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ABSTRACT

Presenting a comparative analysis of seven different science programs designed for education at the elementary level, these proceedings focus on science education training and leadership roles for Bureau of Indian Affairs educators. Included are: (1) a description of the University of New Mexico's summer training program, detailing program objectives, activities, and evaluation procedures; (2) the philosophy of science (distinctions between process and products); (3) the goals of science education (Craig's "basic purpose", Newport's six basic goals, the scientifically literate person, basic training assumptions); (4) an overview of the seven science programs detailing costs and objectives (Science Curriculum Improvement Study; Science A Process Approach; Individualized Science; Conceptually Oriented Program in Elementary Science; Outdoor Biology Instructional Strategies; Space Time Energy and Matter; Elementary Science Study); (5) a comparative analysis of the seven programs by program participants in terms of process (observing, measuring, recording, interpreting data, using data, predicting, classifying, etc.) and general characteristics (grade level; activity and/or process orientation; teacher and student materials available; nonreading; life, physical, or general science; complete or supplementary program; etc.). (JC)

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LEADERSHIP CONFERENCE IN ELEMENTARY SCIENCE EDUCATION

UNIVERSITY OF NEW MEXICO

SUMMER, 1975

UNITED STATES DEPARTMENT OF THE INTERIOR
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INTRODUCTION

During the past decade elementary school science has received national attention reflecting an increased concern with the science instruction taking place in the schools. This concern helped to generate an impetus toward innovative answers and programs to improve the quality of the science curriculum in the educational process. The explosion of science knowledge has led to the development of logical sequential programs of science curricula for the elementary, middle school, and high school students.

In order to improve Indian education a concentrated effort needs to be made to upgrade the quality of our curricula as well as increase the competency of the staff in the newly developed science curricula. Many of the students who attend school in the Bureau of Indian Affairs schools lack interest, desire and motivation to participate in the school programs. This attitude could be alleviated by preparing teachers in programs that are exciting and challenging, and offer the student the opportunity to become actively involved in the educational enterprise which will affect himself, his family, his tribe and his future as a successful citizen within the framework of a society which has many values different from which he is accustomed.

Indian students vary in ability, motivation, interest, as well as, social and cultural orientation to learning. To make the most of the learning situation, both teacher and student need to be constantly apprised of the effectiveness of the learning patterns and the student progress through them.

A summer program designed to help upgrade science teaching skills in Bureau of Indian Affairs schools throughout the United States was conducted during the summer of 1975 at the University of New Mexico. The National Science Foundation provided a grant of $33,333 to the University of New Mexico for this program. Dr. Paul W. Tweeten, professor of secondary education at the University of New Mexico was the director of this program. Participants in the program were selected with the cooperation of the education specialists of each of the Bureau of Indian Affairs Area Offices. The Bureau of Indian Affairs educators were given instruction in science teaching to help them assume leadership roles in improving the science curriculum and teaching skills in the schools under the jurisdiction of the Bureau of Indian Affairs.

The main purpose of this project was to identify general curriculum consultants in the Bureau of Indian Affairs who have expressed special interests in science education and to train them for leadership roles in science curriculum in their respective areas.

The major objectives of the project were:

1. To train a group of twenty curriculum consultants in the philosophy, teaching methodology, and materials of the new curricular projects available in elementary science education for the purpose of developing an in-service model for implementation of those materials appropriate to their administrative area.

2. To develop within the twenty participants a role model for the science curriculum consultant.

3. To develop a set of criteria and recommendations for an effective science education program.

4. To develop a model for the most effective means of bringing about change in science education in the participants' administrative area.

5. To develop a model for evaluation of the science program in the participants' administrative area.

The Aims and Objectives of the participants were:

1. To gain experience in the philosophy, approach, and operation of the ESS, S-APA, and SCIS materials.

2. To gain further experiences in using these materials with elementary school children.

3. To develop a specific model for working with teachers in an in-service situation for the implementation of the new curricular materials after having become confident and knowledgeable on a personal basis.

4. To develop a set of criteria for an effective science education program in order to better communicate with the local school administrators.

5. To develop a model for bringing about subsequent change in the area assigned.

6. To develop an evaluation model and thus give necessary feedback to the local schools attempting change.

Activities were designed to meet these objectives. They were:

1. They participated as learners and teachers in the activities included in the three programs emphasized -- S-APA, ESS, and SCIS. The materials for each of these programs were available at the University of New Mexico.

2. Interaction took place between the participants and specialists brought in from the three projects. Interaction was encouraged to

broaden the content and framework of each project and to introduce a third important aspect -- cost and logistics of ordering, storing, and otherwise administering a new science program that involves a substantial amount of hardware as well as software.

3. Interaction with consultants brought into the sessions on the topics of leadership roles, professional response, and supervisory techniques.

4. Sessions were devoted to trying in-service programs developed by the various projects and from these the participants teams were able to determine, adapt, and adopt the most effective program for their administrative area.

5. Evaluation procedures are necessary in the administrative structure within which the participants must operate. It was therefore necessary for the participants to have access during the summer session for various alternative means. The resources available at the University of New Mexico provided for these alternatives as well as contacts with project resource personnel.

Each of the participants received up to eight semester hours of credit by successful participation in the program. Credit was given in: Elementary Education 453 -- The Science Program in the Elementary School (three credits). Elementary Education 447 -- Topics in the Supervision of Elementary School Science Programs (three credits). Elementary Education 551 -- Special Problems (two credits).

The participants received credit for the two three-credit courses, Elementary Education 453 and Elementary Education 447 during the summer phase. The problems course will be a part of the academic year follow-up and also serve as an evaluation tool.

Evaluation of the project will proceed along two parallel courses:

1. Formative Evaluation:

   Major objectives of the project include:

   a. To develop within the twenty participants a role model for the science curriculum consultant.

   b. To develop a set of criteria and recommendations for an effective science education program.

   c. To develop a model for the most effective means of bringing about change in science education in the participants administrative area.

   d. To develop a model for evaluation of the science program in the participants administrative area.

<u>During the developmental process</u>, the University of New Mexico will insure that guidelines and procedures being developed that will accomplish these objectives will be consistent with:

   a. The philosophy and objectives of the science curricula and,

   b. the philosophy and objectives of the schools and school areas involved in the project.

2. Summative Evaluation:

   a. The development of evaluation instruments that focus on the major project objectives and,

   b. the use of these instruments to determine the effectiveness of the implementation phase in each of the ten school areas.

PHILOSOPHY OF SCIENCE

Science could be defined as an organized body of knowledge supported by factual evidence. Within the academic world there are numerous "grocery lists" pertaining to definitions of science, philosophies of science, as well as, a "vegetable soup" variety of programs available on the open market.[8] However we define science, we soon come to distinguish between its processes and its products.

This concerted effort toward curriculum reform, development and dissemination has initiated more than 15 elementary science curriculum projects all in various stages of fruition. Some of the better known names include Science - A Process Approach (SAPA), the Elementary School Science Study (ESS), the Science Curriculum Improvement Study (SCIS), the Conceptually Oriented Program In Elementary Science (COPES), the Elementary School Science Project (ESSP), The School Science Curriculum Project (SSCP), the Minnesota Mathematics and Science Teacning Project (MINNEMAST), the Elementary School Science Project (ESSP) conducted at Utah State University and a project of the same title developed by Howard Univers ty.[6]

The majority of these programs received substantial funding from the National Science Foundation with smaller amounts of financial assistance coming from private foundations and the U. S. Office of Education. Since Sputnik more funds have been invested in mathematics and science than in any other curricular area. This financial backing made possible the intensive involvement of scientists, science educators, teachers and children in the development, implementation, evaluation and dissemination of the projects.

Another major contribution to come from these projects was the exciting concern with teaching science as a process of inquiry. This much needed and long-overdue reform promotes the investigative nature of science helping to transform classrooms into something resembling science laboratories with children participating in activities similar to those of professional scientists. The teacher's role and methods have had to change in order to implement the philosophies of the new science programs.[12] Emphasis on factual recall, memorization and reading from textbooks has shifted to where the investigative side of science is emphasized.[11]

GOALS OF SCIENCE EDUCATION

There has been much discussion in educational circles concerning the basic purposes or goals of teaching science to children. The teaching of scientific fact has been emphasized by many as the ultimate goal of elementary science. Others have recognized the natural curosity of children and have stressed the need of satisfying the child's desire to know while others feel that the process of science is science and must be emphasized. The idea that science should not be taught below the high school level has also been suggested.

Craig's Basic Purpose

Craig believes one basic purpose of elementary school science is to contribute to the development of desirable social behavior and lists (1) open-mindedness, (2) distinguishing between fact and fiction, (3) seeking reliable information and (4) intelligent planning as essential contributors to that goal.[2]

Newport's Six Basic Goals

Newport attempted to determine if the new curriculum developments and the revitalizing of the field of elementary school science changed the goals or objectives of science between 1927 and 1965. The year 1957 was used as a dividing line due to the strong interest caused by Russian space activity. The only difference found by Newport between the goals of pre-1957 as compared to the post-1957 period was one of semantics. The six basic goals reported by Newport are:

1. Develop scientific methods as a way of thinking and solving problems.

2. Develop understandings of the child's environment and his relationship to the physical world.

3. Develop scientific attitudes.

4. Develop fundamental scientific skills.

5. Develop an appreciation of the contributions of science and of the work of scientists.

6. Develop interests for leisure time activities.[10]

The Scientifically Literate Person

The position of the National Science Teachers Association is that the major goal of science education for the 1970's is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action. This position emphasizes the concept, process and attitudinal principles of science and that the scientifically literate person should:

1. Uses science concepts, process, skills and values in making everyday decisions as he interacts with other people and his environment.

2. Understands that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories.

3. Distinguishes between scientific evidence and personal opinion.

4. Identifies the relationship between facts and theory.

5. Recognizes the limitations as well as the usefulness of science and technology in advancing human welfare.

6. Understands the interrelationships between science, technology, and other facets of society, including social and economic development.

7. Recognizes the human origin of science and understands that scientific knowledge is tentative, subject to change as evidence accumulates.

8. Has sufficient knowledge and experience so that he can appreciate the scientific work being carried out by others.

9. Has a richer and more exciting view of the world as a result of his science education.

10. Has adopted values similar to those that underlie science so that he can use and enjoy science for its intellectual stimulation, its elegance of explanation, and its excitement of inquiry.

11. Continues to inquire and increase his scientific knowledge throughout his life.[9]

Broad support for the goal of scientific literacy is also given by Hurd (5), Carin and Sund (1), Karplus (7) and Evans (4).

The increasing acceleration of scientific knowledge and the influence of science upon technology and society mandates that scientific literacy begins in the primary grades and continues through life. The person who is well educated in the 1980's will have to be scientifically literate.

Volumes have been written concerning the merits of the so called "Inquiry" methods of teaching versus the traditional "textbook" approach. Therefore, we submit the following comments:

1. Students are capable of learning much more than they have so far demonstrated in school. The students achievement level is due to many factors, including the way in which the student has previously been taught in school.

2. Indian students can reason and think. The importance of the concrete illustrative material is not only that this may be a medium

through which the individual may learn, but potentially he has a situation in which he has more fundamental and thorough understanding of the concept or principle involved.

3. <u>Individuals under appropriate conditions will learn and behave at maximal, rather than minimal levels</u>. Essential conditions are interest, curiosity, and an opportunity to help shape the direction of their learning. The teacher is committed to certain kinds of education values and goals in terms of both subject matter and behavior. One of the teachers' functions should be to find ways to bridge the difference between the students' interest and the desired interest in the subject matter.

4. <u>Individuals differ with regard to the media or channels through which they learn</u>. The written and spoken words are not the only channels of learning. Confrontation with and manipulation of actual science objects and phenomena, use of tools for observation and measurement, discussion of findings, and ways they relate to other findings, and/or to everyday experiences are some very powerful means of learning.

SCIENCE PROGRAMS--AN OVERVIEW

SCIS -- Science Curriculum Improvement Study

The primary emphasis of SCIS is on concepts, but attention is given to the development of attitudes, abilities, and skills including habits of careful observation, methods of recording observations and experiences, discrimination of fine differences and recognition of broad similarities, gathering data along with the appropriate vocabulary to assist in the development of meaningful concepts.

The designers of SCIS are not suggesting that students learn only what they observe for themselves; in our complex world much learning must be based upon observations reported by others. Children are encouraged to discuss their observations with others in the class and to use evidence or settle controversies that arise. Interest and involvement of children in the lessons is a major concern.

Cost -- $2,800 -- Grades K-6

SAPA -- Science A Process Approach

Science A Process Approach first appeared only a few years ago. It is an active hands-on approach to learning and has a non-textbook format. It begins with identifying objects and object properties, this sequence proceeds to the identification of changes in various physical systems, the making of controlled observations, and the ordering of a series of observations. This is done by using your senses as observing.

They define scientific skills by eight basic processes of science: <u>Observing</u>, <u>using space/time relationship</u>, <u>using numbers</u>, <u>measuring</u>, <u>classifying</u>, <u>communicating</u>, <u>predicting</u>, and <u>inferring</u>. The new science approaches are not confined exclusively to the science classroom, but all classrooms. Activities build confidence in varied situations, social as well as scientific. It helps prepare children for useful and effective citizenship.

Cost -- $2,375 -- Grades K-6

IS -- Individualized Science

Individualized Science is a unique new approach to elementary science instruction. The program is individualized, aimed at making each student an independent learner, able to help plan and manage his own learning. As an independent learner, he is able to proceed at his own learning pace, choosing the materials he needs to achieve his learning goals. He also learns to assess his own progress and -- in conference with his teacher -- to make any necessary revisions in his learning plan. As the student progresses through the program, he assumes increasing responsibilities for planning and evaluating his own work.

Individualized Science and its management system have been thoroughly field tested in a variety of school settings, ranging from the self-contained classroom to the open-concept school. Individualized Science is specifically structured to meet the needs of the individual student. The non-reader can listen to tapes.

Cost -- $1,700 -- Grades K-6

COPES -- Conceptually Oriented Program in Elementary Science

COPES is a hands-on curriculum. It involves active exploration by children in the learning of concepts. COPES is a non-reading science program. No materials other than worksheets have been written for children. For this and other reasons such as the highly exploratory nature of the program, it has been particularly effective with children who have reading problems. Because of their basic nature, the teaching materials in the K-2 guides can be used to introduce any good elementary science program. Specifically, the activities in these guides develop the concepts and skills needed before the main sequences start at Grade 3. Thus, the K-2 guides form the foundation for the COPES program and are called the "pre-sequence".

COPES is a highly structured elementary science curriculum. Teachers using this program have a clear idea of where the activities are leading and how the earlier activities prepare the groundwork. Although COPES is highly structured, it is possible to "tune in" at any grade level with only a minimum of preliminary preparation. How this is done is made clear to the prerequisites developed in earlier grades, or even in an earlier part of the guide.

COPES is not only a basic elementary science program, it also consists of selected learning mini-sequences. Single concept units of COPES have been found especially suitable as enrichment materials in on going elementary science programs. Assessment materials are a part of each guide. They are used to evaluate the children's understanding of the concepts developed in each mini-sequence. Also included are suggestions regarding what may be done to help those children who have not mastered the concepts. Teachers have found the assessments extremely helpful.

Cost -- $65.00 Guides and Assessments -- Grades K-6

OBIS -- Outdoor Biology Instructional Strategies

OBIS activities are oriented toward community-sponsored youth organizations such as scouts, recreation center clubs, summer camps, and nature center groups.

The project is not primarily a school science curriculum, although many of the materials may be suited for use by school groups. Some of the units are styled after those of the Science Curriculum Improvement Study (SCIS).

OBIS departs from the common curriculum development procedure of determining a single sequence of learning activities leading to specific concepts. Instead, the OBIS staff is identifying and trying out a variety of alternative strategies and techniques for environmental study. Assuming that no single learning pathway can be either interesting or applicable to all youngsters in all locales, OBIS plans flexible modules involving multipl entrance and exit points. The folio format makes is possible for the group leaders and participants to have a flexible sequencing of activities over a period of time. The first year of the project was 1972-73.

Cost -- $100.00 Guides and Materials

STEM -- Space Time Energy and Matter

STEM Elementary School Science provides direction, structure, and content. It has four conceptual strands: space, time, energy, and matter.

It was developed because elementary school teachers felt uneasy with traditional fact-oriented science books that weren't very interesting, nor did little to stimulate students' natural curiosity. Memorizing facts didn't teach the processes of science which are observing, formulating hypotheses, classifying, and predicting.

The program is not designed to make scientists out of elementary school children. But it is designed to encourage all students to think rationally and to act responsibly in dealing with their environment. It is further designed to challenge the gifted, yet not overwhelm the slower learners.

Its purpose is to develop in all children, clearly understood, useful concepts about their world of space, time, energy, and matter.

The material requirements are carefully described and are made up primarily of everyday things, common in the experience of most school children. Thus, the program requires little or no specialized equipment beyond standard items such as balances, hand magnifiers, and magnets. In addition, the teachers' edition outlines enrichment activities which may be used with materials that most teachers may have available. This use of simple, everyday materials permits a wide range of flexibility in what can be done in class and at home, by individuals or by groups.

Cost -- $1,033 Kit -- $100.00 Guides and Evaluation -- Grades K-6

<u>ESS -- Elementary Science Study</u>

Elementary Science Study is the least structured of the "hands-on" programs. Over fifty independent units have been constructed. These units are not book oriented and will work well with students with poor reading skills, as well as, those with superior skills in reading.

In a typical school year, a class would normally cover between 8-10 different units. It would be necessary for the different grade teachers to decide which grade would offer which units to avoid undue repetition. The units are open-ended and let the teacher and student explore unit concepts to the depth which they choose. The units are flexible in that one may be taught at the 4th grade or at the 7th grade level.

If kits are purchased the price of ESS becomes relatively high. The teacher's manuals alone for each unit are very reasonable.

Cost -- $3,050 -- Kits $32.50 x 5 = $162.50 -- Grades K-8

COMPARATIVE ANALYSIS OF SEVEN SCIENCE PROGRAMS GENERAL CHARACTISTICS	COPES Conceptually Oriented Program in Elem. Science	ESS Elementary Science Study Mc Graw-Hill	Individualized Instruction Learning Research & Development Univ. - Pittsburg	OBIS Outdoor Biology Instructional Strategy - Grant Nat. Science Found. U.of C.- Berkley	SAPA Science-A Process Approach Ginn	SCIS Science Curriculum Improvement Study Rand-McNally	STEM Space-Time Energy-Matter Addison-Wesley
1. Grade Level k-6	X		X		X	X	X
2. Grade Level K-8		X		10 - 15 yrs.			
3. Activity Oriented	X	X	X	X			X
4. Process Oriented	X	X	X	X	X	X	
5. Structured	X		X		X		X
6. Independent Units	X	X	X	X	X		X
7. Units Sequenced	X			X FLEXIBLE	X	X	X
8. Readibility		X			X	X	X
9. Non-Reading	X		X minimum	X			X
10. Life Science		X		X		X	X
11. Physical Science	X	X	X	X	X	X	X
12. General Science	X	X		X	X	X	X
13. Complete Program		X OR			X	X	X
14. Supplementary Program	X	X	X	X			
15. Individual Differences Provided		X	X	X	X	X	X
16. Teacher Prequisites Needed	X						
17. Teacher Materials Available	X	X	X SAME	X SAME	X	X	X
18. Student Materials Available		X	X	X	X	X	X
19. Kits Available		X	X		X	X	X
20. Affordable	X	X	X	X	X	X	X
21. Language Development	X		X			X	X
22. Assessment Materials							
23. Adaptable to Other Areas							

COMPARATIVE ANALYSIS OF SEVEN SCIENCE PROGRAMS	COPES	ESS	Individualized Instruction	OBIS	SAPA	SCIS	STEM
PROCESS							
1, Observing	X	X	X	X	X	X	X
2. Measuring	X	X	X		X	X	X
3. Recording		X		X		X	X
4. Interpreting Data	X	X	X	X	X	X	X
5. Using Data	X	X	X	X	X	X	X
6. Predicting	X	X		X	X	X	X
7. Classifying		X	X	X	X	X	X
8. Communicating	X	X	X	X	X	X	X
9. Formutating Hyphotheses		X		X	X	X	X
10. Sorting		X	X	X	X	X	X
11. Identifying	X	X	X	X	X	X	X
12. Collecting	X	X	X	X		X	X
13. Describing	X	X	X	X	X	X	X
14. Constructing		X		X	X	X	X
15. Inferring	X	X	X	X	X	X	X
16. Experimenting	X	X	X	X	X	X	X
17, Calculating	X	X			X	X	X
18. Estimating	X	X			X	X	X

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COMPARATIVE ANALYSIS OF SEVEN SCIENCE PROGRAMS CONTENT	COPES	ESS	INDIVIDUALIZED INSTRUCTION	OBIS	SAPA	SCIS	STEM
1. Living Things & Their Environment	X	X	X	X	X	X	X
2. Human Biology		Bones	X				X
3. Force & Motion	X	X	X		X	X	X
4. Heat & Temperature	X	X	X	X	X	X	X
5. Air & Weather		X	X	X		X	X
6. Objects in Space		X					X
7. Rocks & the Land		X		X	X	X	X
8. Light & Sound		X		X		X	X
9. Models: Electricity & Magnetism	X	X			X	X	X
10. Interaction & Systems	X	X	X		X	X	X
11. Energy Sources		X	X			X	X
12. Metric Measurement		X	X		X		X
13. Ecosystems		X	X	X		X	X
14. Communities		X	X	X		X	X
15. Subsystems & Variables		X	X	X	X	X	
16. Matter and its Behavior	X	X	X			X	X

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Conclusions:

All students need experiences that will help them learn how to: Be observant; be descriptive; be analytical; be categorical; be able to make comparisons; and to be able to generalize about a subject.

What do we want to provide the students with an elementary school curriculum? In a nutshell -- "a variety of experiences". Experiences in dealing with facts, by eliminating guessing. To be able to hypothesize with facts, to be able to verify facts, and to utilize facts in helping each individual solve his/her problems.

A word of caution: Science Education will not solve all problems nor eliminate the influence of prejudice in decision making. But the results should allow each individual to make better decisions based on the information available because of the catalog of educational experiences obtained by each individual through his participation in the programs described in this paper.

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