DOCUMENT RESUME

ED 064 066 24 SE 013 507

AUTHOR Sanderson, Barbara A.; Kratochvil, Daniel W.
TITLE Science--A Process Approach, Product Development Report No. 8.
INSTITUTION American Institutes for Research in the Behavioral Sciences, Palo Alto, Calif.
SPONS AGENCY Office of Program Planning and Evaluation (DHEW/OE), Washington, D.C.
REPORT NO AIR-21900-12-71-TR-8
PUB DATE Dec 71
CONTRACT OEC-0-70-4892
NOTE 53p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Curriculum Development; Curriculum Evaluation; Educational Strategies; *Elementary School Science; Program Descriptions; *Program Planning; Scientific Methodology
IDENTIFIERS *Science A Process Approach

ABSTRACT

Science - A Process Approach, a science program for grades kindergarten through sixth, mainly focuses on scientific processes: observing, classifying, using numbers, measuring, space/time relationships, communicating, predicting, inferring, defining operationally, formulating hypotheses, interpreting data, controlling variables, and experimenting. The program, its development, and implementation are discussed in this report, including these major aspects: program characteristics, rationale, and materials; the origins of the program including personnel, sources, and funding; program development; summative evaluation; and diffusion and adoption of the program. The program is currently being used extensively across the country by millions of students (no exact figure is available). (PR)

PRODUCT DEVELOPMENT REPORT NO. 8

SCIENCE—A PROCESS APPROACH

DEVELOPED BY
THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

December, 1971

Contract No. OEC-0-70-4892

AMERICAN INSTITUTES FOR RESEARCH
Post Office Box 1113 / Palo Alto, California 94302

AIR-21900-12/71-TR(8)

PRODUCT DEVELOPMENT REPORT NO. 8

Contract No. OEC-0-70-4892

SCIENCE--A PROCESS APPROACH

DEVELOPED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Barbara A. Sanderson
Daniel W. Kratochvil

American Institutes for Research
in the Behavioral Sciences

Palo Alto, California

December, 1971

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Office of Program Planning and Evaluation

PREFACE

This product development report is one of 21 such reports, each dealing with the developmental history of a recent educational product. A list of the 21 products, and the agencies responsible for their development, is contained in Appendix C to this report. The study, of which this report is a component, was supported by U.S. Office of Education Contract No. OEC-0-70-4892, entitled "The Evaluation of the Impact of Educational Research and Development Products." The overall project was designed to examine the process of development of "successful educational products."

This report represents a relatively unique attempt to document what occurred in the development of a recent educational product that appears to have potential impact. The report is based upon published materials, documents in the files of the developing agency, and interviews with staff who were involved in the development of the product. A draft of each study was reviewed by the developer's staff. Generally, their suggestions for revisions were incorporated into the text; however, complete responsibility for interpretations concerning any facet of development, evaluation, and diffusion rests with the authors of this report.

Although awareness of the full impact of the study requires reading both the individual product development reports and the separate final report, each study may be read individually. For a quick overview of essential events in the product history, the reader is referred to those sections of the report containing the flow chart and the critical decision record.

The final report contains: a complete discussion of the procedures and the selection criteria used to identify exemplary educational products; generalizations drawn from the 21 product development case studies; a comparison of these generalizations with hypotheses currently existing in the literature regarding the processes of innovation and change; and the identification of some proposed data sources through which the U.S. Office of Education could monitor the impact of developing products. The final report also includes a detailed outline of the search procedures and the information sought for each case report.

Permanent project staff consisted of Calvin E. Wright, Principal Investigator; Jack J. Crawford, Project Director; Daniel W. Kratochvil, Research Scientist; and Carolyn A. Morrow, Administrative Assistant. In addition, other staff who assisted in the preparation of individual product reports are identified on the appropriate title pages. The Project Monitor was Dr. Alice Y. Scates of the USOE Office of Program Planning and Evaluation.

Sincere gratitude is extended to those overburdened staff members of the 21 product development studies who courteously and freely gave their time so that we might present a detailed and relatively accurate picture of the events in the development of some exemplary educational research and development products. If we have chronicled a just and moderately complete account of the birth of these products and the hard work that spawned them, credit lies with those staff members of each product development team who ransacked memory and files to recreate history.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PRODUCT DESCRIPTION

Product Characteristics

Name

Science--A Process Approach.

Developer

American Association for the Advancement of Science.

Distributor

Xerox Education Sciences.

Focus

Science--A Process Approach is a complete general science program whose focus is on scientific processes: observing, classifying, using numbers, measuring, space/time relationships, communicating, predicting, inferring, defining operationally, formulating hypotheses, interpreting data, controlling variables, and experimenting. Concepts and facts are necessary parts of the program, but they are not its major focus.

Grade Level

Kindergarten through sixth grade.

Target Population

The program is intended for all students in grades K-6. The program was tested in 14 tryout centers across the country. These tryouts indicated that economic, ethnic, educational, social, or geographical factors did not have marked effects on student achievement. One of the reasons that the developers believe that the program has been successful with all students, even those who have previously been thought of as slow or as underachievers, is that the program does not depend heavily upon reading skills. Only limited instructional materials for children are presented in a written form. Furthermore, mathematics skills for the science exercises which are not taught early or at all in the regular mathematics program are taught as part of the science curriculum.

Rationale for Product

Long-Range Goals of Product

The long-range goal of Science--A Process Approach is to develop student competencies to apply a scientific mode of thought to problems. The scientist gains information about the world in certain ways: observing, classifying, making hypotheses, and experimenting. Science--A Process Approach attempts to develop in the students the intellectual and investigative skills of the scientist, and hopefully these skills will provide a generalized method of defining and solving problems which can be applied in other subject areas as well.

The complete K-6 program is commercially available. The publisher is working with the developer to design and test a revised version to be released around 1974.

Objectives of Product

The goal of Science--A Process Approach is student mastery of scientific processes. Exercises, which are arranged in a sequence of instruction which leads from the simple to the complex, are organized around these processes. The objectives of individual exercises or lessons are stated as specific, operational behaviors that students are expected to perform. For example, here are two objectives of a kindergarten exercise on the process using space/time relationships:

At the end of this exercise the child should be able to:

1. Construct and name the following plane, or two-dimensional, shapes: triangle, circle, square, rectangle, and ellipse.
2. Indentify the following three-dimensional shapes: sphere, cube, cylinder, pyramid, and cone.

By specifying the outcomes expected of a lesson and by establishing behavioral hierarchies, this science program differs sharply from those programs deliberately designed to be unstructured and open-ended.

Philosophy and Theories Supporting Product

The developers assumed that scientific procedures are similar at all levels of sophistication, although the knowledge they produce varies with the maturity and understanding of the learner. Teaching verbal content knowledge was rejected because it was felt that such knowledge would be incomplete and would soon be outdated as new scientific advances were made. The developers believed that there are distinct intellectual processes--essentially the ones the scientist uses--that must be identified and taught to the child in a highly systematic way.

Robert Gagné was one of the chief architects who was responsible for developing the systematic structure of Science--A Process Approach. The entire curriculum was based on the theory that any learning act--such as a process of science--can be broken down into component skills, and that these skills can be arranged and taught in a hierarchical order from simple to complex. Furthermore, successive exercises in each process should build upon earlier exercises in a progressive sequence, and at the same time should introduce variations in subject matter.

The importance of freedom for the young learner was considered fully as important as the specification of a systematic program. The developers felt that learning would be most effective when relationships are "discovered" rather than "copied," and when generalizations are attained rather than imposed. They qualify this stance by stating that a student's natural curiosity and exploratory nature will not by themselves lead him to practice real science; a systematic program that formalizes the enterprise of scientific investigation is also necessary. In short, the main theoretical difference between the developers of Science--A Process Approach and developers of less structured science programs is not in their views of science or the nature of children, but in their opinions about which teaching methods result in more efficient learning.

Description of Materials

Organization and Format of Materials

Science--A Process Approach is divided into seven parts, each divided into 20-25 sequenced exercises. One part is normally, though not necessarily, taught at each grade level. Each exercise in a part is designed to teach one or more behaviors and has one or more behavioral objectives. The exercise is labeled with the name of the process intended to develop and with a number to indicate approximately its position in the learning hierarchy for that process.

In Science--A Process Approach there are no printed materials for students, except for some data sheets and short worksheets in the intermediate grades. Classroom kits of laboratory equipment, the Process Development Laboratories, are provided for the student and the teacher. These kits are organized in storage modules and provide the equipment and materials necessary for experiments in all the exercises. The following materials are provided for the teacher: Teacher texts in the form of individual booklets for each exercise; hierarchy charts which represent visually the development of process skills in the program; and a Commentary for Teachers, which is a self-instructional manual for teachers on the processes and content of the program.

Each part of the program includes a Process Development Laboratory which contains equipment and supplies for a class of 30 children. The equipment comes in storage drawers designed for self-stacking and is available either in corrugated cardboard or styrene. The equipment includes reusable equipment such as meter-sticks, equal-arm balances, spring scales, and magnets; and also consumable supplies such as litmus paper and balloons. The Process Development Laboratory is available in both a Standard Classroom Unit or a Comprehensive Classroom Unit. The Standard Classroom Unit does not include materials which are readily available locally. Neither unit includes living or perishable items or common supplies such as paper and pencils. Sets of replacement consumable materials are available.

The teacher texts are the core of the program and contain the objectives, activities, and evaluation procedures for each exercise. There is a separate booklet for each exercise, and all follow this format:

1. Behavioral Objectives for the Exercise--What the child should be able to do at the end of the exercise.

2. Sequence--The relationship of this exercise to the rest of the program is illustrated by showing the section of the hierarchy in which this exercise appears; prerequisite skills and successive skills are identified.

3. Rationale--A discussion of the importance of the exercise in the learning sequence and of the scientific background information necessary to teach the exercise.

4. Vocabulary--New words for the students.

5. Materials--A list of all the materials the students will be working with in the exercise.

6. Instructional Procedures--Suggests how to introduce the activities in the exercise and describes the activities (both required and optional).

7. Generalizing Experience--An activity in which students relate what they have learned in the exercise to a new situation in a different context.

8. Appraisal (replaced by Group Competency Measure in Parts E, F, and G)--A group activity designed to evaluate overall class performance to help the teacher determine how well the class can meet the objectives of the exercise.

9. Competency Measure--A test that can be administered individually as a more precise assessment of competencies of individual students than the appraisal.

Teachers generally require some special training to implement Science--A Process Approach; a self-instructional manual, the Commentary for Teachers, and a manual for teacher training, the Guide for Inservice Instruction, are available. The commentary includes an explanation of the program, a section on the basic processes, a section on the integrated processes, an overview of the content, and a group of science background papers on various topics. The Commentary for Teachers is designed to make the teacher an active participant in the learning process, and the sections on the basic and integrated processes follow a format similar to the exercises in the program itself. The background papers provides teachers with a resource for learning about topics in the program with which they are unfamiliar. The Guide for Inservice Instruction is also helpful and is used in teacher training programs. It contains lessons modeled after those in the teacher text and deals with the process skills.

The Behavioral Hierarchy Charts present in flow chart form the program's organizational structure. The charts illustrate the sequence in which the process skills are developed from simple to complex behaviors and also the dependencies and interrelationships of the skills. The hierarchy is intended as a tool for teachers. The charts provide teachers with an overview of the total program and the sequence of the steps within it, and can guide teachers in their appraisal of students. The hierarchies are not intended as a rigid system or as the only hierarchies, but as a guide. It was found in tryouts that the students who could perform the subordinate behaviors had a high probability of being able to achieve the next higher behavior, while students who could not perform the subordinate behaviors had a low probability of achieving the higher behaviors. There are two hierarchy charts, one for the eight basic skills and another for the integrated skills (discussed below under Content of Materials). The chart for the basic processes is approximately 76" by 39" and is color coded to correspond with parts of the teacher texts and the Process Development Laboratory.

Content of Materials

Science--A Process Approach classifies the intellectual tools of science into a number of process skills. The program is designed to help students develop ability to use each process skill in interrelated ways. The following processes serve as bases of the units of instruction: the basic processes--observing, classifying, using numbers, measuring, using space/time relationships, communicating, predicting, inferring; and the integrated processes--defining operationally, formulating hypotheses, interpreting data, controlling variables, experimenting. Processes in the first group, the "basic processes," are taught in the primary grades; the second group, the "integrated processes," are taught in intermediate grades.

While Science--A Process Approach emphasizes processes, accepted facts, concepts and principles of science form the context of all the learning experience of the curriculum. The curriculum relies heavily on laboratory methods and a wide variety of materials. For example:

> ...the children examine and make explorations of solid objects, liquids, gases, plants, animals, rocks, and even moon photographs. But, with some notable exceptions, they are not asked to learn and remember particular facts or principles about these objects and phenomena. Rather, they are expected to learn such things as how to observe solid objects and their motions, how to classify liquids, how to infer internal mechanisms in plants, how to make and verify hypotheses about animal behavior, and how to perform experiments on the actions of gases [Gagné, 1967, p.3]

The following are some of the topics covered by the program: color, density, forces, graphing, learning and instinct, mass, temperature, velocity, rocks, and weight. The coverage of science is broad and includes some exercises drawn from the social and behavioral sciences. However, most involve physics, chemistry, biology, mathematics, earth sciences, and astronomy.

Cost of Materials to User

Material costs, when based on classes of 30 and average over a three year period, are $4 to $5 per pupil per year. Kits are available in either "standard" or "comprehensive" units; both are designed for a class of 30 students, and both contain one exercise booklet (teacher's text) for every exercise in the part. Inservice education and supervision is an additional cost, but materials for such training are minimal.

Following are the prices for both comprehensive and Standard Classroom Units, designed for 30 students and delivered in corrugated carboard storage modules, and for expendable laboratory materials for both types of units. Prices are based on a price list dated November 1970.

	Standard Classroom Unit	Set of Standard Expendable Materials	Comprehensive Classroom Unit	Set of Comprehensive Expendable Materials
Part A	$ 93.00	$ 20.00	$141.00	$ 35.00
Part B	217.00	30.00	280.00	58.00
Part C	247.00	35.00	314.00	63.00
Part D	261.00	45.00	336.00	70.00
Part E	385.00	85.00	469.00	98.00
Part F	440.00	115.00	540.00	130.00
Part G	490.00	125.00	610.00	185.00

The Hierarchy Chart for K-3 is $6.00; the Hierarchy Chart for 4-6 is $10.50; the Commentary for Teachers is $7.00.

Learner Activities

Each exercise in each part involves the following: an introduction by the teacher to arouse interest, to demonstrate, or to ask questions; activities which are the main part of the exercise; generalizing experiences in which students apply what they learned; and evaluation in the form of a competency measure or appraisal. Throughout every exercise priority is attached to laboratory experiences so that the student can "learn from his senses or literally to operate on reality." Thus, Science--A Process Approach stresses active participation of the student through manipulation of materials. Individuals or small groups of students are given opportunities to plan and carry out investigation of science problems. For example, the program includes student activities such as measuring the lengths and directions of shadows at different times of the day, investigating the acceleration of small carts, and constructing electric circuits.

The program intends student learning to be through discovery. However, by structuring each exercise, it has attempted to eliminate some randomness in the discovery approachs. Although students in the program learn science primarily from manipulation and observation of things in his environment rather than from written materials, they are still encouraged to read about science and a bibliography of science reading for children is available. The amount of time per day devoted to the science program varies from about 25 minutes in kindergarten to 45 minutes at higher grade levels.

Teacher Activities

The teacher begins an exercise with an introduction designed to arouse interest in, define, or demonstrate a problem or task. During the laboratory activities which comprise the actual instruction, the teacher demonstrates, questions, helps children construct materials, perform experiments, keep records, and interpret data. The teacher is urged to keep the focus of the activities on the process to be developed rather than the factual content. It is recommended that the inexperienced teachers follow the program closely since the activities are sequentially arranged. The program does have flexibility and experienced teachers who understand the processes may rearrange or introduce their own activities to meet the learning objectives.

Teacher training is strongly recommended for Science--A Process Approach and is available through summer workshops, preschool orientation or training during the school year. The Commentary for Teachers is designed for self-instruction and as a reference for teachers using the program. Most teachers need some special instruction in the basic and integrated processes to teach the program effectively.

Out-of-class preparation time during the year varies with the teacher and the exercise. Many of the materials for the exercises are in the laboratory kits, but common materials or living specimens are supplied by the teacher. Teachers who are teaching the program for the first time or who do not feel confident about their understanding of the processes or content of the program spend considerable preparation time reviewing the exercises and studying the Commentary for Teachers. Teachers in the tryout schools reported that the amount of time spent in planning for instruction and in gathering materials was considerable and at early levels about equal to time spent in instruction, but it diminished with experience.

Provisions for Parent/Community Involvement

Science--A Process Approach has no special provisions for parent or community involvement, but teacher aides can be of great assistance in preparing materials, helping the teacher in class during the activities, and keeping records on student achievement. Users are encourage to inform the parents about the objectives of the program and how they can support and reinforce the program aims.

Special Physical Facilities or Equipment

No special facilities are required for most classrooms. The materials used in the activities are included in the laboratory kit or are commonly available. The students work on the floor in some exercises. If the classroom desks are fastened to the floor, other places to work are required. Flat work areas, such as desk tops, are needed and a source of light, natural or artificial, is needed for growing plants. Many activities involve water and a sink in the classroom is convenient, but not necessary. Some activities are done outside. Storage space is required for materials and equipment.

Recommended Assessment Techniques for Users

Two types of evaluation techniques are incorporated into each exercise in Science--A Process Approach: an Appraisal Activity and a Competency Measure. At the end of each exercise is an Appraisal Activity, which is a class activity carried out in much the same manner as the other activities in the exercise. The teacher uses the activity as a general indicator of the ability of the class as a whole to meet the objectives in order to decide whether students need further instruction in these objective. Each exercise also includes a Competency Measure which consists of tasks designed to assess the students' achievement of the objectives of the exercise. The Competency Measure provides a more precise measure of an individual student's abilities than the Appraisal Activity. The measure is individually administered in the lower grades, but since individual administration for all students is impractical in most classrooms, a group task is introduced at as early a stage as possible. In the individual tasks the student actually performs the behavior while the administrator observes the student and records the response. In group tasks the responses are recorded by the students. The Competency Measures employ content and materials different from those used in the exercises so the student must apply what he has learned in a new situation.

ORIGINS

Key Personnel

Science--A Process Approach is the result of a group effort and many people contributed to its development. These people included the staff of the Commission on Science Education of the American Association for the Advancement of Science, the more than 100 scientists, teachers, psychologists, and other educators who participated in the summer writing conferences, and also members of the Commission itself.

The Commission on Science Education was created for the purpose of developing an elementary science program and the Commission staff coordinated the development efforts. The Commission staff arranged the summer writing conferences, edited the materials, arranged for printing and production of materials, distributed materials, planned the evaluation, arranged for tryouts, and processed tryout results. These duties were carried out by three or four professional staff members. John R. Mayor directed the project throughout its development and was directly responsible for the project. He had been Professor of Mathematics and Education and Acting Dean of the School of Education at the University of Wisconsin prior to joining the AAAS staff in 1955. For six years he conducted a science teaching improvement program and he was also active in the School Mathematics Study Group and spent several summers at writing conferences developing mathematics materials. While working for AAAS, he was also on a part-time appointment with the University of Maryland. Thus, Dr. Mayor had a background in mathematics, science and education, experience in directing projects, and experience in curriculum development. When the AAAS Commission on Science Education was formed, he was appointed director.

The deputy director was Arthur H. Livermore, a chemistry professor who had co-directed the Chemical Bond Study, a high school chemistry curriculum development project funded by the National Science Foundation. Edwin B. Kurtz, Jr., a biologist from the University of Arizona, served as assistant director for two years of the project; and Henry H. Walbesser, who had a background in educational research, worked on evaluation during most of the project.

The more than 100 participants in the five 8-week summer writing conferences made a major contribution to the development of the program. Participants included scientists, teachers, psychologists, and educators, each contributing his own expertise. Some of the participants attended only one of the conferences, while others attended all of them and made major contributions to all parts of the program.

The Commission on Science Education is composed of 14 scientists appointed by AAAS who are rotated on a three year basis. The Commission establishes policy and advises the staff on Commission activities. Many of the Commission members were influential in shaping Science--A Process Approach, and some took an active part in its development. Robert Gagné was a member of the first Commission. Dr. Gagné played a major role in establishing the basic structure of the program and attended all the summer writing sessions.

Sources and Evolution of Ideas for the Product

In spring 1961, the National Science Foundation asked AAAS to conduct a feasibility study to examine the question of whether NSF should become involved in the area of elementary school science. Several secondary curriculum projects supported by NSF were under way or close to completion (BSCS, Chem Study, CBA, PSSC, SMSG). However, the National Science Foundation questioned whether they should extend their efforts to the elementary level, and wanted to determine: (1) if scientists would be interested in working at that level and (2) if teachers felt a need for new science programs. AAAS conducted three regional conferences to discuss science instruction in elementary and junior high school. Each conference included about fifty teachers and school administrators, science educators, scientists, and psychologists. These conferences concluded that there was an urgent need for improved instruction in science at this level and recommended that a major effort be undertaken to meet this need. They further recommended that science instruction be interdisciplinary, that it should be presented in a progressive sequence of instruction, that science teaching should stress the spirit of discovery, and that teacher training should be an integral part of the program. They also recommended that there should not be a single national curriculum in science, but rather that schools should be presented with choices among alternative programs. Furthermore, the preparation of materials should involve scientists, classroom teachers and administrators, science educators, and educational psychologists. The conclusions of the conferences were reported in the AAAS magazine, Science, in June 1961 (AAAS).

As a result of these recommendations, NSF decided to extend their efforts into the field of elementary science and funded five curriculum development projects, including a project by AAAS. The Commission of Science Education was formed to administer this and other science education projects of AAAS.

The procedures for product development and the nature of Science--A Process Approach reflect the pattern set by the high school curriculum studies, recommendations of the initial conferences, later conferences, and the contributions of the Commission staff and members. The secondary science curriculum studies sponsored by NSF differed from traditional curriculum development methods in several respects. They were prepared by teams of scientists and teachers working together and stressed a method of inquiry rather than a set of facts. Science--A Process Approach followed the pattern set by these earlier projects and had teams of scientists and educators work together to develop materials using a process approach to teaching science. Science--A Process Approach also reflects the recommendations of the early conferences. The curriculum is interdisciplinary, sequential and discovery oriented, and includes a teacher training component. The program was further shaped by two 8-day planning conferences held in the summer of 1962. These conferences involved a variety of people, including directors of the high school projects, university science methods instructors, teachers and school administrators, and even people who were opposed to the idea of a curriculum project. The result was not a consensus, but a direction, an emerging definition of process and how it could be related to elementary science curriculum, and a concern that evaluation be an important part of the program. The Commission staff and certain Commission members took these recommendations and formulated a general development plan.

Funding for Product

NSF funded the project from spring 1962 to September 1969 at a total amount of approximately $2,250,000. A major expense were the five 8-week summer writing sessions. Participants at these sessions received 1-1/3 of their regular salary, a per diem allowance, and travel expenses. Tryout of materials was another major expense, including the costs of printing and producing materials and payments to teachers and center advisors. Other expenses included the two planning conferences, Commission staff salaries, overhead, and supplies. Approximately 10 percent of the budget can be attributed to Commission expenses.

The over $2 million investment produced only the experimental version. Xerox Corporation made a major additional investment to produce and market the commercial materials.

PRODUCT DEVELOPMENT

Management and Organization

The American Association for the Advancement of Science, a group of 130,000 American scientists, is the only national interdisciplinary professional organization for scientists and was an appropriate organization to develop an interdisciplinary science program. The major activities of AAAS include an annual meeting and the publication of Science magazine. AAAS conducts other projects and created the Commission on Science Education to administer the development of Science--A Process Approach and to handle other projects in the area of science education.

The Commission has intentially remained small. Typically, Commission staff is comprised of four professional staff members. Their role during the project was to organize the writing conferences and the tryouts and to coordinate project activities. Since the completion of the project, the Commission has continued to function and has a number of projects under way, including a Science and Society Program, the publication of bibliographies, and the administration of short courses for college teachers. The Commission also continues to work with Xerox on further development of Science--A Process Approach. Having the support of a strong professional organization such as AAAS was helpful in recruiting people to assist in the development and tryouts of the program and in generating interest in the program.

Original Development Plan

From the conferences there emerged the notions that the program should be process oriented, that formative evaluation should be a part of the program, and that the materials should be developed by teams of scientists and teachers. The Commission staff had an overview of a development plan involving summer writing conferences and tryouts in the schools, but did not prepare a detailed schedule far in advance.

Modification of Original Development Plan

The project followed the original development scheme, but there were some modifications and the staff was not able to finish all intended tasks. The major modifications were the number of revisions and tryouts. At first, the staff expected to try each part of the program for only two years. However, on the basis of feedback data from tryout centers they decided that some parts required further revision, and each part was tried out three or four times. The staff felt that there were sufficient revisions at the lower grades, but that the upper grades could have been improved with additional tryout and revision. There were several aspects of the project which the staff would have preferred to develop further, but were unable to do because of lack of time and funds. They produced three teacher training films, but did not feel these were of sufficiently high quality to warrant continued wide-spread distribution.

They were not able to validate the second hierarchy, the hierarchy on the integrated processes, or to validate the Science Process Instrument, a longitudinal performance test designed to measure student achievement of basic process skills. In addition, they did not prepare the tryout results for the last two years of the program in report form nor did they prepare measures of student attitudes toward science. Other tasks were delayed and the bibliography of science reading for children, Supplementary Science Reading for Children, was not published until 1971. The Commission staff also planned to communicate frequently with the other NSF funded elementary science programs, but this was somewhat neglected in the press of other duties on their own project, and there was less interaction than was thought desirable. However, many of these tasks represented additional self-imposed objectives and were not integral parts of the original program.

Actual Procedures for Development of Product

Development

The development progressed in an annual cycle of activities repeated each year from 1963 through 1968. In the winter and spring the Commission staff planned and organized the development activities; in the summer a writing session was held for scientists and teachers; in the fall the staff would edit, compile, and produce the materials and distribute them to the tryout centers; during the school year teachers at the tryout centers used the materials in their classroom and provided feedback and competency measure data to be used for revising the materials during the next summer writing session.

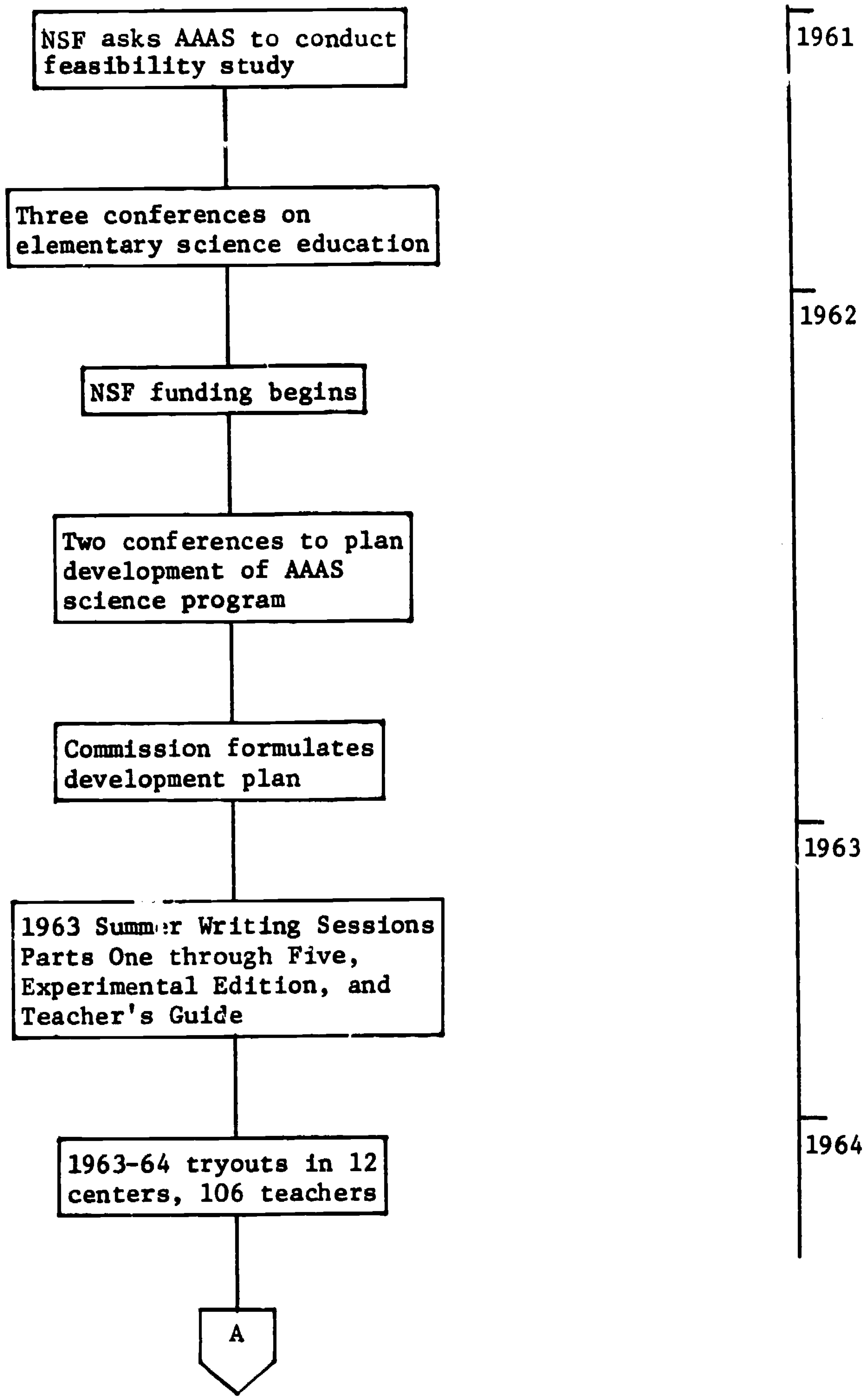
Figure 1, Major Event Flow Chart, illustrates the time schedule for the development of the program. The parts for grades kindergarten through four were developed first, then these parts were revised while the program was gradually extended to the sixth grade. At the same time other components of the program were prepared either during the summer writing session or by the Commission staff; these included the Commentary for Teachers, Guide for Inservice Instruction, the Science Process Instrument, the Hierarchy Charts, the teacher training films, the evaluation report, and a bibliography of science readings for children.

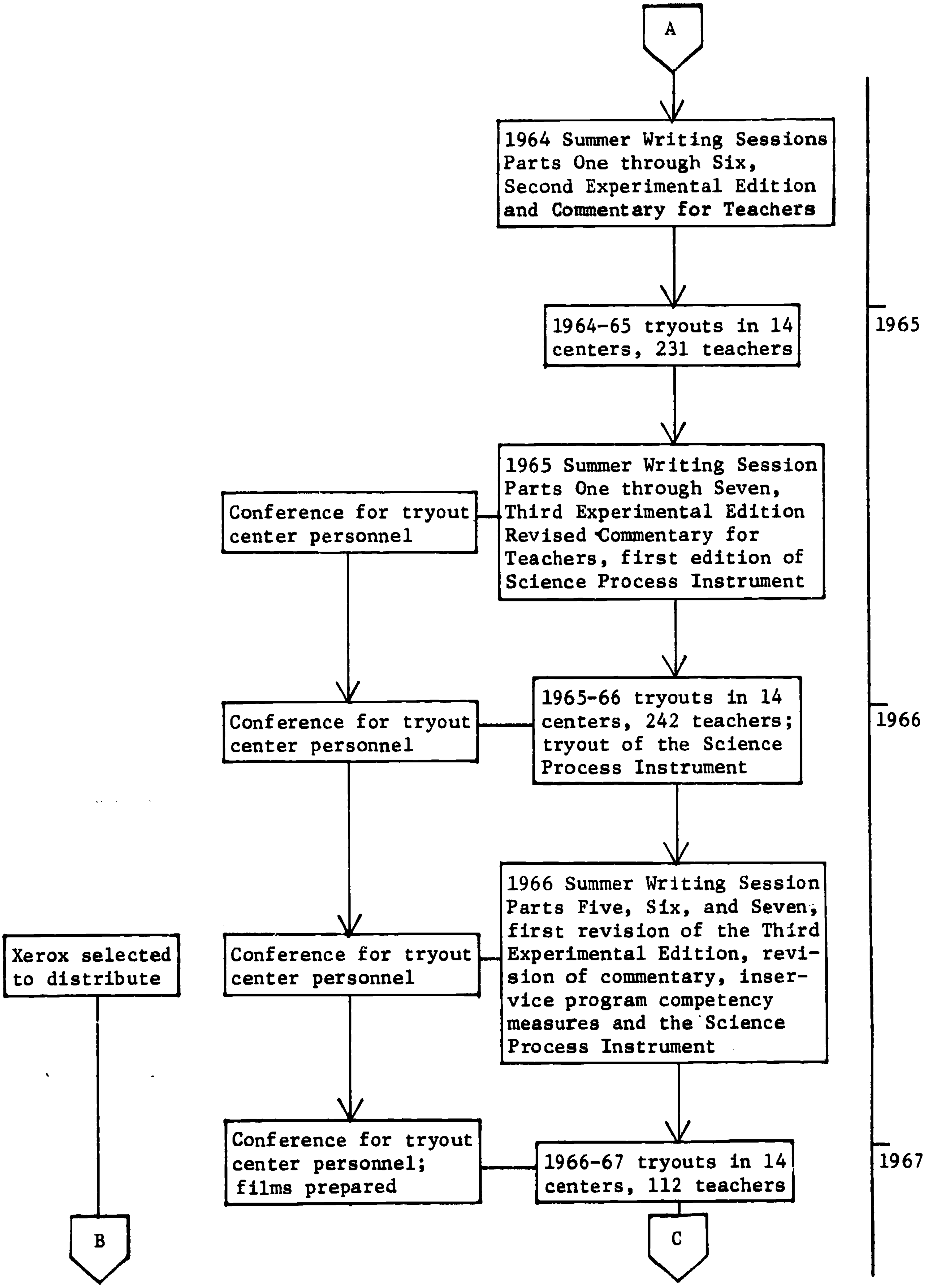
Most of the development of materials was done at the five summer writing sessions. The sessions generally involved 35 to 50 participants, lasted from six to eight weeks, and were held at universities. Participants included scientists from all disciplines, science educators, elementary teachers, school administrators, and psychologists. One hundred and six participants, about two-thirds of whom were scientists, attended the writing sessions. The Commission staff asked for recommendations for participants from a variety of sources and invited scientists, who had reputations as both distinguished scientists and good teachers, and elementary teachers who were talented and interested in innovation. Approximately 75 percent of those invited attended the sessions, and many of them attended for two or more years. The summer writing sessions appeared to be an effective method for developing a program. The participants worked intensively during the session and were very productive.

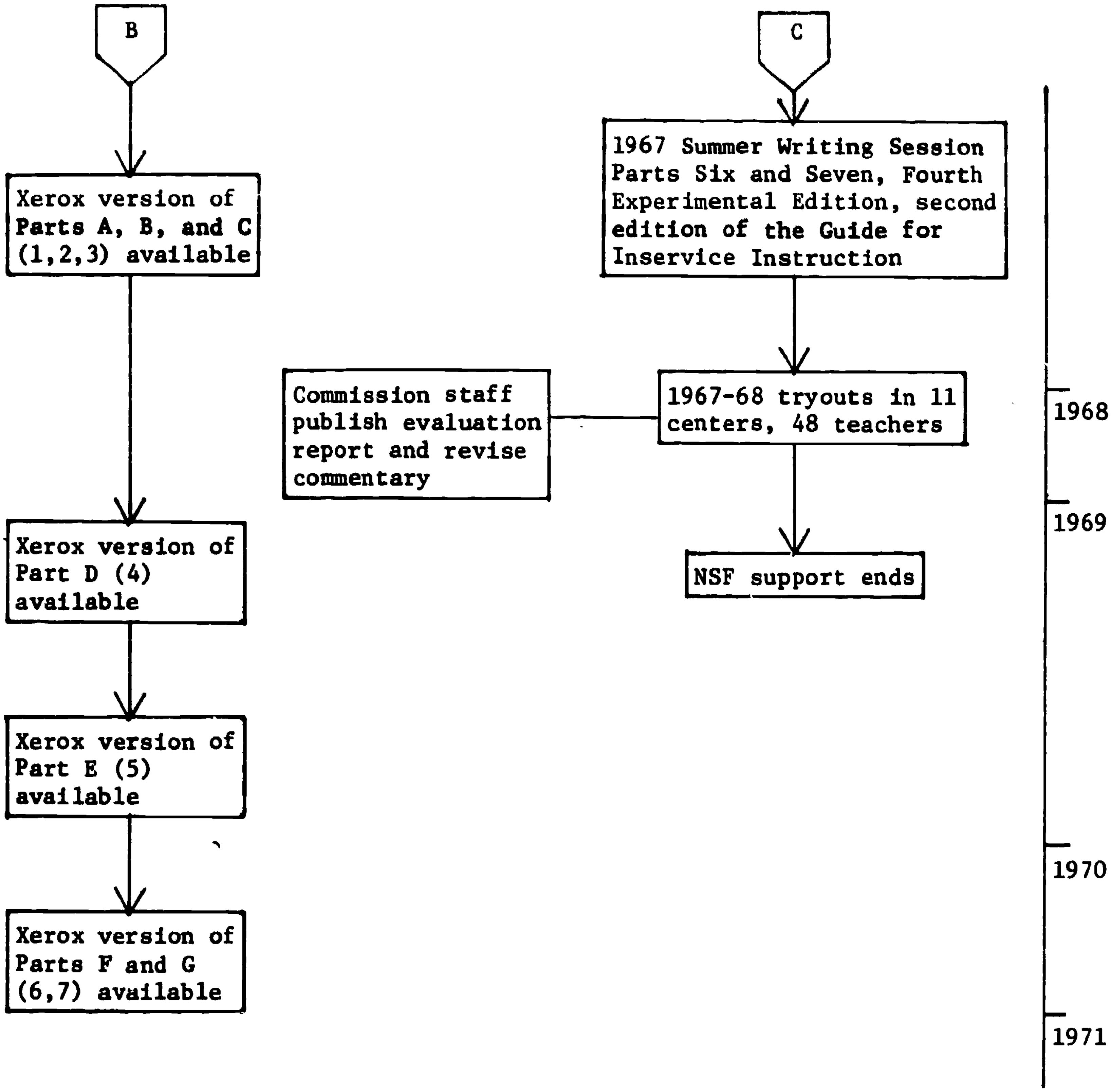
At the sessions the writing was done by individuals organized into

Figure 1

Major Event Flow Chart




A
1964 Summer Writing Sessions Parts One through Six, Second Experimental Edition and Commentary for Teachers
1964-65 tryouts in 14 centers, 231 teachers
1965
1965 Summer Writing Session Parts One through Seven, Third Experimental Edition Revised Commentary for Teachers, first edition of Science Process Instrument
Conference for tryout center personnel
1965-66 tryouts in 14 centers, 242 teachers; tryout of the Science Process Instrument
Conference for tryout center personnel
1966
1966 Summer Writing Session Parts Five, Six, and Seven, first revision of the Third Experimental Edition, revision of commentary, inservice program competency measures and the Science Process Instrument
Conference for tryout center personnel
Xerox selected to distribute
Conference for tryout center personnel; films prepared
1966-67 tryouts in 14 centers, 112 teachers
1967
B
C


B
C
Xerox version of Parts A, B, and C (1,2,3) available
1967 Summer Writing Session Parts Six and Seven, Fourth Experimental Edition, second edition of the Guide for Inservice Instruction
Commission staff publish evaluation report and revise commentary
1967-68 tryouts in 11 centers, 48 teachers
1968
1969
Xerox version of Part D (4) available
NSF support ends
Xerox version of Part E (5) available
1970
Xerox version of Parts F and G (6,7) available
1971

the activities. Each summer a laboratory was available and one or two laboratory personnel obtained or designed equipment. The writers worked with them in specifying equipment for activities.

In addition to developing new exercises, the committees revised exercises that had been tried out the previous year. The committees used feedback from tryout teachers as the primary basis for revisions. The most important indicator considered was the percentage of students who achieved the objectives as reported by the teachers who had administered a competency measure to a sample of students. The goal was that ninty percent of the students achieve ninty percent of the objectives. The team also reviewed the teachers' comments on the appropriateness of the activities and equipment, and incorporated many of their suggestions in the revised exercise.

The Commission staff summarized and tabulated the feedback data for the convenience of the committees. For some exercises a committee would decide that only minor changes were needed, while other exercises were almost completely rewritten or were discarded. A significant aspect of this program was the extensive use of tryout data in revising the program; the inclusion of competency measures for each exercise was a key to obtaining feedback on effectiveness.

The summer writing sessions ran smoothly and were productive, but there were differences of opinion among the participants and critical decisions had to be made. A crucial decision, which some participants were reluctant to accept, was the focus on process rather than content. Some felt that students would not receive an adequate background in the basic scientific disciplines and that more factual content should be included in the program. But, they were willing to attempt a process approach and realized that they were also able to develop important concepts in the exercises. Some scientists tended to be primarily concerned about their own discipline, although they frequently found they could contribute to exercises using content from other fields. A balance across subject areas was maintained by having representation from all the scientific disciplines.

There was also resistance to methods suggested by the psychologists. Some of the participants were dubious about the value of both behavioral objectives and evaluation measures. Almost all found these difficult to write. As a result, the Commission staff often had to write these sections of the exercises during the early stages of the project.

Another issue was how much and what kind of mathematics to include in the program. Some participants hoped to incorporate some of the new developments in elementary mathematics into the science program. The first two sessions were held at Stanford University in order to facilitate interaction with the School Mathematics Study Group, but most of the scientists and teachers were not comfortable with new concepts in mathematics and did not incorporate them into the program. Mathematics became an important part of the program, but it is presented in terms of the science problems. Decimals and graphing are particularly stressed. Considerable debate among participants regarding the use of the metric system led to a decision to use the metric system exclusively.

The suggestion to develop measures of student attitudes toward science brought the most resistance and development in this area was eventually dropped. Most other aspects of the program such as the decision not to include written student materials raised little disagreement. Final decisions on controversial and noncontroversial matters were made by the Commission based on the opinions of those involved.

The material produced during the summer was turned over to the Commission staff who then spent a hectic two months preparing the materials for use in the schools that fall. The Commission staff was too small to effectively perform this job in the time allowed and felt severe pressure during this period. Editing the large volume of materials was a major task, as was balancing content among subject areas and checking for consistency within the program. The teacher texts were typed, printed, and then mailed to the tryout centers. The laboratory kits also had to be produced, and this was subcontracted to supply companies.

During the winter and spring the staff worked on different aspects of the program. The development of the hierarchy charts and the Science Process Instrument were completely staff operations. Commission staff also worked with personnel from tryout centers, processed the data received from centers, and prepared for the next writing conference.

Formative Evaluation

Formative evaluation was a major part of the development of Science--A Process Approach. Feedback was collected from 15 tryout centers and used as a basis for program modification. Following is a summary of the number of centers and teachers and the parts tried out each year of the project:

	Number of Centers	Number of Teachers	Components Tried Out
1963-64	12	106	1-4
1964-65	14	231	1-6
1965-66	14	242	1-7
1966-67	14	112	5,6,7
1967-68	11	48	6,7

Schools were eager to cooperate in the tryout efforts. The centers were selected to include students with a broad range of ethnic, social economic, and geographical backgrounds. A complete list of the tryout centers is in Appendix A. Generally sites were selected because someone on the Commission or at the summer writing sessions could recommend a local person who would be an effective consultant and assist the teachers in implementing the program. Each center selected their own teachers, generally drawn from two or more schools. The teachers received $300 a year for participating in the tryouts, evaluating the performance of students, and filling out a feedback form on each exercise. The consultants were also paid and served as a link between the teachers and the Commission. They were responsible for assisting the teachers and for sending the feedback to the Commission staff. Generally, the consultants met with the teachers as a group once every two weeks to discuss the program. Occasionally a Commission staff member would visit a center. The centers received free all the printed and laboratory materials required for the program. Thus, there was a financial incentive for the centers to participate in the tryouts in the form of free materials and payments to teachers and consultants.

The teachers administered a competency measure at the end of each exercise to three randomly selected students. The three students who were tested rotated each month. Thus, the teacher tested a sample of ten percent of the students. The teachers were cautioned to be objective in their scoring of the competency measure in order to provide the information needed in making revisions.

The results were tabulated and used as the primary indication of the effectiveness of each exercise. The intention was that the objectives could be obtained by most of the students, and the goal for each exercise was that ninety percent of the students to perform ninety percent of the behaviors specified in the objectives of the exercise, a 90/90 level of attainment. The exercises were categorized on the basis of the following levels of attainment:

Group 1: 90/90 to 100/90
Group 2: 80/90 to 89/90
Group 3: 70/90 to 79/90
Group 4: Below 70/90

Exercises not categorized as Group 1 were considered in need or revision.

The teacher also filled out a six page Feedback Form after completing each exercise which provided subjective as well as objective feedback. Appendix B includes a copy of this form. The Feedback Form asked for the following information:

Time Data--preparation and instruction
Activity Omitted and why
Comments on the Written Materials
Additions to the Exercise
Teacher Education Required
Anecdotes
Opinion of Exercise Placement
Reaction of the Class
Overall Reaction of Teach
Additional Comments

The writing committees at the summer sessions were given a summary of student performance on competency measures and the Feedback Forms. They used the competency measure results as a guide for deciding which exercises required revision and the information on the Feedback Forms to identify problems in exercises. There can be no guarantee that all the committees based their revisions on the tryout feedback, but the information was available and was certainly utilized to a large extent. The tryout results were also an important factor in deciding which parts of the program should have additional revisions and tryouts and which parts did not require further work. Dr. Mayor felt that the tryout sample was probably larger than was necessary and that sufficient data for revision purposes could have been obtained from a smaller number of classes.

A description of the evaluation model and detailed results from the second and third year evaluations are reported in An Evaluation Model and Its

Applications, Second Report, (AAAS, 1968). The results for the third year can be viewed as a summative evaluation for Parts One through Four as these parts did not undergo any additional revision cycles. The results of the first year evaluation were not produced in report form because the information gathering techniques were not yet refined and the results were not as meaningful as the later years. However, the results are discussed in the April 1965 issue of the Commission newsletter (AAAS). The results of the last two years were not published in report form due to lack of time and funds and the press of other project priorities. However, evaluation results for all years were available for the summer writing sessions.

In the first year of tryouts (1963-64) there were from 51 to 123 responses on most competency measure tasks, (AAAS, 1965). However, in all the tryouts only a few teachers completed an entire part so the number of responses for later exercises was often quite small. The results of the first year tryouts were very encouraging, but their significance is questionable since there was not always a good correlation between the objectives and the measures in the first version and because the selected tryout teachers were exceptionally well qualified in terms of years of teaching experience and science background.

In the second year tryouts there were from 81 to 156 responses on most competency measure tasks, but again, the number was considerably less for exercises toward the end of the program. The results of this tryout indicated that the writers had overestimated the capabilities of the learners and that modifications were needed. Competency measure scores for Parts One through Five were encouraging and showed over seventy percent of the exercises as being classified as 1 or 2, but Parts Five and Six, which had been tried out for the first time, were in need of extensive revisions (AAAS, 1968).

The third year tryout results (1965-66) are of particular interest since they can be viewed as a summative evaluation for Parts One through Four which subsequently were given only minor editorial revisions. Parts One through Seven were tried out and from 78 to 165 responses were obtained on most competency measure tasks. In Table 1 is a summary of the results (AAAS, 1967a).

Table 1

Number of Exercises in Each Part for Each Level of Attainment

Level of Attainment	PARTS						
	One	Two	Three	Four	Five	Six	Seven
1. 90/90–100/90	16	20	4	13	6	8	9
2. 80/90– 89/90	6	6	16	7	7	6	11
3. 70/90– 79/90	0	0	3	4	6	10	3
4. Below 70/90	0	0	3	2	8	4	3

Parts One through Four were considered adequate, but Parts Five through Seven were revised further. Parts One and Two showed marked improvement from tryout results in the previous year, but this was not the case for the other parts of the program.

As reported in An Evaluation Model and its Implications, Second Report, the tryout data was used to explore some important questions concerning the program. For example, it was found that students who had the previous exposure to the program performed better than students who had spent less time in the program. The differences between first- and third-year students ranged from two to twenty percent with a median of six percent in favor of the third-year. It was also found that children from low socioeconomic backgrounds performed as well as more advantaged students on the basic processes, although they did not complete as many exercises (AAAS, 1968).

A distinctive aspect of the formative evaluation, drawing on the work of Gagné, was the development of the Science Process Instrument, its use in validating the hierarchy chart, and the effect this had on the sequence of the exercises. The Science Process Instrument is a test designed to assess student performance on the basic process skills. The test is individually administered and is quite long. It was developed to correspond to the hierarchy chart and includes one test item for each cell in the hierarchy. An early version of the Science Process Instrument was administered to about 1,000 students at tryout centers and these results were used to validate the basic hierarchy chart. An explanation of the procedures used for validating the hierarchy appear in Appendix B of An Evaluation Model and Its Application, Second Report (AAAS, 1968). The hierarchy for the integrated process has not been validated. The Science Process Instrument could be a suitable measure for a summative evaluation study on Science--A Process Approach, although it has not been validated. Copies are available from the Commission on Science Education of AAAS.

SUMMATIVE EVALUATION

While AAAS did obtain some summative evaluation findings, as noted above, the most complete summative evaluation on Science--A Process Approach was conducted by the Eastern Regional Institute for Education (ERIE), and the results were favorable. ERIE evaluated the effects of the Xerox edition of Parts One through Five over three years as part of a project to install process-oriented curriculum in elementary schools in their region. ERIE selected 21 pilot schools of diverse characteristics and provided training for both teachers and administrators, materials for Science--A Process Approach, and consultant services. The results of the project were reported in Evaluation of Curriculum Installation and other ERIE publications. Table 2 (Ritz, 1970) shows that student achievement on competency measures was high. The mean percent correct on competency measures ranged from 75.2 to 87.4 percent over the three years of the study. The table also shows the sample size. No control group was included. ERIE also surveyed teacher attitudes toward Science--A Process Approach and teacher response was quite favorable. Below is the scale teachers used to rate their statisfaction and a summary of their responses (Ritz, 1970 p. 22):

Scale

Greatest teacher dis-satisfaction	1	2	3	4	5	6	7	8	9	Greatest teacher satisfaction

Mean Teacher Attitude Toward Science--A Process Approach

Grade Level	Mean Teacher Attitude Year 2 (1968-1969)	Year 3 (1969-1970)
Kindergarten	7.4	7.4
First Grade	7.4	7.3
Second Grade	7.2	6.7
Third	6.7	6.3
Fourth Grade	7.0	6.7

Table 2

Mean Percent Correct Competency Measure Items

Grade Levels	Year 1 (1967-1968)			Year 2 (1968-1969)			Year 3 (1969-1970)		
	Total Number of Pupils Tested	Average Number of Pupils Tested per Exercise	Mean Percent Correct	Total Number of Pupils Tested	Average Number of Pupils Tested per Exercise	Mean Percent Correct	Total Number of Pupils Tested	Average Number of Pupils Tested per Exercise	Mean Percent Correct
Kindergarten	3141	143	87.1	4293	195	84.8	814	74	87.4
First Grade	2853	110	87.4	3893	150	87.2	1516	117	84.4
Second Grade	2115	92	86.6	3350	146	84.6	952	79	82.0
Third Grade	--	--	--	2321	106	79.8	938	85	75.2
Fourth Grade	--	--	--	1575	68	83.0	862	72	77.4

(Ritz, 1970, p. 27)

Another interesting aspect of the study explored the transfer of skills taught in Science--A Process Approach to other subject areas. Supporters of the program contend that it can have a positive influence on learning in general, and that students can transfer the skills they learn in Science--A Process Approach to other subjects. ERIE asked teachers how much they felt the process skills related to other areas and the teachers reported that the processes were taught in other areas to come extent. Teachers responded on this scale with the following results (Ritz, 1970, p. 28):

Scale

These "processes" are constantly taught in other areas	1	2	3	4	5	6	7	These "processes" are seldom taught in other areas

Transfer of Processes to Other Curricular Areas

Year 2 (1968-1969)

Grade Level	Mean Numerical Response	Standard Deviation
Kindergarten	2.2	1.3
First Grade	2.9	1.4
Second Grade	2.9	1.4
Third Grade	3.0	1.4
Fourth Grade	3.3	1.5

Mean (K-4) = 2.9

DIFFUSION

Agency Participation

AAAS conducted diffusion activities as part of the product development project and about half way through the project, in 1966, AAAS selected Xerox Corporation to commercially produce and distribute the program. Since the end of the project in the summer of 1969, Xerox has been primarily responsible for continued dissemination. NSF had several restrictions on granting publication rights. First, they required that all publishers have an opportunity to bid on the program, that the copyright be limited to five years from publication, and that a royalty of six percent be paid to AAAS and then sent to the U.S. Treasury. This policy was more restrictive than that imposed by NSF on the earlier secondary school science programs which did not have copyright regulations, but less restrictive than the policy of the Office of Education at that time which required that all materials produced with O.E. funds be released to the public domain. It was further specified that in any agreement AAAS would make the final decisions on what should be included in the written materials and in the kits.

AAAS accepted bids from a number of publishers and selected Xerox because of their concern with teacher training, their willingness to set aside a percentage of receipts for revision and supplementary materials, their plan to rely on a specially trained sales force, and the enthusiasm of the Xerox representative. AAAS and Xerox established a close working relationship and continue to cooperate on the program. Policy decisions are made by an advisory council composed of two voting members from AAAS, two voting members from Xerox, a non-voting chairman from AAAS, and a non-voting secretary from Xerox. AAAS has the final decision on the content of the program and Xerox has the final decision of pricing and sales practices. A Xerox employee has worked full time at the Commission offices to assist in the design of the laboratory kits and other aspects of the program. The two organizations are in frequent communication, and they feel they have a very good working relationship.

Other institutions involved in diffusion include the University of Texas, Florida State University, ERIE, and numberous other colleges and universities across the country who, on their own initiative, sponsored training sessions for large numbers of supervisors, teachers, and teacher trainers. These training programs were critical in the diffusion of Science--A Process Approach since they provided supervisors and teachers with the background and skills they needed to implement the new curriculum.

Diffusion Strategy

Diffusion was not a major part of the development plan although extensive tryouts across the country involved up to 7,000 students each year and experimental versions of the written materials were distributed to those who requested them. AAAS turned to Xerox for continued production and widespread distribution of the program. Xerox markets Science--A Process Approach through a force of about twenty highly qualified sales representatives whose main task is to market the program to schools.

Actual Diffusion Efforts

The Commission conducted many diffusion efforts during the seven years of the project. First, they involved influential science educators in the planning and development of the course in the early conferences and summer writing sessions. Through the extensive nationwide tryouts involving up to 7,000 students each year, they generated an interest in the program in all parts of the country and trained teachers to use the program. They also created an awareness of the program through presentations at meetings such as the conference of the National Science Teachers Association. About thirty speeches or presentations were given each year by Commission staff or other people involved in the project. The project also received publicity through NSF and through articles which appeared in various publications. The Commission staff answered numerous requests for information and sent brochures to those who expressed an interest. They also sold about 5,000 copies of the written material of each experimental version at the cost of printing, but did not sell the laboratory kits. Generally, only a few copies were sold in each order and schools were discouraged from using the program without the laboratory kits; however, sometimes they were sold in large quantities to individuals who were familiar with the program. Three films which show classroom scenes demonstrating how to teach the different processes were loaned out widely, and actually worn out through extensive use. Finally, a newsletter describing project activities was published four times a year during the project and distributed to approximately to 11,000 scientists and educators. Since the end of the project, the newsletter has been published twice a year and the Commission staff continues to respond to requests for information.

Since 1966 when Xerox contracted to produce and distribute the materials, they have played a major role in the diffusion process. Xerox Corporation had begun to expand into the educational field and had created a new division, the Xerox Education Group. At first, the program was a product of a subsidiary called Basic Systems, Inc., but now it is marketed by Xerox Education Sciences, a small company whose major product is Science--A Process Approach. When Xerox commercialized Science--A Process Approach, they made minor rather than major changes in the product.

The product is sold by a force of about twenty Xerox curriculum representatives whose primary job is to market Science--A Process Approach. The representatives were selected on the basis of the interest in educational innovation and their ability to deal effectively with teachers and administrators. Generally, they have a teaching background with an average of five and a half years experience in education. The representatives do more than take orders for the program--they explain the philosophy behind the program, organize teacher training sessions, and assist in the implementation. Thus, the representative functions as a consultant as well as a salesman and provides services to the schools which help assure the success of the program. This marketing approach has been quite successful in terms of the number of schools adopting the program.

However, after three years, Science--A Process Approach is not yet a profitable product for Xerox; first, because of the large investment which was required to produce the laboratory kits, and also because of competitors who have produced low cost kits not inspected or approved by AAAS. Xerox had intended to subcontract the production of the laboratory kits, but felt that the bids they received were too high. Therefore they decided to produce the kits themselves. In every part there are generally 10-20 items per exercise, or 200-500 items per part. Many of these items were not commercially available and had to be specially designed and manufactured. All the items had to be obtained, assembled, and then packaged in such a way as to minimize the danger of breakage and yet be convenient for classroom use. Any changes or substitutions in materials had to be closely checked with the science activity and appropriate changes made in the teacher texts. In producing the later parts of the program, Xerox benefited from their experiences and reduced the number of items by consolidating materials and reusing items in several activities wherever possible. Thus, production of the kits was much more complicated and expensive than Xerox had anticipated.

Another problem Xerox faced was that they did not have any protection on their rights to the kits since they are largely a collection of readily available non-patentable materials and supplies. Competitors have produced kits to accompany the written materials and can afford to charge a lower price since they need not meet the AAS specifications and do not support a large marketing force. The type of competition is still a problem for Xerox in marketing Science--A Process Approach. Xerox offers two versions in an attempt to provide a lower cost option for the product. The Comprehensive Classroom Unit includes all the materials except for supplies such as paper and pencils, while the more economical Standard Classroom Unit includes the basic materials, but does not contain certain commonly available items.

Currently, the Xerox Education Sciences' major product is Science--A Process Approach, but they are exploring the possibility of marketing other products with an inquiry and activity orientation in subject areas such as mathematics and social studies. Xerox does not feel they can support the entire development and tryout costs of a well formulated product and are interested in programs which have already had some development work.

Colleges and universities and ERIE also performed an important function in the dissemination process through training programs. During the period 1967-1971, the Commission newsletter listed over 100 inservice programs and workshops for supervisors and teachers. The programs were held across the country and their effects were widespread.

Product Characteristics and Other Factors Affecting Diffusion

The laboratory kits make Science--A Process Approach substantially more expensive than a set of textbooks and schools are often reluctant to make the required investment. Also, it is a program which requires teacher training in order to be implemented effectively. However, educators receptive to inquiry and activity-centered programs are enthusiastic about Science--A Process Approach. The prestige of AAAS as a scientific organization and the reputation of the Xerox Corporation have both been positive factors. The program faces competition from several other activity-oriented science programs developed with funding from NSF and the Office of Education, including ESS, MINNEMAST, SCIS, and COPES. Other new science programs are also reflecting and emphasis on inquiry, on process, and on student involvement. AAAS and Xerox feel that this is healthy competition and that schools should have alternative programs from which to select.

ADOPTION

Extent of Product Use

No figures are available on the number of users of Science--A Process Approach, but it is being used on a widespread basis across the country. Even by November 1967, the Commission reported in its newsletter that an estimated 25,000 teachers were using the program. Students being taught with the program probably numbered into the millions by 1971, but there are no exact numbers.

Installation Procedures

Implementation procedures are described in a twenty page brochure entitled How to Plan for Science--A Process Approach, which was prepared by AAAS to answer some frequently asked questions. Installation does not require special facilities and no extra staff are required. It is important, however, for the teacher to have some type of preparation in the process skills and how they should be taught. A Guide for Inservice Instruction was prepared by AAAS with the cooperation of tryout personnel and is available for use in teacher training. The guide is divided into modules, each following a format similar to the exercises in the teacher texts with objectives, activities in which the teacher takes an active part and becomes involved with materials, and an appraisal activity. Teachers are generally given a pre- and posttest as part of their training. Thus, the training program is patterned after the program itself and the teachers are taught using teaching strategies they can use in their own classroom. The experimental edition of the guide has been used in different training schedules. A two week summer workshop is recommended, but shorter workshops or a combination of preschool orientation and inservice sessions during the year have also been successful. A commercial version of Guide for Inser.ice Instruction will be available from Xerox early in 1972.

Available Information from Users

The only available information from users is reported in the evaluation sections.

FUTURE OF THE PRODUCT

Xerox plans to continue to market the program and to work in cooperation with AAAS. A revised version is being planned which will be released around 1974 when the copyright agreement expires and the original version goes into the public domain. Revisions will be based on information from users, earlier tryouts, and the ERIE study, and tryout of revised materials.

CRITICAL DECISIONS

The following events are a good approximation of crucial decisions made in the history of Science--A Process Approach. For each decision point, the following types of information were considered: the decision that had to be made, the alternatives available, the alternative chosen, the forces leading up to choosing a particular alternative, and the consequences resulting from choosing an alternative.

Although an attempt has been made to present the critical decisions or turning points in chronological order, it must be clearly pointed out that these decisions were not usually made at one point in time, nor did they necessarily lead to the next decision presented in the sequence. Many of the critical decisions led to consequences that, in some important way, affected all subsequent decision making processes.

Decision 1: To Use a Process Approach

The decision to use a process approach was made at an early stage. The decision was based on the recommendations made at the three conferences in 1961 as part of the AAAS feasibility study for NSF, and on the two conferences in 1962 held to plan the development of the AAAS program. There were several alternatives considered, including an emphasis upon scientific content, a scientific method or problem solving approach, and an approach emphasizing creativity. The decision was made to use a process approach which would actively involve students in experiences.

Decision 2: To have Summer Writing Sessions for Scientists and Teachers

Earlier NSF funded curriculum development projects had been written in summer writing sessions and this procedure had proved to be quite effective. Dr. Mayor had participated in several such summer sessions of the School Mathematics Study Group and was familiar with ways of organizing development in this way and Dr. Livermore was a co-director of the Chemical Bonds Approach Project. The conclusions of the early conferences recommended that both scientists and teachers be involved in the development and the Commission wanted contributions from a large number of people. Therefore, the summer writing conference seemed a suitable technique of intergrating input from these diverse groups.

Decision 3: To Keep the Commission Staff Small

The AAAS did not want to house a permanent curriculum development staff or hire personnel they could not retain at the conclusion of the project, so the Commission staff size was limited to three or four professionals. As As a result, there was a heavy work load for the staff, particularly in the fall of each year. However, at the end of the project the Commission had a smooth transition to other activities.

Decision 4: To Emphasize Behavioral Objectives and Evaluation Measures

Robert Gagné was a major contributor to the structure and philosophy of the program and he felt that the objectives for the program should be stated in behavioral terms and that evaluation measures should be included in order to assess whether students could demonstrate the behaviors stated in the objectives. The Commission staff supported this approach, although it required additional preparation and development.

Decision 5: To Try Out the Program and Revise it on the Basis of Feedback

This decision was also made as a result of group recommendations that the program undergo formative evaluation. Again, Robert Gagné was an important contributor to the actual tryout plan. This decision lengthened time and expense but provided for necessary pilot testing and modification.

Decision 6: To Base the Program on the Basic and Integrated Processes and to Construct a Hierarchy Chart

The conferences had recommended that the program use a process approach, but the processes required further definition. The basic and integrated processes were outlined by Gagné and were adopted as the organizing concepts of the program. The hierarchy chart was used as a method of determining the sequence of activities within each process so students would progress from simple to more complex behaviors.

Decision 7: To Have Xerox Distribute the Program

The Commission had a five year copyright on the program and planned to have the program published as earlier materials developed by NSF had been. They accepted bids from publishers and selected Xerox Corporation as the publisher and distributer.

REFERENCES

AAAS Commission on Science Education, Commission on Science Education Newsletter, 1965, 1 (2).

AAAS Commission on Science Education, Commission on Science Education Newsletter, 1967, 3 (3). (a)

AAAS Commission on Science Education, Commission on Science Education Newsletter, 1967, 4 (1). (b)

AAAS Commission on Science Education. Guide for Inservice Instruction and Response Sheet. Washington, D.C.: The Commission, 1967. (c)

AAAS Commission on Science Education. How to Plan for Science--A Process Approach. Washington, D.C.: The Commission, 1970.

AAAS Commission on Science Education. Science--A Process Approach Commentary for Teachers. New York: Xerox Corporation, 1970.

AAAS Commission on Science Education. Science--A Process Approach, An Evaluation Model and its Application, Second Report. Washington, D.G.: The Commission, 1968.

AAAS Commission on Science Education. Science teaching in elementary and junior high schools. Science, 1961, 133, pp. 2019-2024.

Gagné, R.M. The individual basis of scientific inquiry. The Psychological Bases of Science--A Process Approach. Washington, D.C.: The Commission, 1965, pp. 9-25. (a)

Gagné, R.M. Psychological issues in Science--A Process Approach. The Psychological Bases of Science--A Process Approach. Washington, D.C.: The Commission, 1965, pp. 1-8. (b)

Gagné, R.M. The scientific approach to knowledge. The Psychological Bases of Science--A Process Approach. Washington, D.C.: The Commission, 1965, pp. 27-35. (c)

Gagné, R.M. Science--A Process Approach, Purposes, Accomplishments, Expectations. Washington, D.C.: The Commission, 1967.

Ritz, W.C.; Harty, H; Brown, F.A. & Wallace, C.W. Evaluation of Curriculum Installation. Eastern Regional Institute for Education, March 1970.

APPENDIX A

TRYOUT CENTERS FOR SCIENCE--A PROCESS APPROACH

Arizona, Tucson
Coordinator and Science Consultant: Dr. Edgar J. McCollough, Department of Geology, University of Arizona, Tucson, Arizona 85721. Lineweaver School; Iola Frans School; Sewell School.

California, Kern County
Coordinator: Mr. D. Dale Easter, Kern Country Schools, Kern County Civic Center, Bakersfield, California 93301. Plantation School, Bakersfield; Desert Park School, Murray School, Groves School and Vieweg School, China Lake.

California, Palo Alto--Berkeley
Coordinator and Science Consultant: Dr. Edmund Pinney, University of California, Berkeley, California 94720. Loma Vista School, Palo Alto; Washington Elementary School, Berkeleu.

Florida, Tallahassee
Coordinator and Science Consultant: Dr. Paul Westmeyer, Department of Science Education, Florida State University, Tallahassee, Florida 32306. Bond School; Kate Sullivan School; University School.

Illinois, Chicago
Coordinator: Miss Illa Podendorf, The Laboratory Schools, University of Chicago, Chicago, Illinois 60637. The Laboratory Schools, Chicago; North School, Glencoe.

Illinois, Rural Western
Coordinator and Science Consultant: Dr. David C. Allison, Biology Department, Monmouth College, Monmouth, Illinois 61462. Garfield School; Harding School; Lincoln School; Willits Elementary School.

Kansas, Overland Park
Coordinator and Science Consultant: Mr. Floyd Kemp, Elementary School District #49, 8101A W. 95th Street, Overland Park, Kansas 66202. Nall Hills School; Valley View School.

Maryland, Baltimore
Coordinator: Mr. Daniel Rochowiak, Oliver Cromwell School #74, Homewood and 22nd Street, Baltimore, Maryland 21218. Columbus School #99; Leith Walk School #245; Yorkwood Elementary School #219.

New York, Ithaca
Coordinator: Dr. Betty J. McKnight, Educational Service Center, North Plain and West Court Streets, Ithaca, New York.
Science Consultant: Dr. Verne Rockcastle, Department of Science Education, Cornell University, Ithaca, New York.
Caroline School; Enfield School; Northeast School; Henry St. John School; Belle Sherman School; South Hill School.

New York, Pelham
Coordinator: Dr. Lloyd Peak, Pelham Public Schools, 17 Franklin Place, Pelham, New York.
Science Consultant: Dr. Albert A. Blank, Institute of Mathematical Sciences, New York University, New York, New York.
Colonial School; Prospect Hill School; Siwanoy School.

Ohio, Lakewood
Coordinator: Mrs. Dora Dean, Lakewood Board of Education, 1470 Warren Road, Lakewood, Ohio 44107. Roosevelt School.

Oregon, Portland
Coordinator: Mr. Leroy G. Moore, Portland Public Schools, 631 N.E. Clackamas Street, Portland, Oregon.
Science Consultant: Dr. Raymond T. Ellickson, Department of Physics, University of Oregon, Eugene, Oregon 97403. Couch Elementary School; Duniway Elementary School; Rice Elementary School; Skyline Elementary School; Vestal Elementary School.

Pennsylvania, Philadelphia
Coordinator: Mrs. Margaret W. Ejraemson, Philadelphia Public Schools, 21st and Parkway, Philadelphia, Pennsylvania 19107.
Science Consultant: Dr. James V. DeRose, Marple Newtown Senior High School, 120 Media Line Road, Newtown Square, Pennsylvania. R. S. Walton Public School.

Texas, Austin
Coordinator and Science Consultant: Dr. David P. Butts, Science Education Center, The University of Texas, Austin, Texas 79712.
Casis Elementary School; Govalle Elementary School; Highland Park Elementary School.

Washington, Seattle
Coordinator: Mrs. Louisa Crook, Seattle Public Schools, 815 Fourth Avenue North, Seattle, Washington 98109.
Science Consultant: Dr. Burton H. Colvin, Boeing Scientific Research Laboratories, P. O. Box 3981, Seattle, Washington 98124.
Roxhill Elementary School; Sacajawea Elementary School; Sand Point Elementary School.

Wisconsin, Oshkosh
Coordinator and Science Consultant: Dr. Richard G. Netzel, Department of Physics and Astronomy, Wisconsin State University, Oshkosh, Wisconsin 54902. H. B. Patch School, Omro; Emmeline Cook School, Oshkosh.

APPENDIX B

EXERCISE FEEDBACK

AAAS Elementary Science

1964 - 1965

I. Identification Data

Title of exercise: ____________________

Date of report: ____________________

Center: ____________________

Teacher's name: ____________________

Grade: K____; 1____; 2____; 3____; 4____; 5____; 6____

II. Time Data

Supply the following information concerning the dates on which this exercise was taught and the actual amount of instructional time devoted to the exercise on each of these days:

Dates taught month and day									
Minutes of actual instructional time									

Time devoted in this exercise to:
1. planning for instruction: ______ hours
2. preparing of instructional materials: ________ hours

III. Activity Omission

A. Which activities, if any, do you believe could be omitted from this exercise without detracting from the children's attainment of the objectives?

____

B. Did you find it necessary to omit any of the activities of this exercise?
Yes _____ No _____

If you answered yes to the previous question state which activity (or activities) was not taught and explain in as much detail as possible what led you to omit this activity. For example, the physical facilities made the presentation of this activity impossible; or this activity seemed to be a repetition of performances most children were already able to accomplish.

____

____

____

IV. Additions to the Exercise

If additional activities were found to be necessary in the instructional procedure, please answer the following questions.

A. Why did you find the addition(s) necessary?

____

____

____

B. What additional activities did you introduce? Attach an activity plan or some similar, complete description.

____

____

____

____

____

____

V. Opinion of Exercise Placement

Would you like to see this exercise included in a science program at the grade level at which you taught it?

Yes ______ Yes with provision______ No______

Please explain your answer.

____

____

____

____

____

____

____

____

VI. Student Performance Data

What part or parts, if any, of this exercise are the children who were least verbal during this exercise unable to perform?

What part or parts, if any, of this exercise are the children who are highly verbal during this exercise unable to perform?

What part or parts, if any, of this exercise are most children unable to perform?

VII. Comments on the Written Material

For each of the following exercise sections please write (in as much detail as you believe will be profitable for the writers of the revision) any comment, criticism, or suggestion for change which may have resulted from teaching this exercise and which you feel should be shared. A constructive criticism is one which points out any and all difficulties, large or small, as well as those items which work exceptionally well. Your suggestions for improvements in any of the exercise sections are desired. You are encouraged to use this section of the feedback form to describe novel methods for originating the problem, pointing out omissions, and in making suggestions for revision.

Exercise section	Comment or criticism
Objectives	
Rationale	
Vocabulary	
Originating the Problem	
Instructional Activities	
Generalizing Activity	
Appraisal	
Checklist of Competencies	

VIII. Reaction of the Class

Read the following list of descriptions carefully. Check those which best describe each activity of this exercise. You may check more than one description in each category or you may check no description in a category. The intent of this section is to obtain the best description you are able to provide of the reaction of the children to the instructional materials. It is important that this section reflect what did happen rather than what we would have liked to happen.

	Child Reaction Items	Activities						
Categories	Descriptions	1	2	3	4	5	6	GE*
Interest	Fascinated with the activity							
	Quiet interest in the activity							
	Actively interested in the activity							
	Active conversations among the children in what is going on							
	Unusually high interest in a science activity							
	Passively interested in the activity							
Attention Span	Abnormally long attention span							
	Impatience							
	Abnormally short attention span							
	Usual attention span for a science activity							
	Fidgety							
	Shuffling of feet, books or other objects							
	Restless							
	Easily distracted by noises from external source							
Question Frequency	Few or no pertinent questions being asked related to this activity							
	Usual number of pertinent questions being asked related to a science activity							
	Large number of pertinent questions being asked related to this activity							
Carry-over	Resulted in children selecting related books to read							
	Resulted in children bringing related materials from home							
	Resulted in children using the vocabulary of the activity at other times							
	Resulted in children using the acquired behaviors at other times							
	Finds the science activities unpleasant							

* This column is to be used for reactions to the generalizing experience.

IX. Anecdotes

If any amusing or interesting events occurred during the exercise or as a result of it, please share these with us. In addition to anecdotes, interesting samples of the children's work might at times also be included. These anecdotes might illustrate how a child used his newly acquired learning in some independent activity, might give some insight into a child's thinking, or might fall into the "bright sayings" category.

X. Mobility Data

Name the children who have withdrawn from your classroll during the exercise.

Name the children who have entered your classroll during this exercise.

XI. Please make any additional comments about the exercise which you were unable to write in the previous sections of the feedback form.

APPENDIX C

LIST OF PRODUCTS AND DEVELOPERS

The following is a list of products for which Product Development Reports will be prepared.

Arithmetic Proficiency Training Program (APTP)
Developer: Science Research Associates

CLG Drug Education Program
Developer: Creative Learning Group
Cambridge, Massachusetts

Cluster Concept Program
Developer: Dr. Donald Maley and Dr. Walter Mietus
University of Maryland

Developmental Economic Education Program (DEEP)
Developer: Joint Council on Economic Education

DISTAR
Developer: Siegfried Engelmann & Associates

Facilitating Inquiry in the Classroom
Developer: Northwest Regional Educational Laboratory

First Year Communication Skills Program
Developer: Southwest Regional Laboratory for Educational Research & Development

Frostig Perceptual-Motor Skills Development Program
Developer: Dr. Marianne Frostig

Hawaii English Program
Developer: Hawaii State Department of Education and the University of Hawaii

Holt Social Studies Curriculum
Developer: Dr. Edwin Fenton
Carnegie Education Center
Carnegie-Mellon University

Individually Prescribed Instruction--Math
Developer: Learning Research and Development Center, University of Pittsburgh

Intermediate Science Curriculum Study
Developer: Florida State University
Dr. Ernest Burkman

MATCH--Materials and Activities for Teachers and Children
Developer: The Children's Museum
Boston, Massachusetts

Project PLAN
Developer: Dr. John C. Flanagan and the
American Institutes for Research

Science: A Process Approach
Developer: American Association for the Advancement
of Science, Commission on Science Education

Science Curriculum Improvement Study
Developer: Dr. Robert Karplus, Director
University of California, Berkeley

Sesame Street
Developer: Children's Television Workshop

Sullivan Reading Program
Developer: Dr. M. L. Sullivan

Taba Social Studies Curriculum
Developer: San Francisco State College

Talking Typewriter
Developer: Omar K. Moore and Responsive
Environments Corporation

Variable Modular Scheduling
Developer: Stanford University and
Educational Coordinates