Elementary Science") as well as the summary of those findings ("Something of Value") by offering teachers, administrators, school committee directors, teacher training leaders, and State Department of Education personnel a description of important management alternatives that can be selected and pursued to bring the benefits of NSF programs to elementary students. Topics presented include research programs developed related to teacher education, implementation of science curricula related to use of skilled teachers to train others, teacher-directed centers for the advancement of teaching and learning, the need for information relating to attitudes and resources, and the need for trials or pilot programs for new curricula. (Author/EB)

Lively Elementary Science Programs

A HANDBOOK OF SUGGESTIONS FOR INTRODUCING AND MAINTAINING INNOVATIVE SCIENCE ACTIVITIES



Submitted to the Massachusetts Advisory Council on Education. by Dean K. Whitla, Project Director, and Dan C. Pinck, Associate Project Director ⚜ Office of Instructional Research and Evaluation, Faculty of Arts and Sciences ⚜ and The Harvard Graduate School of Education ⚜ Harvard University, Cambridge, Massachusetts
January 1974

PROJECT STAFF

Dean K. Whitla, Director
Charles McArthur
Marvin C. Grossman
Nancy S. Lindsay
L. Wallace Clausen
Kristi Moore
M. Joseph Bastian
George T. Ladd
Mary Sheffield Rutherford
Dan C. Pinck

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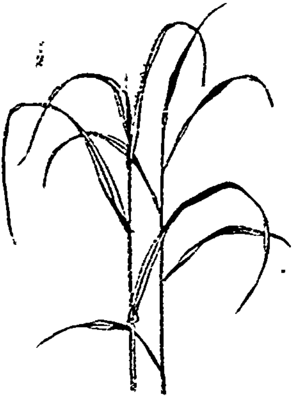

SUBMITTED TO THE MASSACHUSETTS ADVISORY COUNCIL ON EDUCATION BY DEAN K. WHITLA, PROJECT DIRECTOR, AND DAN C. PINCK, ASSOCIATE PROJECT DIRECTOR

OFFICE OF INSTRUCTIONAL RESEARCH AND EVALUATION
FACULTY OF ARTS AND SCIENCES
AND
THE HARVARD GRADUATE SCHOOL OF EDUCATION
HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS

JANUARY 1974

"In explaining to a child the general phenomena of Nature," T. H. Huxley wrote in 1869, "you must, as far as possible, give reality to your teaching by object-lessons; in teaching him botany, he must handle the plants and dissect the flowers for himself; in teaching him physics . . . don't be satisfied with telling him that a magnet attracts iron. Let him see that it does; let him feel the pull of the one upon the other for himself. And, especially, tell him that it is his duty to doubt until he is compelled, by the absolute authority of Nature, to believe that which is written in books."

PREFACE

Extensive research by the Harvard Study Committee funded by the Massachusetts Advisory Council on Education indicates that the National Science Foundation elementary science programs represent a significant improvement over other programs and other ways commonly practiced in introducing science to young children. These national programs offer a change from reading about science to a discovery-by-doing approach that is more effective in developing critical thinking skills and more enjoyable for both students and teachers.

This handbook supplements the published research findings of the Harvard Study Committee (*Essentially Elementary Science*) as well as the summary of those findings (*Something of Value*) by offering teachers, administrators, school committee directors, teacher training leaders, and State Department of Education personnel a description of important management alternatives that can be selected and pursued to bring the benefits of NSF programs to elementary students In addition, regardless of which alternatives a group might select or even invent for themselves, four major themes stated or implied in this presentation deserve careful attention. These themes are:

1. Collaborative efforts can usually be more effective and economical than isolated efforts in offering fine science programs to elementary school students

2. Inservice staff members represent a critical resource in arranging such collaborative efforts.

3. Individual leadership is a necessary catalyst to implementing and maintaining an effective elementary science program.

4. The previous three themes deserve serious consideration for evolving a high quality of curriculum service to students in other areas besides science.

Considering these four themes, this handbook implies very important questions well beyond the area of science — questions for state legislators and education officers and for college and university officials as well as for directors of local school districts:

1. Are our laws and State Department of Education programs designed to offer strong encouragement and support for collaborative efforts?

2. Do college and school district administrators cooperate in arranging ways to utilize the exchange of talents and information among inservice staff members from school districts?

3. What programs and working conditions exist at state and local levels to encourage and reward individual leadership?

4. Are efforts at collaboration on elementary science perceived as an example of a process that might be profitably extended to many other areas of service to students and taxpayers?

To summarize, this brief handbook raises important management considerations for everyone interested in improving educational service. It is, therefore, more than a handbook on the development of lively elementary science programs.

DR. RONALD J. FITZGERALD
Director of Research
Massachusetts Advisory Council
on Education

INTRODUCTION

The Massachusetts Advisory Council on Education commissioned the Office of Instructional Research and Evaluation at Harvard University to conduct a study to determine the extent to which the new elementary science curricula are being used in Massachusetts schools, to make a broad appraisal of the quality of instruction in elementary science; to determine the effects and utilization of the innovative curricular programs — with particular emphasis on *American Association for the Advancement of Science* (AAAS); *Elementary Science Study* (ESS); *Science Curriculum Improvement Study* (SCIS); and *Minnesota Mathematics and Science Teaching Project* (Minnemast), each of the four initially supported by funds from the National Science Foundation; and to make recommendations and suggestions to further the sound use of elementary science in Massachusetts schools.

In the committee's previous reports [1] on elementary science in Massachusetts schools, the findings of the research study and the interpretation of them indicated how powerfully the elementary science course content improvement projects were in changing a rather static textbook-oriented classroom into a lively one with a great deal of pleasure by students and teachers in making their own scientific investigations of the world about them. Compelling reasons for expanding the use of new curricula were presented in the various discussions concerning each of the science programs.

[1] *Something of Value. A Summary of Findings and Recommendations for Improving Elementary Science in Massachusetts.* The Office of Instructional Research and Evaluation, Harvard University, March 1973.

Essentially Elementary Science. A Report on the Status of Elementary Science in Massachusetts Schools. The Office of Instructional Research and Evaluation, Harvard University, March 1973.

A summary of some of the findings is presented in the appendix of this document.

The Committee's intention in this handbook is to offer suggestions about expanding the use of these programs; it is not a blueprint for change in any sense. Elementary science works best when its use fully reflects the dynamics and idiosyncracies of the individual school and when the teachers are treated with great respect and are given some time and help to solve their particular problems. Even five years ago, such a handbook would have focused *solely* on devising ambitious and relatively costly training programs and implementation strategies, involving federal programming assistance; however, with the downturn in federal support for education in the past few years, such a tack would be as foolhardy and unrealistic as it would be remiss. Accordingly, this handbook is addressed to suggesting relatively inexpensive strategies and notions that require collaboration and cooperation among schools and school systems.

There may be a narrowing of choices as a result of decreasing federal aid, but, in facing low-cost alternatives in teacher training, for example, the perceptive and ingenious educator knows, and his observations can be reinforced in the two previous reports, that a hidden and little used resource, the classroom teacher, can make important contributions in effecting new patterns of training in the future. In the long run, the schools are responsible for their own strengths and weaknesses; the suggestions made in this report may assist teachers and administrators to utilize their own strengths that can make them more self-reliant.

DEAN K. WHITLA
DAN C. PINCK
Office of Instructional Research
and Evaluation
University Hall
Harvard University

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The Committee found that faculty using the NSF programs spend much more time meeting informally than do teachers of textbook science programs. By simply providing teachers with a facility in which to meet, some common and perplexing problems might be resolved. There are more than four hundred teacher centers in England. There is one in Massachusetts, in Pittsfield. The Centers are one way in which systems can have an organized and systematic way of placing some of the responsibility for making innovations in the hands of the classroom teachers. With the downturn in federal funding for making innovations and for teacher training, it will increasingly become the responsibility of systems to provide staff development for themselves. The Committee notes how desirable it may be for standards to be set and teaching practices to be determined locally.

Before a system embarks on a new science program, it is important to know the feelings and attitudes of the faculty first and to discover also what technical and physical resources already exist. A sample of questions that might be asked of teachers is presented.

Customarily, many systems have used the new programs first on a trial basis, with a few teachers in a few schools using the new materials. The change effort can be strengthened by having trials in all classrooms in one or more schools, thereby removing to some degree the isolation of the trial teacher when he or she is using a new program but when the rest of the teachers are using textbook-oriented science programs. The NSF curricula have been tested and piloted by a number of systems, beginning in the development phase of the curriculum programs in the early sixties. Change takes time, but some of the trials and plans for implementation need not now require as much time to develop. The Committee suggests having a co-alignment of decision making about using new programs; the co-alignment exists at two levels, the administrative (well-supported NSF programs which will form the basis for the science program) and the faculty (which curricula they would like to use and how they would like to use them).

VI SOME NOTES TOWARD A DEFINITION OF AN IDEAL TRAINING PROGRAM 30

The Committee rightly states that there is no ideal training program and that too much teacher training is simply the mechanical use of materials. Unifying *what* is taught with *how* it is taught is a desirable goal, and this cannot be achieved without a sensitive approach and components that somehow are a reflection of what the teachers would like to see happen in the classroom. In addition to the consideration and mix of knowledge of subject matter, knowledge of children, and an awareness of some of the inhibitions caused by various teaching methods, equally pertinent consideration should be given to removing sex-role stereotyping (that says that girls and women cannot do experimental work) and the use of new science programs with children with special learning problems. The new elementary science programs offer a sound way to give all children more options and opportunities for growth. Again, the Committee advocates making greater use of the skilled teacher in conducting training programs and in addressing what appear to be some of the common problems, even including storage and distribution of science materials.

VII EVALUATION, CONSIDERATION OF 33

While each of the new program has or suggests an evaluative scheme or frame of reference, an eclectic approach may be the most felicitous and useful one. Evaluation should be an integral part of the implementation process from the beginning and not be added as a required afterthought after a curriculum has been adopted. There are many ways to evaluate learning and to be accountable. They are and should be broader than objective tests.

VIII A NOTE ON UNDERGRADUATE EDUCATION IN SCIENCE 34

The suggestion is presented that more exposure and experience with the new curricula may be helpful

I Schools Science Collaborative Program

The Broad Aims

1. Reduced-cost alternatives in teacher training and staff development may be possible in new voluntary confederations of school systems that want to share their expertise on elementary science. School Science Collaborative Programs can be started by the schools. Such programs will encourage the wider use of the new curricula in systems that are now using them and assist in the sound introduction of the new programs in systems that presently are using traditional approaches. The focus of the program is on staff development in a shared role among groups of five or more cooperating school systems beginning with summer workshops and carrying on during the school year. The program is modelled somewhat on the League of Cooperating Schools in California (eighteen systems work together on staff development in elementary schools). These could become regional instruction centers in the schools and work in voluntary partnership with university scientists and members of certain groups, such as the Massachusetts Association of Science Supervisors. The program attempts to promote a process of which the essential elements are as follows:

(a) An introductory experience at a summer workshop is a sensible way to allow teachers and principals to become immersed in the techniques and philosophies of the new elementary science programs, and this experience is heightened when elementary age students attend, for a portion of time, the summer workshop. The kind of laboratory experience offered at a summer workshop — when the opportunity exists to become familiar with the methods and materials in a comparatively informal atmosphere — is conducive to effecting more adequate implementation practices during the regular academic year. The summer workshop, moreover, offers a shared starting point for teachers and principals starting a Schools Science Collaborative Program.

(b) Centers of excellence exist in all sections of Massachusetts. Schools successfully using each of the new programs can be found in all counties. in these schools, there are skilled teachers and administrators, familiar with the science programs and past attendees at National Science Foundation summer and academic year institutes, a nucleus of able teachers of teachers. Forty-five out of 244 school systems in the state with elementary schools have designated K-12 or K-6 science coordinators, the majority of the systems with such people are using NSF programs (18 systems have designated K-6 science coordinators and each of these systems uses NSF curricula) and they can be identified as central systems that can reach out to other systems. This combination of resources — skilled teachers and science coordinators — provides knowledge and informed judgment and experience in implementing the science programs.

(c) Planning teams in systems considering joining a Schools Science Collaborative Program should consist of administrators, teachers and the science coordinator. One school district might stimulate discussion of the possibility of forming such a collaborative by requesting the appropriate Regional Education Center of the Department of Education to publicize and host an initial meeting. Or, in some cases, the structure of an existing collaborative formed for other purposes might be utilized. Then the team members will develop specific plans on how their system will cooperate with other systems and as the work progresses they will prepare their own implementation schemes. The key factors are the continuing responsibilities of the planning team throughout the implementation process, from program selection, monitoring trials, arranging feedback, devising a flexible long-range plan — all consonant with the aims of the Schools Science Collaborative Program.

(d) The notion that people in the schools take the responsibility for staff improvement is not new (the normal schools in some cities more than sixty years ago did this and from most accounts did it well); but perhaps it needs to be re-invented at this time.

(e) Much has been written about the isolated teacher, less about the isolated schools and school systems. It seems wasteful to live with this kind of isolation, especially when the notably responsive Athens of a school system may be contiguous to the Sparta. In the past, innovative programs have often been initiated in leading systems, and the "lighthouse" systems' exemplary practices were intended to induce similar practices in the more conservative and hesitant systems. To a considerable extent, the result of funding "lighthouses" appears that the maintenance of the superior system is ensured, but that little spillover is evident in the less innovative system. It seems that in education opposites do not attract each other — and possibly for good reasons. It is desirable that collaborating systems in the School Science Collaborative Program reflect a rather common background. As the Committee discovered in its research, even in spite of depressed economic conditions of some school systems, whether in the city or town or country, superb elementary science programs are offered.

SOME PRACTICAL CONSIDERATIONS

2. A demonstration or target school in which sound programs are apparent is selected in the central system with this school as a focal point for training and summer workshops among the five or more collaborating systems. Each of the systems will select two or more teachers from each of two schools within the system to work in the program, with their principals, from the beginning. At least twenty or more teachers and their principals and science coordinators (or the person most responsible for science) will plan the summer workshop. At least seventy students from grades one through six would attend the summer school for three of the four-week summer program.

3. Pre-planning for the program will be done by teachers and science coordinators; this group will decide how large a part elementary science will play in the summer school's curriculum (a range of subject offerings and activities will be offered) and they will decide their strategies for the summer and during the

academic year. ungraded classes, team teaching, grading, activity centers or self-contained teaching arrangements, the space needed, equipment and materials in subjects other than science. They will present their plan in the spring to the respective school administrations for the consideration of superintendents and school board members. The plan essentially is a first step in implementing new science curricula, and it should meet the Committee's primary consideration that the motive power should come from local groups of teachers and science coordinators accessible to one another and operating with sensitive administrative support to break through the harmful isolation that now impedes cooperative work.

4. An NSF institute training experience for teachers costs the federal government more than $700 for each participant. To reach only the 28,800 elementary teachers in Massachusetts schools would cost over $200 million. With the decrease already in government funding for teacher training and the likelihood that the already minute funding will be cut back even further during the next few years, alternative schemes should be considered to provide teachers the equivalent experience. (Roughly 300,000 high school science and mathematics teachers attended NSF institutes in the United States; less than 40,000 elementary teachers have been able to do so.) Since training is an important component of implementing the elementary science programs and since several hundred or more skilled elementary science teachers and science coordinators in Massachusetts have participated in NSF programs, it would seem wise to exploit their skills and experiences. Certain points need to be raised about the financial implications of new confederations within the schools; some of them are:

(a) The Schools Science Collaborative Program is predicated on the sharing of facilities, materials, and the expertise of teachers and administrators by many cooperating systems. At the present time, it is still possible that the costs of trial packages of elementary science curricula can be reduced by cooperative use of NDEA Title III funds (as they become available) for elementary science. For example, through this Title the state reimburses a local system one-half the cost of materials purchased for the summer program. If one system, for example, wants to spend $4.000 on the new curricula — not regular classroom quantities but enough to start an experimental or trial program, NDEA Title III will reimburse the system with $2,000. If five systems collaborate on a summer program, the actual cost for each system would be $400 in materials outlay. Additional expenditures might be needed, of course. additional expenditures on travel and sometimes subsistence costs for teachers during the summer and at group meetings during the academic year may be some of the requirements. It may well be that the costs for this kind of support would add very little more than many systems now budget. Similarly, the additional costs for science coordinators may make a comparatively small addition to the salary structure. (Naturally, many systems regularly offer summer programs now, to a certain extent, the Schools Science Collaborative Program is an elaboration upon existing practices.)

(b) Broadly stated, while exact estimates about the costs of operating Schools Science Collaborative Programs cannot be made, we feel that even without outside funding, the benefits likely to accrue over a period of time are worth the investment of the individual school systems.

GETTING STARTED

5. As in most innovative programs, the initiative comes from someone who cares deeply and wants to help people in the schools. And, as we have seen in the study, this person can be a teacher, a science coordinator, a principal, a school board member, a superintendent. While elementary science programs apparently run without the obvious virtuoso performances by individuals (this is revealed by an accumulation of statistical data and the interpretation of it) beneath the surface, there is evidence of a specific presence (however quiet and imperceptible they may at times be) of a "prime mover." Should a number of persons wish to investigate the development of the

program, one caveat seems to be in order: educational fads have come and gone with the seasonableness of external program funding, a particular new program — it can be differentiated staffing, behavioral objectives, modular scheduling, and the like — lasts a year or two, then ceases. Long-range commitment is desirable: collaborating school systems ought to be committed to this new science confederation for a minimum of five years. Otherwise, it may be the wisest course not to instigate such a consortium. The Committee's hope is that teachers' hopes will not again be raised and then lowered, as has happened with so many "crisis programs." The Schools Science Collaborative Program aims to build self-reliance in systems. Change takes time, and as teachers in the program become more adept in the new materials they will train other teachers in their own systems. The program is not a one or two-year effort. Without the possibility of gaining sustained support and institutional commitment it may be the sounder decision not to embark on it at all.

What Critics Might Say

6. Even though cost reductions might be made by certain joint practices among school systems, the idea of collaboration among them is uncommon in the extreme (when the school systems themselves manage their programs). Important questions can be raised. *What is so compelling about the proposed program to warrant collaboration?* Under existing statutes, collaborating school systems would have to submit individual proposals to NDEA Title III. *Wouldn't such a process be too cumbersome? Who would coordinate it?* Wouldn't it be better if such training services were offered in the fifty-four colleges and universities in the state that prepare teachers? *Teachers in the schools are not scientists, but aren't the professionals able to help them?* Joint programs of one sort or another have been tried across the state for the past twenty years, but none of them, so far as we know, has been managed by the teachers and science coordinators in the schools.

Why should we assume that teachers and administrators want to engage in such a program now? Teacher centers in each system might accomplish the same tasks. *Wouldn't they be less expensive?* Elementary science has a low priority in the schools. *Why should school systems embark on this program when reading and mathematics have higher priorities?*

Answer:

This program stresses people, not money. For too long, innovation has stressed building costly administrative devices to transplant curriculum training programs from one system to another, via outside-the-classroom direction, without emphasizing the fit between programs and local needs. There are now networks of "innovative" systems and agencies to encourage joint work; but too many of them offer minimal services to the classroom teacher; e.g., one agency offers the ERIC microfiche service to collaborating systems, another offers computer services in personnel selection.

Answer:

Of course it would be helpful if teachers of science in colleges and universities offered help regularly to teachers in the schools; but they don't. Furthermore, there aren't enough "experts" available to serve all the schools simultaneously. And teachers in the study reported some dismay with their undergraduate preparation in science. Consequently, the Committee recognizes that inservice training must often provide the necessary exposure to elementary science. And skilled teachers in the schools are able to do this.

Answer:

There is a cost saving in sharing materials; but, even more importantly, there are immense benefits in sharing interest and expertise. And skilled teachers are experts.

Answer:

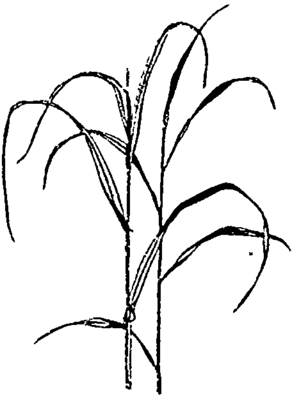
This collaborative program could be the mechanism to support innovation in smaller systems, many of which spend less than $700 per pupil and are not committed to taking new directions in elementary science.

Answer:

The program offers benefits in the teaching of other subjects and activities; it is not limited to science; elementary science offers a way to give teachers and students pleasurable and worthwhile experiences that may affect learning in other subjects. The program is a sound way to help create responsive learning atmospheres.

Answer:

The program is one way to remove some of the isolation in the schools, a desirable and healthy goal.



II A Comprehensive Title III Effort

7. An alternative way of developing a comprehensive implementation program in the state is possible within the present-day financing potential of the state and local school systems. There are Title III Centers located regionally in Massachusetts; these centers engage in varied activities, from planning and developing new programs to aiding systems implement the ones they have. Most subjects are dealt with in varying degrees by the Centers. Allocated for various purposes, Title III funds do not represent large sums of money for any one program — and, as a matter of fact, they are quite restricted. However, taken into a cumulative amount, the monies represented are considerable. What is needed is the development of an implementation system for elementary science which utilizes these funds, without asking for additional funds.

8. The science implementation system would be composed of perhaps fifteen regions, each representing geographically the area served by selected Title III Centers. Within each of these regions target schools would be selected to serve as demonstration and implementation centers. These schools would receive concentrated support during the first year of operation. Little or no attempt would be made to work with schools or systems outside the designated target schools. During the first year, the target schools would begin to develop exemplary training programs. Training would be provided for teachers in these schools while at the same time teachers in these schools are developing training programs for others, to be used in the future. The Title III Centers would work with system personnel and selected science coordinators in designing the program that would serve particular areas. These Title III personnel already exist and are paid for

under current funding. Competent help could be selected from the schools and universities.

9. Target schools would receive a major portion of available funding to train staff and future science trainers. During the second year of operation auxiliary schools would be selected to work with elementary science programs. A teacher, trained in a target school, would thus be seconded for a year at the auxiliary school. A teacher from the auxiliary school, selected because of his or her skills in science and at working with others, would be sent to the original target school. Consequently, the teacher from the auxiliary school would be working with a team of experts in the target school. In the meantime, the teacher on leave from the target school would be having an influence on the auxiliary staff, in elementary science and teaching strategies. During the third year, the teachers involved would go back to their original schools. The teacher from the auxiliary school could now continue the leadership role previously shown by the target school teacher. By the fourth year, the auxiliary school could then be considered a target school with trained personnel available for assignment to new auxiliary schools. During the fourth year, the target schools would have multiplied considerably. It would take four or five years to make durable inroads in full-state implementation of NSF elementary science curricula. The Committee feels that this plan is workable because there are already many able elementary science teachers and science coordinators in systems throughout Massachusetts. Admirable target schools are now in operation.

10. A statewide implementation plan is desirable. This plan would arrange a pooling of resources in the schools and state agencies. Not only would it help to remove the provincialism of systems, but it would also serve to infuse useful new approaches in other subjects and activities along the way. To make it work, a readjustment in priorities must be made. Instead of sprayshooting rather small grants on disparate projects on

a number of fronts, it means that a concerted effort and commitment be made to targeting work in elementary science, perhaps having Regional Education Center resources arranged to contact and support all Title III centers interested in joining this commitment. The procedural model could then be addressed to other curriculum areas in the future.

FURTHER FINANCIAL IMPLICATIONS

11. Target teachers might receive additional stipends for both training and demonstrating from the Title III Centers. Teachers moving from one community to another "on loan" would receive regular salaries from their local school systems, plus increases as they earn them. Additional stipends for travel and per diem might be provided by Title III funds. (This outside support would be minimal in relation to the total effort.)

12. It is not realistic to expect large increases in money during the next few years; what must be done must be done essentially within the constraints of funds that are currently available.

III Centers for the Advancement of Teaching and Learning

13. In an editorial in *The Christian Science Monitor*, on September 25, 1968, advocacy of several attempts to build in the public schools teacher-directed Centers for the Advancement of Teaching and Learning was made. The editorial discussed how "a school system's best teachers, plus experts they invite from elsewhere, would help set community teaching standards." Further, the editorial noted that "It makes a good deal of sense at this time, when teachers like students and other groups feel resentful of pressure from the top, that their best energies be utilized for self-reform. The universities will not have to give up the research and materials role they now hold, but the moment does seem ripe for a switch in emphasis from campus theory to classroom results." Many teachers feel that in the past proposals for change have emanated from administrative or other non-teaching sources, and the power to initiate change has remained the almost exclusive prerogative of administrators. As a result many proposals are most likely to be framed in terms of administrative efficiency and evaluated in terms of administrative problems, with the teachers often feeling that they have been "used" for the benefit of someone else. Great gains are to be had by shifting some of the emphasis for change and implementation more to classroom teachers. Productivity of whatever nature appears to increase when those on the firing line feel that they have had a hand in shaping the institution's direction and when they are consulted about policy and not peremptorily directed to implement it. (It is not essential to refer to the pioneering work about the social attributes of effective organizational governance of

F. J. Roethlisberger and Elton Mayo, but it may be extremely illuminating.[2])

14. The Centers may have many purposes, in curriculum implementation and teacher training; the Centers can be supplementary and complementary to other progressive institutional arrangements. Regardless of whether a system decides to join a collaborative effort with other systems, strong teacher centers should be started; the Committee believes that they will play an increasingly important role in raising standards and performance. Among the proposed activities and services of the Centers — focused initially on elementary science — are the following:

(a) The Centers will provide teachers with the opportunities to develop their ideas and share their thoughts on curricular matters, they may come together and counsel one another informally on a variety of topics. As the Committee's research noted, teachers of the NSF curricula spend a lot more time talking to one another about science and teaching than do teachers of the traditional textbook programs.

(b) The Centers will plan and conduct inservice training programs to implement the new science courses.

(c) The Centers will help to assemble materials for classroom use and by offering help they will assume informal advisory functions.

(d) The Centers will serve as liaison forces to marshall the resources of the system for the benefit of the teachers: some teachers especially in large systems may often be unaware of the many services the system itself offers to teachers. The Centers will serve as useful channels of information.

(e) The Centers will sponsor system-wide conferences on elementary science, offer symposia, and invite scientific experts in for short periods of time.

[2] Elton Mayo, *The Social Problems of An Industrial Civilization*. Division of Research, Graduate School of Business Administration, Harvard University, 1945.

(f) The Centers will work in close cooperation with the principals, in planning science programs, as well as with science coordinators and other administrative officers. The Centers will serve in the planning and development of long-range system goals in elementary science. If planning teams are formed by systems that are considering adopting new science curricula, the teams might work through the Centers. science coordinators, administrators and teachers — all members of the planning team — might use the Centers as a focal point to initiate their deliberations.

Local Support of the Centers

15. The costs are unlikely, in relative terms, to be great; the growth of the Centers will vary from community to community. Part-time services of a director will be needed in one community, full-time in another. Space in a building not in the schools seems preferable to running Centers in the schools. Centers may be located in "found" space — rather inelegant facilities presently lying fallow, in the community. More than four hundred teacher centers exist in England and the facilities in which they're located range from factory buildings, garages, office buildings, to local libraries; and the centers grew out of the local implementation planning for new elementary science programs. The one teachers center in Massachusetts that operates in the fashion outlined in this handbook is in Pittsfield; the superintendent there is Dr. Thomas J. Whalen. (Teacher Renewal Centers was an aborted federal project of recent history: planned were four hundred teacher centers across the United States. None was begun, and the program folded.) Local support is essential to move this good idea.

Structural Implications

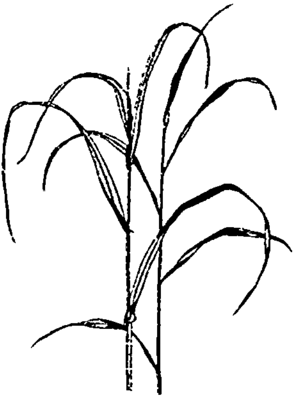
16. The Centers would be directed through a board of ten or more members appointed by the superintendents of the associated systems. The board would

include especially teachers, principals, and the person most responsible for science. Authority would naturally derive from the superintendent and the school board. Centers would work closely with the systems' present curriculum department to prevent duplication. The structure of the Centers will vary, but it is desirable for them to be run by small steering committees, and no complex machinery should be necessary to make the Centers run smoothly.

SELF-RELIANT TEACHERS IN SELF-RELIANT SCHOOLS

17. The Plowden Report in England (published in 1963) and considered by many critics as a landmark in suggesting improvements in elementary education noted ". . . The only uniformity of practice that the Board of Education desires to see in the teaching of elementary schools is that each teacher shall think for himself, and work out for himself such methods of teaching as may use his powers to the best advantage and be best suited to the particular needs and conditions of the school. Uniformity in detail of practice (except in the mere routine of school management) is not desirable, even if it were obtainable." Balance this statement with the observation of an elementary principal about the need for teacher-directed centers: a principal said, "It has become quite apparent that our local institutions of higher learning either do not have the inclination or do not have the demonstrated capacity to assist in training teachers in the new mode. As a result, it will fall upon our shoulders to locate, invite, and evaluate educational practitioners who have made meaningful gains." An administrative board made up of teachers, principals and perhaps central office administrators who would run a center through a director of their own choice was a sound practice, according to a superintendent. He said, "This would place teachers and other instructional people in a position of making policy through staff development in a way that is not possible in the present institutional form of school administration. It might make possible a consolidation

of all inservice training into a new, creative and energetic approach to educational problems." In short, it will be up to the community to set its teaching standards, to raise them, and to respect the quality and ability of its present instructional staff to help do this. "Only when training programs are created by teachers for their own clear purposes will the efforts, encouraged by minimal funding, survive," Fletcher G. Watson, the Henry Lee Shattuck Professor of Science Education at Harvard University, said recently. "When teachers plan and act for their own purposes, they'll get the job done."



IV Beginning Again: An Inventory of Attitudes and Resources

18. Is it desirable to gain a bedrock of information about the attitudes of faculty and classroom resources before embarking upon a new science program? What does a system already have that gives strong evidence of the need for a change in program and how can a system evaluate a new one? The Committee feels that an inventory is a useful way to begin assessing the need for a new program, how well it might be received and what help teachers might desire. The following questionnaire lists some of the concerns. Someone needs to delete questions that may be inappropriate and add others which are pertinent.

THE HARVARD ELEMENTARY SCIENCE QUESTIONNAIRE

This questionnaire may be helpful to you in making a preliminary assessment and inventory of experiences, attitudes, materials, and expectations among the teachers in your elementary schools, in schools that are trying out new curricula as well as those in which the textbook is the present mode of instruction. We hope you will delete questions that you feel are not pertinent, add others of your own choosing that are, and feel that the final document is your own.

School ______________________________

Grade(s) or grade equivalents you are teaching:

Kindergarten: ______

Grade: 1 ______

2 ______

3 ______

4 ______

5 ______

6 ______

Number of children in class: ______

Other teachers involved: ______

1. How many years have you taught·

in this system ________1)
in total ________2)

2. How many college *science* courses nave you taken?

________1) none ________4) 5-6
________2) 1-2 ________5) more than 6

3. How many of the above courses were *laboratory* courses? ________

4. Teachers naturally differ in their attitudes toward science and science teaching. Please indicate how you *feel* about each of the following statements. Rank them:

1 — strongly agree
2 — agree
3 — tend to agree
4 — tend to disagree
5 — disagree
6 — strongly disagree

a. Teaching science is satisfying because children who are weak in skill subjects often succeed in science	1 2 3 4 5 6
b. Science is too complex a subject to be taught at the elementary level	1 2 3 4 5 6
c. Teaching science gives me a chance to be more flexible and try out new approaches with children	1 2 3 4 5 6
d. Teaching science makes me uneasy because I'm never sure what, if anything, children are learning	1 2 3 4 5 6
e. Teaching science is fun because I learn as much as my students	1 2 3 4 5 6
f. Teaching science makes me uneasy because I'm never sure what will happen and what questions will be asked	1 2 3 4 5 6
g. Science is the one subject where all children are highly motivated	1 2 3 4 5 6
h. Teaching science is enjoyable because I like the subject matter	1 2 3 4 5 6

COMPARISON OF SCIENCE AND OTHER SUBJECTS

5. Compared with other subjects, I like science
   ______1) more
   ______2) the same
   ______3) less

6. Compared with other subjects, my teaching skill in science is
   ______1) better
   ______2) the same
   ______3) not as good

7. Compared with other subjects, the progress of children in science is
   ______1) better
   ______2) the same
   ______3) not as good

8. Compared with other subjects, I feel children generally like science
   ______1) more
   ______2) the same
   ______3) less

9. What science program(s) have you used:
   a) AAAS (SAPA) — *Science — A Process Approach* __1) __2)
   b) CIS — *Concepts in Science* with labs __1) __2)
   c) EIS — *Experiences in Science* __1) __2)
   d) ESS — *Elementary Science Study* __1) __2)
   e) MINNEMAST — *Minnesota Math & Science Teaching Project* __1) __2)
   f) SCIS — *Science Curriculum Improvement Study* __1) __2)
   g) Text (publisher: ______________) __1) __2)
   h) Text & Lab Kit (______________) __1) __2)
   i) Lab Kit (______________) __1) __2)
   j) Local curriculum guide __1) __2)
   k) Units I developed myself __1) __2)

10. How long have you been using your *current* science program?
   ______1) first year
   ______2) 2 years
   ______3) 3 or more years

11. Did you volunteer to start using this program?

______1) yes

______2) no

12. Were you among the first teachers in your system to use this program?

______1) yes

______2) no

13. Please characterize your current program on the following dimensions. Consider the four lines as gradations between each pair of statements. Please check where you feel your program falls on each dimension.

	1	2	3	4	
a) Requires much preparation	___	___	___	___	Requires little preparation
b) Adequate teaching guide	___	___	___	___	Inadequate teaching guide
c) Repeats topics	___	___	___	___	Varies topics
d) Suitable for all pupils	___	___	___	___	Not suitable for all pupils
e) Very structured	___	___	___	___	Very flexible
f) Produces unacceptable noise and activity	___	___	___	___	Produces acceptable noise and activity

14. If you have previously used other science programs, how do they compare with your current program? (Please indicate which programs you are discussing.)

15. How do you feel about present science programs?

______1) Very satisfied

______2) Fairly acceptable

______3) Rather dull

______4) Very disatisfied

16. Teachers have suggested many factors that make it difficult for them to carry out an effective science program. Which of the following do you see as obstacles to you in teaching your science program?

Rate them: 1 — causes great difficulty

2 — causes some difficulty

3 — causes little or no difficulty

MATERIALS

	Great	Some	Little No
a) Lack of equipment	1	2	3
b) Need to share materials with other classes	1	2	3
c) Difficulty in replacing materials	1	2	3
d) Poor quality of equipment — often faulty or doesn't work	1	2	3
e) Lack of suitable textbooks	1	2	3
f) Lack of storage space for materials	1	2	3
g) Lack of space and facilities for science in my room	1	2	3
h) other ________________	1	2	3

SYSTEM

a) Lack of time for science in our schedule	1	2	3
b) Lack of time to attend inservice sessions	1	2	3
c) Time consuming innovations in other subjects	1	2	3
d) Lack of support from principal	1	2	3
e) Lack of active assistance from principal	1	2	3
f) Lack of help from science consultant/ specialist	1	2	3
g) Community resistance to science program	1	2	3
h) other ________________	1	2	3

17. Have you attended any science workshops, institutes, or courses conducted *outside* your system? (e.g. at a local college or another school system)

______1) yes
______2) no

18. In the past 3 years, approximately how many hours of science workshops have you attended?

______ hours

19. What help in teaching science has been available to you? (Check all applicable.)

______a) an "on-call" consultant, coordinator, or specialist
______b) scheduled time to meet with others using the program
______c) demonstration classes conducted by a qualified person
______d) literature on science methods, concepts, etc.

e) publishers' representatives
f) other ______

20. How often do you get together informally with other teachers using the program to discuss problems and ideas?
____1) often ____2) seldom ____3) never

21. Which best describes how you *usually* fit science in with your teaching? (Check one)
____1) teach it as a separate subject
____2) teach it correlated with other subjects
____3) teach it incidentally as need and interest arise
____4) teach it as enrichment for children who are interested
____5) other ______

22. How are your science classes?
____1) fantastic
____2) ok
____3) mediocre
____4) disastrous

23. What comments can you make about how science is going in your classroom?

24. How would you prefer to have science classes operate?

25. What help would you like to have?

26. How many *minutes per week* do you teach science? (approximately) ______ minutes

27. Some science programs include a lot of materials and equipment. If you use materials in science, which best describes how you organize and store them? Check one.)
____1) materials are kept in school storage area until needed for a specific lesson
____2) materials are stored in my room safely out of reach
____3) materials are stored in my room where children can get them
____4) materials are kept out and around the room
____5) other ______

28. Some people find that teaching science has influenced certain ideas and methods of teaching in general. What has been your experience?

29. Would you please list the materials in your classroom that pertain to science, noting the quantity.

Item *Quantity*

30. Would you please list the different textbooks and the quantity that you have now and would you please note the publisher's name and the date of the publication of the books.

Textbook *Quantity*

31. Would you make a diagram of your classroom noting the desks or tables and windows.

32. Do you have a sink?

______1) yes
______2) no

33. What kind of storage space do you have and how adequate is it?

34. Would you prefer to have a summer workshop in science as a way of becoming familiar with the techniques and methods of a new program, or would you rather have school-year training programs held after classes? (Pleace check one)

______1) summer program
______2) after-school program

35. If you prefer summer workshops would you also like to be able to teach children during the summer, using the new science materials?

______1) yes
______2) no

36. Please indicate:
the frequency with which students undertake experimental work in science in your class *at present.*

Every, or nearly every, science lesson ____
Regularly — one or two periods per week on average ____
Sometimes ____
Rarely or never ____

37. Please indicate:
the frequency with which, in your opinion, science lessons should undertake experimental work *if ideal conditions prevailed.*
Every, or nearly every, science lesson ——
Regularly — one or two periods per week on average ——
Sometimes ——
Rarely or never ——

END OF SAMPLE QUESTIONNAIRE

19. Information elicited by this questionnaire is a helpful beginning for ,etting the stage for deciding how to decide about making a successful exploration in the NSF science programs and in implementing a program once it has been selected. The right questions must be asked before the system begins — and not after the decision has been made to use a particular program. Continual improvising is not conducive to success. A system that initiates a new program without being absolutely certain of its background will not easily be in a position to know at a subsequent date whether, in fact, it has made the right decision — or more importantly, why and where it went wrong. The kind of information gained through this questionnaire may help in setting community goals and expectations in elementary science. Having this information, the system may better ask whether it's willing to make a sustained commitment to science.

20. Likely, discernible differences will apear in different schools within a system when the information from this questionnaire is analyzed. When such differences do appear, one's interpretation of the data may reflect differences in a philosophical point of view. Some people may feel there is an irreducible minimum level of consistency which should be found in the school curricula and practices. Reinforcement permits easy transfer of students and teachers from school to school; it is often motivated by the hope that it will insure at

least a minimum of achievement. We tend to support, as more realistic and effective, the school of thought that it is not possible to obtain consistency and conformity in the teaching program, that teachers might wish to adapt any materials or programs to their individual styles. Clearly, if wide differences appear, it may be harmful to try to impose a uniform pattern on all schools and it may be wiser to effect better ways of delegating responsibility to the individual schools. Although a high degree of cooperation and coordination is desirable to maintain among the various schools in the system, the Committee feels that curricula decisions respecting the rights and inclinations of individual teachers in all classrooms in all schools is a *sine qua non* of managerial competence. The Committee noted in the previous research reports that the strongest elementary science programs occurred in schools in which teachers had the privilege of making choices among curricula themselves.

V Trials or Pilot Programs

21. The Committee feels that the change effort can be strengthened by not having the customary trials of new programs in a few classrooms in several schools and that it is preferable to concentrate the trial efforts throughout all of the appropriate classrooms in the schools involved. This practice can remove some of the isolation a trial teacher presently has when she alone or with two or three others is using the new program in a school, by increasing the opportunity for teachers in a building to share their experiences with a new curriculum Information travels more readily and evaluation is easier to effect when all of the teachers are working toward a common teaching goal.

EXPLORING NEW PROGRAMS TAKES TIME

22. The quick decision may often be the wrong one. It's desirable to see how people fare with different programs before deciding on one particular program. (Forty systems in the state use several programs as a matter of policy, and the trial becomes in them a continuing search for a more responsive environment.) A brief outline of curriculum implementation in elementary science by a Massachusetts system follows:

1963-1964 Seven staff members at ESS in Watertown for summer unit development conference.
Trial teaching.
Inservice training for 80 teachers using available printed materials.

1964-1967 Continued use of existing materials as supplement to existing traditional curriculum.
Waiting for more materials to become available.
Inservice training on limited scale.

1967 (summer) Mrs. ——— at ESS for four-week teacher training institute.

1967-1968 Inservice training on a limited scale.
Selling idea of ESS for school-wide adoption.
Development of system philosophy.
Development of K-6 sequence and Preliminary Guide.
Devising model for implementation and inservice training.

1968-1969 Mrs. ______ made full-time Elementary Science Coordinator.
Pilot program. use of total K-6 sequence in six schools.
Inservice training for teachers on particular units.
Leadership training in 28 schools, one person primary grades, one person intermediate grades.
Acceptance of program.
Equipment purchased: $2,000 per school.
Schools accept cost of supplies at 70 cents per pupil. (This compares to 5 cents and 10 cents a year ago.)
Equipment and supplies placed in warehouse.
Six hours inservice training for principals.

1969 (summer) Revision of Guide by Science Coordinator and selected teachers.

1969-1970 Leaders conduct inservice programs in 28 schools during the school year.
Each teacher in system receives 12-20 hours of inservice training.
Pay for leaders, credit for participants.
Leadership training for balance of schools.
Equipment purchased.
Science textbooks eliminated from approved list.
Leaders conduct inservice training in 23 schools.
Equipment and supply storage system developed for all schools.
Articulation meetings, secondary and elementary teachers.

1970-1973 Developing equipment replacement procedures.
Help teachers loosen up classroom atmosphere and provide a wider variety of activities and materials.
Develop list of quality reading books to support program.
Provide variety of evaluation strategies to be used voluntarily.
Give teachers detailed assistance in reporting student progress to parents.

But History Doesn't Have To Repeat Itself

23. Trials no longer need be conducted by the schools to find out whether the new science programs are good — they are, and the Committee's work confirms this; rather they should be conducted to see how the people in the schools fare with different programs. Change does take time, but the schools know a lot more about the programs than they did even five years ago. What seems desirable, as systems plan implementation strategies, is for them to develop ways to provide for continuous and flexible master planning — and not become locked into a plan.

First Decisions

24 An effective atmosphere for making innovations in elementary science can be fostered by the co-alignment of decision making at two levels, the administrative and the faculty. It seems desirable at this time for the school committee and administrative policy decision to be that well-supported NSF curricula will be used in the system; once this decision has been made, then the teaching faculty — possibly at the individual building level — should decide, following experiences with the curricula, which ones they would like to use and how they would like to use them. This recommendation, to a certain extent, recognizes a customary but inexplicitly-formulated policy. To recognize formally this procedure can lessen the confusion, resistance and frustration that sometimes results from not having a clearly-stated policy, with decision making shared by the two groups.[3] It is important to recognize that

[3] Some educational historians might consider that this Committee was reverting to the progressive faith of the twenties that called for developing a curriculum, a standard one, to fit local requirements that would be sifted through learning experiences in each classroom, and come out without any curriculum at all but rather an unchoate faith in everyone doing his own thing, as it's described today. But the Committee would claim that this is a wrong and facile interpretation of

superior programs are available and that greater and more responsive use is made of them when faculty share in the decision. This is the first decision — to have a co-alignment of decision making.

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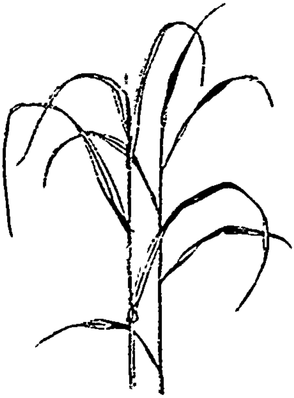
this handbook. What is called for is the kind of responsibility for the public school teacher as is found in leading universities and in many of the best schools.



VI Some Notes Toward A Definition of An Ideal Training Program

25. Of course there is no ideal training program; some observers claim that we can transport packaged materials, concepts and training programs from one system to another, but so far no one has devised a way to transplant generous attitudes, feelings and beliefs from one community to another. To impose a training program upon a group of teachers would be as wrongheaded as imposing a specific curriculum. The Committee feels that one must first discover the feelings beneath the surface before even considering the development of training programs: where do the teachers begin? what do they know? what do they want to know? and how do they want to go about learning? The Committee's research revealed that unfortunately much of the present training in science is antithetical to the aims and techniques of the NSF elementary science programs. And, equally important, teachers are greatly dissatisfied with their training programs and isolated the primary reasons for their discontent as being told how to discover something in a lecture-demonstration. (Eighty-four percent of the teachers in the sample reported that the workshops they attended consisted of demonstrations, and 54 percent reported that the workshops seldom or never dealt with the units they were teaching, and 68 percent of the teachers said that the workshops seldom or never gave them the opportunity to try out materials with children.) But considerable success has been demonstrated in systems in which science coordinators invite the participation of skilled science teachers to conduct inservice programs with them. Because cadres of skilled teachers of science exist in many school system now, the collaborative programs mentioned earlier in this paper offer unusually fine opportunities to give vital and pertinent training

programs. Teachers teaching teachers — whether in a Schools Science Collaborative Program, a Center for the Advancement of Teaching and Learning, or the single school — is one way to maintain adequate training in science. In an ideal world, most of the training would occur at summer workshops where the opportunity to try out materials with children informally exists. But the world is not ideal, and, moreover, to perpetuate the notion that only an elementary knowledge of science is necessary to teach science well, might be injurious: so training, as well as the possibility of having consultant help available during the school year, ought to go on all the time.

THE TRAINING MIX

26. The teaching situations of a training program should be a model of what one would like to see happen in the elementary classroom. formal lecture and presentation kept to a minimum and group work and individualized instruction emphasized. The content of much of the beginning part of the training program may be draw from classroom situations with which the teachers are coping daily. Other objectives should be:

(a) endeavoring to find ways in which children can assume greater responsibility for their own learning.
(b) helping teachers to become more aware of their own styles of teaching and learning.
(c) assisting teachers to organize and manage classroom learning for their students in a manner that enables students to make choices of activity.
(d) helping to individualize children's learning and teaching practices.
(e) gaining insights in alternative ways of learning the concepts of the science curriculum.
(f) imaginatively considering the use of the science materials of all sorts, not pedantically stressing the *mechanical* use of one curriculum.
(g) drawing upon the experience of skilled science teachers and their administrators in illuminating how they successfully solved rather common problems that may seem mundane but that aren't. Storing and distributing materials can be important considerations.

An elementary teacher in a training program said, "Since the freedom to be yourself in the classroom is personal, naturally no individual teacher will be forced to do that which she doesn't 'feel'. If one stops to think about it, the explanation is very uncomplicated. Were one forced or directed to do this or that, the total effect would be lost since it is in being oneself that any tool becomes useful to the total environment."

Removing Sex-Role Stereotypes

27. The Committee found that the NSF programs stressing experiential activities could help to remove the sex-role stereotyping that is reflected in our society: the NSF programs permit girls — as well as boys — to confront their perceptions directly with their personal data. Clearly, girls can do experimental work, and from this work gain a new reinforcing sense of achievement and competence — one needed by all students but especially if the science door is to be opened to women. Accordingly, great gains are possible when the training mix includes discussions about attitudes toward sex-role stereotyping.[4]

A Note on Special Education and Children with Special Learning Problems

28. Training programs in the future should deal with providing skills at the early identification of children with special learning problems — sometimes severe ones — and how the school faculty and staff may function effectively in concert in providing needed services. Elementary science — especially experiential curricula can offer a sensitive bridge to meeting some of the needs of children with special problems. In its report, *Half Our Future*, the Central Advisory Council for Education in England noted how experiential science programs benefited children with unique learning problems.

[4] Some teaching suggestions and a bibliography may be obtained from the Women's Equity Action League (WEAL), 538 National Press Building, Washington, D.C., 20004, in their *WEAL K-12 Education Kit.*

VII Evaluation, Consideration of

29. Prime initiative for evaluation rests with teachers and with each school system. Despite widespread interest and support of national and even international standardized testing, most school systems in the state have approached it with considerable reluctance, and wisely so. The Committee believes that procedures and instruments for evaluating pupil progress in elementary science should be based on the schemes suggested by each of the NSF programs, but they must be geared to the school's educational goals and how the teachers use the various units and programs. National assessments, some behavioral objectives (those that encourage rote memorization rather than critical thinking) and standardized tests in elementary science are weak and often irrelevant to many of the aims of the NSF curricula. Evaluation ideally ought to be an integral part of the planning and implementation processes and should not be appended on to a science program once it is being used in the classroom. There are many ways to evaluate learning and to be accountable; they are, and should be, broader than objective tests. They should include the use of orally conducted interviews, creative projects, demonstrations, experiments, written reports, classroom observing and classroom environment checklists.[5]

[5] The reader may gain added insight into developing pertinent and imaginative evaluation strategies from the book *Evaluation Strategies*. This book was based on intensive research and evaluation of *Man. A Course of Study*, a social studies curriculum developed with National Science Foundation support at Education Development Center, Inc., in Cambridge, Massachusetts. Varied evaluation strategies are presented that are directed to these concerns. How do teachers devise workable techniques for evaluation? How do teachers make judgments about student learning? How do students gain an insight into their own masteries or problems in developing the intellectual competencies and human understandings at the core of the course? Many of the strategies are adaptable to the science programs.

VIII A Note on Undergraduate Education in Science

30. As the schools increasingly adopt the new elementary science programs, some faculty in science and science education departments in the state's colleges and universities will consider offering more courses that reflect the aims and techniques of experiential science curricula in the elementary school. Obviously strong collaboration among school districts can encourage and even insist on this development. While some faculty have been pioneers in developing such courses in Massachusetts colleges and universities — and a few have received grants from the National Science Foundation to run Cooperative College-School Science Programs — it is probably useful to consider again what reforms and readjustments might help the prospective elementary teacher. Fifty percent or more of the teachers in the sample felt that their undergraduate science preparation was not as helpful as it might have been; they noted what they considered to be deficiencies in their collegiate science studies:

(a) The lack of science courses and too much reliance on science methods courses.
(b) The lack of familiarization with less formal teaching strategies and with the NSF elementary science programs.
(c) The absence of sustained opportunities to use NSF materials with children.
(d) The lack of laboratory experience in their science courses.*

* These criticisms in the report were made by teachers currently in the schools and the reader is advised to note that the teacher who received his or her degree as late as 1967 would hardly have been exposed to the NSF elementary science curricula in college because the curricula were either still being developed or prepared for commercial distribution at that date. (And the average number of years in teaching of

In *School Curriculum Reform in the United States* (1964), John I. Goodlad said, "Tomorrow's teachers of teachers are not being educated in the new curriculum movement." He also said, "The most pressing need for curriculum reform today is in the four-year college." Some observers feel that this is relevant criticism today. In *A Study On The Continuing Education Of Teachers*, conducted several years ago at the Center For Coordinated Education at the University of California at Santa Barbara they reported, "In the making of a teacher, it is highly probable that inservice training is infinitely more important than preservice training. In most instances, the preservice preparation of a teacher cannot anticipate what life in a particular classroom will be like. Nor does it equip a teacher to keep pace with rapid social and technological changes affecting education."

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the sample group was seven.) For many teachers their undergraduate training occurred several years before the new programs were widely available. Also, qualitative evaluations of science methods courses are difficult to form. And, naturally, it is possible that many more science courses are available than undergraduates take.

IX Science Information Services

31. Systems that are using the NSF programs might consider whether useful support can be gained by informing parents about their childrens' science activities. Although the research revealed that parents made no demands — one way or the other — upon a school's science program, common sense advises that many parents cannot help but be pleased to learn what teachers are doing and how their children are progressing. At least one Massachusetts public school system publishes science bulletins for parents several times a year. An introductory paragraph reads as follows:

Our efforts to improve science instruction have been well received by students, parents, and teachers since the inception of the SCIS program in September of this year.
We presently have all teachers in grades One, Two and Three (57 teachers) actively participating in either the physical or life science segment of the program in a unit appropriate to their individual level. They anticipate a mid-year switch. In addition, two 'special classes' are pursuing this 'discovery approach to learning.' These classes especially demonstrate the flexibility of the program.

Eight pages of comments by teachers followed, and most of the comments by the teachers were very thoughtful, not encomiums. The science bulletins are sent to the school department's administration and to all of the elementary principals. The elementary science coordinator also discusses in some detail, at the end, further implementation phases of SCIS. There's a notion that good ideas in education travel by themselves. They don't, and by giving some attention to providing reports of activities, then it's possible to gather sensitive support and understanding from the schools and their constituencies.

The following examples have been taken from the comments of a number of teachers:

In preparing for the experiment of transferring the aphids to the pea plants some children were impatient while I transferred the aphids from the culture to the cups they were to get their aphids from. I stopped and asked the class if they preferred me to put the aphids on their pea plants out of class for them. A girl said No — *that would not be science* — we must prepare our own experiments and manage them ourselves.

I think a mark of A to F would defeat the purpose of this program. Evaluation would be better as attitudes and behaviors.

J. had been observing a vial of fruit flies for many days. With the use of a magnifying glass he observed that one of the pupa did not develop into a full-fruit fly, as did his others. Conclusion from others in class was that this also happens to human babies and all other living things.

Children are most enthusiastic. They are delighted to have their *own* materials and opportunity to manipulate: Planting unit successful. A great boost to one of my perceptually handicapped students who can really relate in the world of nature.

Amazingly enough the initiative shown by the slower children is far more evident than in the other classes.

Children were at first hesitant to explore, wanted definite instructions. Once convinced none was forthcoming, most proceeded to put *everything* in the water. (Next year I will wear hip boots.) Discovery began: the magnet worked through glass, the candies were coloring the water, etc. One boy discovered the picture turning green and insisted this was impossible since his water was reddish-blue And the light bulb was finally lit by a girl working with the bulb facing the floor. Everyone screamed so loud when it went on, she dropped everything.

X Safety in the Classroom

32. To the best of the Committee's knowledge, very few serious accidents have occurred in elementary science classrooms in Massachusetts. But serious accidents have happened in some other states. It is wise to review some ordinary safety precautions, and not to forget them. Some precautions are:

a. Do not permit children to work around an open flame wearing braids, ribbons, ties, or long sleeves.
b. Keep burning candles or alcohol lamps from being toppled over by mounting them on wide-based supports.
c. Keep all materials on a metal tray or other fireproof surface.
d. Keep all combustible materials away from flames.
e. Keep a pail of water, a fire extinguisher, and a blanket on hand.
f. Caution children not to touch electric hot plates. They remain hot for some time after they are turned off.
g. Do not heat materials in glass containers other than the heat-resistant type such as the "Pyrex" brand. Tightly stoppered containers should not be heated.

And, in inserting a glass tube into a hole in a cork or rubber stopper, the following precautions should be taken:

a. The hole should be just a trifle smaller than the tube.
b. The end of the tube should be smooth (fire polished).
c. The tube should be moistened or greased and pushed into the stopper gently with a twisting motion.
d. The stopper should be held in such a way that, if the tube should break, the sharp, jagged edges will not pierce the hand holding the stopper.

Children should not be encouraged to taste unknown or hazardous substances.

XI Initiatives

33. Who will lead Massachusetts schools in making innovations in elementary science? Disentangling the elements of dissemination and diffusion is a task of some complexity, but there is no doubt that over a period of time the main element is the personal commitment to help and to lead. Since the publication of *Something of Value* and *Essentially Elementary Science*, the Committee has learned about the initiatives of persons in other states to lead in expanding the use of NSF elementary science programs in their states. A professor of science education wrote about the Committee's reports. "*Something of Value* is a very significant study and set of recommendations. The booklet should be circulated widely to administrators, supervisors, consultants and other leadership personnel around the country. . . . In my own small state of New Jersey I have initiated a modest dissemination project of this report through a network of twenty-one county superintendents. I feel that this type of dissemination might well be carried out in each state. Certainly the findings and recommendations in this report should be of value to educators and interested citizens (such as board members) beyond the confines of Massachusetts." Who will lead in Massachusetts?

XII A Further Note on the NSF Curricula

34. Let people in traditional systems read the comments of a science coordinator who feels that his system is not making progress in elementary science. The coordinator wrote to the members of the Committee:

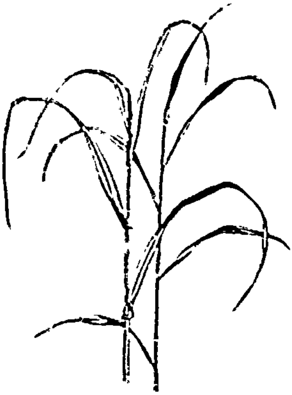
"At present, our science program might possibly challenge a moron. It is so traditional and dated that it is a burden for me to even visit the classes. The level of real student inquiry is abysmal. Of the current staff, one is an enthusiastic novice lacking any real exposure to any innovative science programs and the other has the graceful sensitivity of a wanton rhino and totally alienates most of the students.

The secondary supervisor considers the elementary program with disdain and to my knowledge has never observed an elementary science lesson. The school was built only a few years after the formal founding of the town in 1826 and has never been renovated.

Our science equipment is minimal. In addition, most of it is never used. The students view 15-25 demonstrations a year.

In short, if national scientific awareness were dependent upon a norm equal to ours, we would have a national disaster."

Some systems may be satisfied with their traditional science programs. for them, change is not inevitable. However, opportunities to give teachers and children enjoyable and useful science experiences is necessarily the function of the NSF programs and not the consequence of this Committee's findings and recommendations. The odds of raising the "level of real student inquiry" are greatly increased when the new curricula are used, and it is our hope that this handbook will be helpful to everyone who seeks to offer the highest practical level of service to children in Massachusetts schools. Let us all accept the opportunity and assume the responsibility for making desirable — and, in some instances, major — changes in educational programs, so that we can say again "It is most gratifying to every citizen in Massachusetts to know that her school system has served as a model for the education of the whole nation". . . . as the famous scientist, Louis Agassiz, said in a statement to the Massachusetts House of Representatives in 1859.



APPENDIX

Summary of Findings of the Study

The reader is advised to consult the full reports for a comprehensive picture of the findings. Here, we present only a *brief* selection of the findings reported in *Something of Value*.

The people who use the NSF curricula find in them a capacity to make classroom instruction lively and interesting. This was as apparent from our research as it was from our classroom observations. The NSF programs — offering an abundance of materials by which students and teachers may gain a firsthand, investigative experience in science — give schools a vehicle and a subject area that can transform a static classroom into a lively one, and make possible a shift from the didactic lecture method to an interactive class mode, from *reading* about science to *doing* science. According to teachers and students, the new curricula tend to be agents of change in themselves, and rather spiritless classrooms can become energized when laboratory experiences are possible.

Do the NSF curricula represent an improvement over other programs and other ways (that are now *commonly* practiced in the schools) of introducing science to children in the elementary school? Our answer is that they do, for the following reasons:

PUPIL DIFFERENCES

The NSF programs allow teachers to become more responsive to a wider range of pupil differences than the non-NSF programs. Forty-two percent of the NSF teachers reported that their programs were "very suitable" for use by all students, while only 23 percent of the non-NSF teachers felt this to be the case. In an NSF program the slow learner can be reached more readily while the ablest child is simultaneously being interested and challenged.

PUPIL PROGRESS

Since elementary science has a low priority in elementary education, it is assumed by some observers that children do not make as much progress in science as they do in their other subjects. We learned that 62 percent of the non-NSF teachers felt that their children made less progress in science compared to their progress in other subjects; yet only 38 percent of the NSF teachers felt the same way about the progress of their children in science.

STUDENTS' LIKING OF SCIENCE

In the analysis of the responses from teachers, we found that a larger proportion of NSF teachers (61 percent) than non-NSF teachers (54 percent) felt that their students liked science more than other subjects. In the analysis of student data, we learned that more of them chose science as their favorite subject (27 percent) than any other subject. Seventy-six percent of them liked science either the same or more than their other subjects. (Only 5 percent reported that they liked science the least.)

'DOING' SCIENCE AND 'READING' ABOUT SCIENCE

NSF classrooms more frequently offer opportunities to 'do' science and not just 'read' about it than non-NSF classrooms, according to the teachers. This is hardly unexpected considering the supply of materials that come with NSF programs. Although there are no significant differences between the two in the writing of reports and making collections and displays and models, other science activities show a difference. NSF classrooms do more experiments and record data from them than non-NSF classrooms. Apparently one effect of being more active is to encourage independent learning; we found that activities such as taking home science materials and supplementary readings, and the like, occurred 25 percent more frequently in NSF classrooms than in non-NSF classrooms.

TEACHERS' LIKING FOR SCIENCE TEACHING

We found that there is neither an overwhelming liking for science teaching nor an overwhelming dislike for science teaching in the elementary grades. One-fourth of the teachers in our sample as a whole reported that they liked teaching science more than teaching other subjects; another quarter said that they liked science teaching less. And one-half the teachers reported that they liked teaching science the same as teaching other subjects. However, we learned in another place in our survey that once a teacher begins using an NSF program the odds were improved. a higher percentage of the NSF teachers (79 percent) liked teaching science more or the same than the non-NSF teachers (62 percent).

A NOTE ON SEX-ROLE STEREOTYPING AND CHILDRENS' INTERESTS IN SCIENCE

While 76 percent of the children in a sample of fifth and sixth graders liked science the same or more than their other subjects — and they like the participatory-experimental mode of learning which is typical of the NSF programs — our data revealed that only 14 percent of the children in these grades felt that society wanted girls to become scientists. Children's attitudes about science as well as the assumption that girls cannot do experimental work appear to be generated in the elementary years. And further that the feeling of the lack of support for science as a possible career is markedly more evident among sixth grade girls than among fifth grade girls.

If elementary teachers want to maintain the interest in science among girls, they may want to address the issues of sex-role stereotypes — both as the stereotypes influence their own behavior and expectations and as they limit the options among their children. Not surprisingly, teachers were found to have an impact on their students' interest in science. The teacher and classroom characteristics which tended to produce the positive science interests were. a positive attitude toward science, a responsive, flexible teaching style, the use of experimental activities that encourage individual experimentation, and the belief that an interest in science and the ability to perform science experiments are not sex-linked functions. When teachers — men or women — had these characteristics and were using science programs that encouraged individual experimentation, then girls had attitudes toward science which were as positive as that of boys.

By encouraging classroom discussions about sex-role stereotypes in science and by offering programs that allow individual participation in experimentation, teachers can help to offset the traditional view that virtually compels elementary school students to question the ability of girls to do science as well as the propriety of their being scientists.

ADEQUACY OF TEACHING GUIDES

More NSF teachers (80 percent) felt that the teachers guides were adequate than did the non-NSF teachers (65 percent).

CLASS SIZE

There is no difference in class size between schools using NSF programs and schools using other programs.

EFFECT ON STUDENTS' ATTITUDES TO LEARNING

According to the teachers, the effect of science instruction on students attitudes to learning was that students showed curiosity, asked questions participated actively in conducting experiments and enjoyed science. The NSF programs were more effective in bringing about these conditions than non-NSF programs by ratios higher than 2:1.

CLASSROOM PREPARATION

A higher percentage of the NSF teachers (38 percent) feel that their programs require 'much preparation' than do the non-NSF teachers (22 percent).

SCHOOLS CAN BE THE DIFFERENCE

In the sample of children the data revealed striking significant differences about the role of the school and the teacher in stimulating the interest of children in science Despite socio-economic differences and despite parental occupations, ranging from the unskilled to the well-to-do professional, the home apparently plays a minor role, and the school a major one in introducing science to children. Thirty-eight percent of the children advised us that they first learned about science from a teacher and only 6 percent reported that the source was a parent, and brother or sister (5 percent). Eleven percent of the children reported that they first learned about science from television and 6 percent from a book. (Thirty-one percent said that they didn't remember where they first learned about science.)

CLASSROOM MANAGEMENT AND DISCIPLINE

Some observers believe that interactive classroom environments — especially those that may be encouraged by the availability of materials that allow each child to engage in his own experimentation and to discuss his work with his peers — create classroom management and discipline problems. Yet from our data we can infer that the NSF curricula do not create undue problems. A larger percentage of NSF teachers (60 percent) than non-NSF teachers (46 percent) felt the 'noise' and activity in their classrooms were in no way disruptive of teaching and learning. Teachers prefer, apparently, to see students involved and working with one another in busy, active classrooms. (At the extreme, only 4 percent of the NSF teachers and 3 percent of the non-NSF teachers felt uncomfortable.)

SHARING IDEAS

Thirty-seven percent of the NSF teachers meet together informally and often to discuss science, while only 18 percent of the non-NSF teachers do.

SCIENCE SPECIALIST HELP

Thirty-one percent of the systems committed to NSF curricula have some specialized science teachers. Only 19 percent of the non-NSF systems provide this kind of help. The customary teaching approach in 51 percent of the NSF systems is a classroom teacher with no assistance from an elementary science specialist or consultant. This percentage rises to 94 percent in non-NSF systems.

TEACHER INVOLVEMENT IN INNOVATION

Seventy-six percent of the teachers felt the need for a new program (whether NSF or text) before they began using their current program, but only 12 percent of the teachers helped select the new program in their system and only 20 percent in their schools. Forty-one percent were among the first teachers in the system to use the new program and thirty-nine percent volunteered to use the new program.

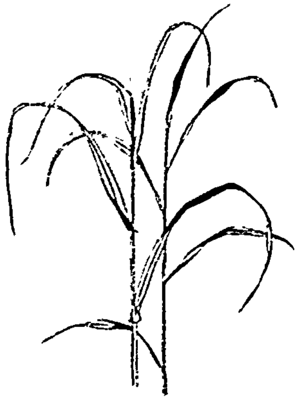
FINANCIAL CONSIDERATIONS AND INNOVATION IN SCIENCE

A striking correlation exists between per pupil expenditures and the use of NSF curricula. Ninety percent of the systems using these programs spend more than $900 per pupil Only 30 percent of the systems spending less than $600 per pupil use the new curricula.

The average amount spent on elementary science materials in the systems is less than $1.00 per pupil yearly. Systems using NSF programs spend $3.00.

The more per pupil expenditure on elementary science, the more outside funding that system receives, and with the exception of National Defense Education Act Title III funds (76 percent of the systems) and Elementary and Secondary Education Act Title II funds (64 percent), little use has been made of federal programs to support elementary science activities. Twenty-two percent of the systems have used Elementary and Secondary Education Act Title III funds to help establish supplementary science centers and innovative programs. Thirty percent of the systems have used Elementary and Secondary Education Act Title I funds to organize innovative science programs. Twenty-four percent of the systems have never used any outside federal funds to allay the costs of science innovation. The proportion of systems using local funds and general state aid to the use of federal funds is 84 percent local and state to 16 percent federal.

Where we found problems they tended not to be in operational areas; e g. classroom management and discipline, nor in the curricula themselves. Rather the problem areas concerned inservice training, consultant help and storage space. The elementary school, however, can be a sufficiently flexible institution to accomodate the problems of teacher specialization and training, and we believe that it can become even more responsive to science teaching needs. Instituting any new program, especially those with equipment, can be expensive, and the NSF programs are not cheap. These programs are also filled with expendible items, such as batteries and bulbs, and they too cost money. But the costs relative to school benefits are very minimal and appear from all the data we have been able to collect worthy of the cost.



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