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ABSTRACT

Presented is a summary of findings and recommendations provided by the Harvard Study Committee under the auspices of the Massachusetts Advisory Council on Education. The study is mainly concerned with the four National Science Foundation (NSF) programs: Elementary Science Study, Science Curriculum Improvement Study, Science - A Process Approach, and Minnesota Mathematics and Science Teaching. Program contributions to Massachusetts elementary science are analyzed in connection with pupil progress, classroom preparation, community involvement, science specialist help, time for elementary science, and adequacy of teaching guides. Teacher training, science coordinators, principals, financial considerations, and sex-role stereotyping are delineated in detail. The booklet concludes with teachers' perceptions about the NSF curricula and with two tables, one showing operational differences between systems committed to NSF and non-NSF curricula and the other showing strengths and weaknesses of the NSF programs perceived by science coordinators. Included are 13 recommendations; a list of the numbers of systems, classrooms, and buildings involved in the programs; and the percentage of use by grade. (CC)

SOMETHING OF VALUE

A Summary of Findings and Recommendations for Improving Elementary Science In Massachusetts

Joan Fitzgerald

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

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MARCH 1973

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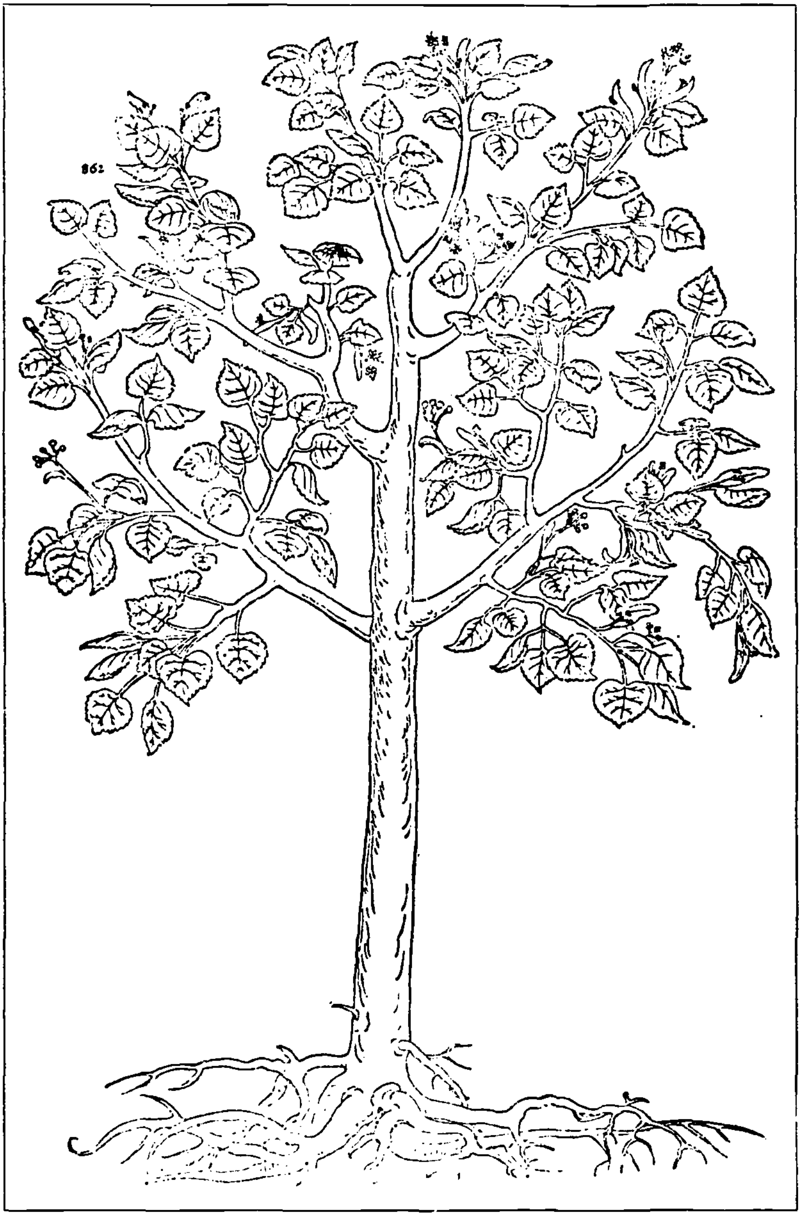
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Foreword

TWO years ago the Advisory Council on Education contracted with Harvard University for a study aimed at increasing the effective installation of soundly-based, innovative science curricula in the elementary classrooms of Massachusetts. During this period, the Harvard Study team, under the leadership of Dr. Dean K. Whitla, visited and observed in over 40 school systems, interviewed over 150 persons involved and concerned with elementary science and administered questionnaires to all public school superintendents and science coordinators in the state as well as to a wide sampling of teachers, elementary principals and students.

What the study team found is summarized in this booklet and, at much greater length, in the team's full report, '*Essentially Elementary Science: The Status of Elementary Science in Massachusetts Schools.*' In addition, the team is preparing a handbook to accompany the full report. The handbook, which represents a new type of publication for the Massachusetts Advisory Council on Education, will translate the report's findings into specific and useful instructions and advice for teachers and principals on how to go about effectively installing and using the new elementary science programs. It is our hope that together these publications will form a corpus from which many school systems can begin or continue to bring about needed changes in their elementary science programs.

The major finding that both pervades and asserts itself throughout all the reports is obvious but in constant need of repeating. If teachers are given choices – are allowed to make decisions – are, in short, treated as both professionals and human beings – better teaching and better programs result. According to the study team, when teachers are not "locked" into programs – are not tied into textbook structured courses of study – their classrooms are alive and stimulating.

The Council hopes that readers of this and the related reports will give their findings and recommendations serious consideration. In addition, we would be pleased to hear your reactions and suggestions to the products of this study.

Dr. Allan S. Hartman conceived this study and shepherded it along. He deserves special mention for his many contributions to the study.

Finally, on behalf of the Council let me thank each member of the study's advisory committee for the help provided in both giving advice and suggestions and in cooperating with the study team in many other ways. Their assistance was invaluable.

Ronald B. Jackson
Acting Director of Research

Summary

The first efforts of national curriculum development groups in the middle fifties were directed at preparing new high school science courses in physics, biology and chemistry, and in mathematics. Supported by the National Science Foundation, these groups developed the Biological Sciences Curriculum Study (BSCS), Chemical Education Materials Study (CHEM Study), Harvard Project Physics (HPP) and the Physical Sciences Study Committee (PSSC); the rate of adoption of these new programs and acceptance by high school science teachers increased at a substantial rate in successive years. Reform efforts in elementary science started in the early sixties; three of the four major NSF-sponsored programs have been commercially available to the schools for several years. Yet it appeared to some observers that the rate of adoption by the schools was somewhat lower than could be expected. This study grew out of the interest of the director of the Massachusetts Advisory Council on Education and his colleagues. They wanted to learn what was happening with the new elementary science curricula in Massachusetts schools and in the spring of 1971 they invited Dr. Dean K. Whitla, director of the Office of Instructional Research and Evaluation, at Harvard University, to direct the study. Dr. Whitla then recruited a committee of nine to join him in planning and conducting the research.

The members of the study committee wanted to draw upon samples of respondents who were representative of all of their peers in Massachusetts schools and to design questionnaires that combined the virtues of sharply-formulated pretested, multiple-choice items on the one hand and open-ended expressions of opinion on the other. Questionnaires were designed separately to be mailed to statewide samples of elementary school teachers, science coordinators, principals, superintendents with elementary school enrollments, and 5th

and 6th grade students. In addition, classroom visits and personal interviews were carried out in forty systems. A description of data collection methods and responses is given in a footnote.*

From the research, we have gained a comprehensive picture of the extent to which the NSF elementary science curricula are being used

*The data from the questionnaires was coded for computer analysis; descriptive statistics, such as frequency distributions, were made available for every variable; and hundreds of relations between variables that seemed of interest were examined by means of contingency tables and analyses of variance.

Some of the statistical work has also been used in separate technical papers that focus on particular issues of interest to members of the committee. The summary offered here is an overview of all of the data and reported without excessive statistical details. (If our conclusions interest researchers among our readers, the computer data will gladly be shared with them.)

The first questionnaire was sent to 244 superintendents in December, 1971. Responses were received from 214 superintendents (88 percent) whose systems represent 90 percent of the elementary schools in the state, 92 percent of the teacher population, and 96 percent of the student population. We heard from 100 percent of all of the systems with more than 2,000 elementary student populations.

Science coordinators in 244 systems next received questionnaires, and 158 coordinators (65 percent) responded. The respondents represented 71 percent of the total number of elementary schools in the state, 79 percent of the elementary school teachers, and 77 percent of the elementary student population.

We then sent questionaires to a teacher sample. We mailed a total of 2,100 questionnaires and we heard from 822 teachers (39 percent) who represented 73 school systems and 1,000 classrooms in 248 schools. They were responsible for teaching 25,000 students, K-6. NSF curricula and non-NSF curricula were about equally distributed in the teacher sample. Fifty of the NSF sample teachers (17 percent) were using a combination of NSF programs; 104 teachers (28 percent) were using Science Curriculum Improvement Study (SCIS); 26 teachers (7 percent) were using Minnesota Mathematics and Science Teaching (Minnemast); 89 teachers (24 percent) were using American Association for the Advancement of Science (AAAS); and 99 teachers (27 percent) were using Elementary Science Study (ESS). One hundred and forty-six teachers were in systems with over 5,000 elementary school students; 407 in systems ranging from 2,000 to 5,000 students; and 255 teachers were in systems with less than 2,000 students.

Principals were the next group to be surveyed. There were 208 respondents (53 percent) from a total of 380 who received questionnaires. The 208 respondents worked in 60 school systems; half of the principals used NSF curricula in their schools and half used non-NSF programs. The respondents' schools taught about 66,000 students.

The sample of students totalled 712 fifth and sixth graders in nine school systems, in varied socio-economic settings.

in Massachusetts schools, and we have learned also a great deal about the manner in which students, teachers, principals, science coordinators and superintendents are affected by them. We have found far fewer obstacles to using these programs well in the schools than we anticipated when we began our study, and there is some reason to feel confident about the continuing acceptance of them. 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.

Yet there are important problems that should be considered in examining the introduction and implementation of new elementary science curricula, and some of these problems may persist even following a system's commitment to the new curricula. Unlike the high school science courses, there is not a small cadre in the elementary school of specialized science teachers. Ninety percent of the elementary teachers teach science, along with their other subjects. Hence it is difficult to provide teacher education opportunities for the beginning elementary teachers as well as for experienced teachers, and to provide such opportunities on a sustained basis. And science is a relatively low priority item in the elementary school curriculum; the concept of scientific literacy has little saliency at the elementary level. Further, it must be recognized that science materials and programs are relatively high budget items considering the instructional expenditures in elementary schools.

Are there compelling reasons to overcome these obstacles? Even though we do not fully subscribe to all of the Jencks' conclusions, we do agree with him that schools should be satisfying places in which to teach and learn and that pleasurable experiences should occur in them. Where we found problems they tended not to be in operational areas; e.g. classroom management and discipline, nor in the cu[illegible]a 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.

The summarization of the findings is grouped in different ways: following our initial reporting on the use of the NSF programs in Massachusetts schools there are paragraphs dealing separately with topics of common concern, such as pupil progress in science, classroom preparation and the adequacy of teaching guides. Teacher training, science coordinators, principals, financial considerations and sex-role stereotyping are delineated at greater length. We conclude the summary information with teachers' perceptions about the NSF curricula and with two tables, one showing some of the differences between systems committed to NSF curricula and those using textbooks, and the other showing how science coordinators view the strengths and weaknesses of the NSF curricula. Our recommendations begin on page 23.

At least 13 percent of Massachusetts public elementary school children – or 78,000 children out of a total elementary population of 600,000 – studied science in NSF programs during the academic year 1971–1972. This is higher than the national estimate of 4.6 percent for the same year. Furthermore, 54 percent of the systems using NSF curricula in limited or trial use indicated that they planned to expand their use in the future. One hundred and sixteen systems (48 percent) are using NSF curricula, ranging from limited trials in a few classrooms to full adoption in the system. One hundred and twenty-eight systems (52 percent) are using non-NSF programs. Some of these non-NSF programs, including the '*Concepts in Science*' series (used in 13 systems) have optional laboratory equipment. Only 12 systems in Massachusetts have either used and discontinued NSF programs or have considered and rejected their use.

Seventy-three systems are using Elementary Science Study (ESS); 44 systems are using Science Curriculum Improvement Study (SCIS); 39 systems are using American Association for the Advancement of Science (AAAS); and 9 systems are using Minnesota Mathematics and Science Teaching (Minnemast).

Of the systems using a particular program the percentage of use by grade is in the following table:

GRADE	SCIS	ESS	AAAS	MINNEMAST (K-3 PROGRAM)
K	27%	34%	51%	67%
1	80	53	95	67
2	80	58	90	67
3	64	63	74	44
4	41	81	44	0
5	34	81	28	0
6	5	85	8	0
TOTAL SYSTEMS	44	73	39	9

An additional table shows the number of systems using the NSF curricula; and the number of classrooms and buildings using these programs:

	SCIS	ESS	AAAS	MINNEMAST
Systems	44	73	39	9
Buildings	218	374	212	36
Classrooms	910	2,680	1,230	159

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 classroom 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).

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).

TIME FOR ELEMENTARY SCIENCE

More time is spent on science in each succeeding grade. Science is given more emphasis in the upper elementary grades, 4 to 6, than in the primary grades. Only 76 minutes weekly are devoted to science in the first grade; 157 minutes weekly are devoted to science in the sixth grade. (There is no significant difference between the time spent on NSF curricula and non-NSF programs.) The average time per week spent on science in all of the elementary grades is 108 minutes.

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 or a 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 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.

COMMUNITY INVOLVEMENT IN ELEMENTARY SCIENCE

Teachers, science coordinators and principals reported that parents play next to no role in elementary science, neither aiding nor hindering what the people in the schools want to do.

STORING MATERIALS

Forty-one percent of the teachers reported that they stored materials in the classroom where children can easily get them. Twenty-three percent said they kept materials in a storage area until they were needed for a specific lesson, and 8 percent stored materials in the classroom but 'safely out of reach.' (Various other accomodations were made by 28 percent of the teachers.)

EDUCATION AND TRAINING OF TEACHERS

Teachers with strong science backgrounds are more satisfied with teaching science than those with weaker backgrounds, and there are no differences in the undergraduate science preparation between NSF and non-NSF teachers. Twelve percent of the teachers in the sample had taken more than six undergraduate science courses. Only 3 percent of the teachers have not had at least one science course as an undergraduate.

Most elementary teachers feel that their undergraduate science education was not as helpful as it should have been, and some were extremely critical of their science methods courses. Seventy-three percent of the teachers had science methods courses, but only one teacher out of every four thought that methods courses were helpful.

Most science workshops apparently are conducted in a manner antithetical to the aims and philosophies of the new curricula. Eighty-four percent of the teachers 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.

Teachers who have participated in science summer workshops like teaching science more, in general, than those who have not.

Forty-six percent of the systems offer inservice work in elementary science. Sixty-seven percent offer it in other subjects, in mathematics and the language arts.

Seventy-three percent of the NSF systems offer workshops in elementary science. Only 23 percent of the non-NSF systems do.

Two-thirds of the teachers (66 percent) who attended science workshops in the summer rated their teaching skill in science as either better or the same as their skill in teaching other subjects. Slightly more than half the teachers (51 percent) who did not participate in the summer workshops felt this way about their skill. This might indicate that summer workshops simply increase a teacher's confidence generally; but perhaps it also helps to have some special help in planning the next year's activities.

Twenty-nine percent of the teachers have attended science workshops, institutes or courses held outside their systems – at a college or university or at another school system; 71 percent have not.

An average of 22 hours was spent by teachers over the preceding three years attending science workshops held either in the system or outside of it.

PRINCIPALS

Principals with NSF curricula in their schools are more satisfied with the science activity (50 percent) than are principals with non-NSF curricula (30 percent). Two out of every three NSF principals would like to supplement their present supply of materials.

Principals ranked science third or fourth in importance in the elementary curriculum, far behind mathematics and reading and sometimes slightly lower than social studies. Only 54 percent ranked science third or higher. (Ninety-nine percent ranked reading first.)

Fifty-seven percent of the principals considered their present science facilities either inadequate or totally inadequate.

Twenty percent of the NSF systems offer workshops in science for elementary principals. Nine percent of the non-NSF systems offer them. Many principals would like to participate in science workshops, if other principals and teachers from their own schools attended the workshops with them.

In the following order are ranked the principals' needs to improve or change the facilities for teaching science: Storage space (52 percent of them needed storage space or additional storage space); a special science room (45 percent); sinks (37 percent); electrical outlets (34 percent); movable furniture (18 percent); better lighting (7 percent); and windows (5 percent).

Three out of every four principals reported that they had been able to obtain replacement and consumable materials; one out of every four could do this only with great difficulty or not at all. Yet 39 percent reported that their budget requests for science were approved in full and only 4 percent said their requests were usually rejected. Fifty-three percent of the principals reported they have little or no petty cash or discretionary funds for science; 21 percent had less than $50 to spend a year. Nine percent had more than $250. Eleven percent had between $50 and $100, and 6 percent had between $100 and $250.

According to the principals, the quality of science instruction in their schools was rated excellent (17 percent), satisfactory (49 percent), fair (28 percent) and poor (6 percent).

Grades are given in science in 73 percent of the principals' schools, but 59 percent of the principals felt that grades should not be given in science.

Principals neither spend very much time in maintaining the science activity in their schools nor do they see themselves having played a key role in encouraging the use of new curricula. The elementary science coordinator (80 percent) and the classroom teacher (44 percent) play larger roles in their opinion than they do themselves (42 percent). Only 3 percent said that parents played a major role. (Only 5 percent of the principals work directly a lot with children in the classroom and only 7 percent spend a lot of time assisting individual teachers.)

Principals reported that there were no overriding hindrances to effecting change in elementary science. There were only three factors in which over 25 percent of the principals reported as being great hindrances. None of these involve the curriculum itself, but rather that other subjects have a higher priority (31 percent); there is inadequate consultant or science specialist help (27 percent); and there is inadequate inservice training (25 percent). The following factors were considered to be some hindrance: teachers do not know methods of teaching science (64 percent); they are afraid of science subject matter (55 percent); and teachers are reluctant to try new methods and materials (53 percent). About half the principals felt hindered by inadequate room facilities, insufficient funds, and an inadequate system of maintaining and distributing materials and equipment. Inadequate inservice training (45 percent) and inadequate consultant help (36 percent) were considered to be of some hindrance.

Only 5 percent of the principals felt that their personal interest was the most important factor in the success of science instruction in their school. They felt that the enthusiasm of the teacher (68 percent) and the teacher's skill (17 percent) were the most important factors.

Only one out of every seven principals has ever taught science full-time, and less than 10 percent of them attend National Science Teacher Association meetings or have attended NSF workshops.

SCIENCE COORDINATORS

In 90 percent of the systems program reviews were conducted by ad hoc committees concerned only with elementary science, not by a general curriculum review committee. These ad hoc committees consisted primarily of elementary teachers and some elementary principals. In less than 40 percent of the cases was the science coordinator or a science specialist a member of the review committee, and in only 28 percent of the systems was the initial suggestion for program change or review made by a K-6 or K-12 science coordinator. Nevertheless, school systems with a designated full-time science coordinator, either K-6 or K-12, are more likely to have NSF curricula than systems that give the responsibility for science to a person who has other duties, such as a principal or an assistant superintendent for curriculum and instruction. Forty-five systems (23 percent) have designated science coordinators and of them 27 systems (14 percent) have K-12 coordinators and 18 systems (9 percent) have K-6 coordinators. Each of the systems with K-6 coordinators uses NSF curricula. Eighty percent of the systems committed to NSF curricula have a K-12 coordinator.

On the average, the 'person most responsible for science' in a system spends only 20 percent of his time coordinating science activities. But we found that almost half of the K-6 coordinators spend more than 50 percent of their time on elementary science, and five of them spend 100 percent of their time on it. Only 9 percent of the K-12 coordinators spend at least half of their time on elementary science.

Both the K-6 and K-12 coordinators spend significantly more time advising teachers and giving inservice workshops than do other ranks in the system who are given science responsibilities along with other duties. Persons with science responsibility in the central administration spend only 8 percent of their time advising teachers and 12 percent of their time on inservice work. (The least innovative systems in elementary science; i.e., those using textbooks and with no plans to consider using NSF curricula, place the elementary science responsibility in the hands of a central administrator or a principal. None of these systems has a K-6 coordinator and only 20 percent of them has a K-12 coordinator.)

Science coordinators conduct most of the inservice programs. Only 20 percent of the systems used other personnel in the system, or consultants outside of it to conduct workshops.

Inservice training is regularly available in only twenty-four systems. Seventy-eight percent of the science coordinators wold like to have more workshops, and 64 percent of them feel that the present workshops are ineffective.

Eighteen percent of the coordinators have never visited another school system to observe innovative work in elementary science. Forty-eight percent made from one to three visits in the past few years. Thirty-four percent of them made four or more visits. However, 44 percent of them reported that personnel from other systems had never visited their systems regarding elementary science.

Most systems first became interested in the new curricula in the sixties (70 percent), according to the science coordinators, and only 30 percent of the systems later, beginning in the academic year 1969–1970.

The science coordinators reported that the teachers' fear of science (45 percent), the teachers' reluctance to try new methods and materials (30 percent), and inadequate consultant help (30 percent) were great hindrances to making innovations in science. The curriculum itself did not appear to be a great hindrance: only 12 percent of the coordinators felt that it required too much teacher planning, 15 percent felt that it required too much teacher training, and 8 percent felt that the curriculum was not clearly articulated from grade to grade. And 12 percent felt that principals' not helping teachers plan or improve the curriculum was a great hindrance.

Teachers play a major role in stimulating change in elementary science, according to 60 percent of the coordinators. Only 6 percent felt that teachers played a minor role.

Only 23 percent of the coordinators in the 60 percent of the systems that have trials as policy felt that they themselves lacked sufficient information about the merits of a new program to implement one without a trial, but 88 percent of these coordinators reported the primary reason for having a trial as wanting to see how teachers and students fared with the new programs.

Thirty-five percent of the science coordinators majored in science as undergraduates. Only 4 percent reported that they had studied little or no science. Before assuming the position of science coordinator 65 percent had been elementary teachers and 47 percent had been elementary principals. Five years ago, 60 percent of them were not science coordinators.

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 for the disadvantaged. 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.

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 [illegible] 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 stereo-

SOME PERCEIVED STRENGTHS AND WEAKNESSES OF THE FOUR NSF PROGRAMS BASED ON RESPONSES FROM SCIENCE COORDINATORS USING THE PROGRAMS

PROGRAM		PERCENTAGE OF RESPONDENTS
American Association for the Advancement of Science (AAAS)	STRENGTHS	
	well organized and structured	67%
	emphasizes development of process skills	58
	provides for active involvement of children	38
	WEAKNESSES	
	requires too much time to teach it	29
	too structured	25
Elementary Science Study (ESS)	STRENGTHS	
	provides for active involvement of children	50
	encourages development of skills of inquiry and learning by discovery	38
	student-centered, enabling children to pursue their own questions in their own ways	28
	WEAKNESSES	
	requires too much time to teach it	27
	does not specify a sequence of skills and concepts for each grade level	26

Science Curriculum Improvement Study (SCIS)	STRENGTHS	
	provides for active involvement of children	54
	emphasizes development of conceptual framework	41
	well-organized and structured	33
	WEAKNESSES	
	difficult to keep alive living specimens	33
Minnesota Mathematics and Science Teaching Project (Minnemast) This program is used in only nine systems	STRENGTHS	
	easily integrated with other subjects	62
	well-organized and structured	37
	WEAKNESSES	
	no built-in *means* of evaluation	—
	may be *too* structured *for some* teachers	—
	program goes only through third grade	—

SOME DIFFERENCES BETWEEN SYSTEMS COMMITTED TO NSF CURRICULA AND THOSE USING TEXTBOOK PROGRAMS BASED ON RESPONSES FROM SCIENCE COORDINATORS

	NSF SYSTEM	NON-NSF SYSTEM
System provides workshops in science for teachers	73%	23%
System provides workshops in science for principals	20	9
System has a person responsible for elementary science who spends more than 25 percent of his time on coordination	40	9
System has designated K-6 or K-12 science coordinator *and* who spends more than 25 percent of his time on coordination	33	5
System has some specialized science teachers	31	19
The common teaching approach in the system is a classroom teacher with no help from an elementary science specialist	51	94
System performs many coordination activities at the central administrative level as opposed to the building level. These activities include purchasing materials, training, budgeting, purchasing and evaluating	38	14
System's policy provides a relatively high degree of support for released time for workshops and visits, and credit and remuneration for workshop attendance	38	23

types – 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.

Inevitably and properly, detailed analyses of the findings about the NSF programs, individually and in concert, are amply presented in the technical report; we invite the reader's attention to it to learn more about the curricula.

Recommendations

In the long run, the schools will be responsible for their own strengths and weaknesses. In reflecting upon the sharp downturn in federal support and encouragement for innovative practices and programs, it seems wisest for us to make recommendations that may assist teachers and administrators to utilize their own strengths and to suggest strategies that can make them more self-reliant.

There are many paths to excellence and many routes to innovation; we do not feel that we should recommend a single strategy for introducing the NSF curricula or for expanding their use. Indigenous methods should be derived from the interests and objectives of each school in each system. No one program or combination of programs appears to have overriding advantages over any other program or combination of programs, except to the people using them. Each school system must make its own choice and in our accompanying technical report and handbook information is given to help them better determine that choice. But there is one choice that we can make: the evidence of the advantages of the new programs is so clear that we recommend their continuing and expanding use in Massachusetts schools.

Because education is an experiment and by its nature an incomplete one, we suggest that school systems exploring the new programs do so in successive, discrete steps, allowing for individual reactions and evaluation, and that they organize for continuous master planning and not develop one master plan. In investigating the NSF curricula a system should look for the ones that reflect its own design for learning and its own educational goals and policies.

Some of the parameters of each program or combination of programs that can help in arriving at a complete selection concern the following: the degree of structure and flexibility in the curriculum;

specified sequences of activities or many options; the degree of teacher training and support required for successful implementation; conceptual and process structures or open-ended discovery; behavioristic orientations and non-restraining orientations; pupil differences and the capacity to reach a wide or narrow range of interests and abilities; balance in the physical, biological and earth sciences; evaluative schemes and philosophies in each of the programs; which programs require more storage space, more facilities, more administrative support; opportunities to engage in experimentation; adaptability of the materials to fit varying teaching styles and student needs; the effect of a program on the student's attitude to learning; teaching time required; class preparation; costs; and adequacy of the teaching guides.

In shaping its search for the more effective program selection and accomodation, the system should encourage its teachers, students and administrators to learn by experiencing the curricula to discover those that best suit them.

We like to think of the course content improvement activity initiated by the National Science Foundation as a continuing search for finding ways to become more responsive to the interests and needs of students and teachers. Because teachers and students are partners in the search with those outside the classroom, we feel that our recommendations must not be intransmutable.

We make the following recommendations:

RECOMMENDATION ➻ Systems should consider the role of the designated science coordinator for this is a critical role in introducing and implementing successfully NSF curricula. Systems that now have designated science coordinators can enhance their effectiveness in this position by allowing them to spend a major portion of their time working on science activities with elementary teachers and principals.

RECOMMENDATION ➻ Inservice training in science appears to be perhaps more important than preservice training, and it should be regularly available in the system. Inservice training is an important component of successful curriculum implementation in elementary science, as it is in the new high school science courses. Inservice training should take account of (a) knowledge of subject matter; (b) knowledge of some of the inhibitions caused by teaching methods; (c) knowledge of children. (If a system wants to try to remove sex-role stereotyping, another component of training would deal with teacher attitudes in this regard.)

These should be integrated in an appropriate training mix, unifying *what* is taught with *how* it is taught.

RECOMMENDATION ❧ Summer workshops, with children attending, are an effective way for teachers and administrators to become initially immersed in the philosophies and techniques of the new curricula. NDEA Title III funds can be used to allay up to fifty percent of the cost of workshop materials in science.

RECOMMENDATION ❧ An effective atmosphere for 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 administrative decision to be that 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 formally recognize this procedure can lessen the confusion, resistance and frustration that sometimes results from not having an operative policy, with decision making shared by the two groups.

RECOMMENDATION ❧ Planning teams in systems that are considering adopting new science programs should consist of administrators, teachers and the person most responsible for elementary science. The team members can select programs they wish to use and develop specific plans on how the new programs will be introduced and extended in the system. The key factors are the continuing responsibilities of the planning team throughout the implementation process, from program selection, monitoring trials, arranging feedback, and devising a flexible long-range plan.

RECOMMENDATION ❧ The change effort can be strengthened by discarding the trials of new curricula in only several classrooms in many schools and by concentrating the trial efforts throughout the individual school or several schools. This practice can remove some of the isolation a trial teacher has by increasing the opportunity for teachers in a building to share their experiences with a new program.

RECOMMENDATION ❧ Teams of principals should meet together at least a half-day every six weeks to discuss their common problems and to learn from one another how science is going in their own schools. Where this practice has been followed in elementary education – West Hartford, Connecticut public schools, for example – the results have been beneficial.

RECOMMENDATION ❧ Procedures and instruments for evaluating pupil progress in elementary science should be based to some extent on the evaluative schemes suggested by the NSF programs, but they must be geared to the school's educational goals and how the teachers use the various units. National assessments and standardized tests in elementary science are pitifully weak and irrelevant to the aims of the NSF curricula.

RECOMMENDATIONS ❧ Systems might start teachers' centers in which the teaching faculty might find the time to talk with each other in an informal way, examining and perhaps solving some of their common problems in science (and in other subjects). Pittsfield has started a teachers' center, and other systems might do the same.

RECOMMENDATION ❧ Reduced-cost alternatives in teacher training and staff development may be possible in new confederations of school systems that want to share their expertise on elementary science. It is suggested that a number of School Science Collaborative Programs be started by the schools. The purposes of this program is to encourage the wider use of the new curricula in systems that are now using them and to 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 the university scientist and members of certain groups, such as the Massachusetts Association of Science Supervisors. The organizational development of the program and possible sources of partial funding are delineated in our handbook.

RECOMMENDATION ❧ Thirty or more science demonstration schools could be identified in the state to serve as intensive teacher training centers and as observation centers at which school board members could see exemplary science in the classroom.

RECOMMENDATION ❧ Industrial firms that employ scientists and science faculty in universities could contribute to the schools by giving informal science workshops for elementary teachers. These workshops or seminars – held in the plant, university or school – would not deal with NSF programs but rather on science.

RECOMMENDATION ❧ During the course of our visits to school we were struck by the apparent shortages of basic educational materials in quantities sufficient for each student to have his own. This appeared to be the case in most elementary subjects, including social studies, mathematics and the language arts. So we suggest the enactment of legislation that would require books or their equivalent for each child.

We discussed our preliminary findings and recommendations with several hundred elementary teachers, school administrators, officials in the State Department of Education, and with science faculty in the State Colleges. We are indebted to them for sharing their thoughts with us. In our technical report and in our handbook their contributions are apparent.

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The area meeting of the National Science Teachers Association will be held in Boston, November 29 – December 1, 1973. At the meeting there will be two seminars about this study. At one, Dean K. Whitla, Dan C. Pinck, Nancy S. Lindsay, Rose Lea Crowley and Irv Marsden will discuss the findings of the study. At another seminar, Nancy S. Lindsay will discuss the findings as they relate to sex-role differences and some of the choices schools may have in lessening those differences. The exact time and place of these seminars will be announced in metropolitan newspapers in the fall.

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