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ABSTRACT

This is the first of a series of three articles, undertaken by the ERIC Center for Science and Mathematics Education, on three national elementary science projects (Elementary Science Study, AAAS--Science - A Process Approach, Science Curriculum Improvement Study) sponsored in part or in whole by the National Science Foundation. Six areas are generally covered for each of the three programs: (1) nature of the program; (2) instructional materials; (3) use of materials; (4) implementation and teacher programs; (5) evaluation; and (6) the role of the teacher. An important aspect of Elementary Science Study (ESS) materials is that they have been developed and designed according to how children respond as they work with the materials. ESS has placed great emphasis on having children work with concrete objects instead of ideas. About 60 units have been developed, with teaching guides, and are now in commercial production. Some of the units are designed to be used by an entire class at the same time. Other less structured and more open-ended units may involve only a small group and may not be taught as a series of connected lessons. Some units are definitely designed for individual or small group work. ESS has an active workshop program to acquaint personnel with ESS and assists schools in the implementation process. (BR)

Programs for Improving Science Instruction in the Elementary School

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THE ERIC Center for Science Education receives numerous requests for information regarding a wide range of educational programs. One such area that is currently of major interest to teachers, teacher-trainers, school administrators, university scientists, and others interested in elementary school programs is that of science for the elementary school. Information regarding programs sponsored on the whole, or in part, by the National Science Foundation are of particular interest. In response to requests for information regarding the NSF programs, the Center has undertaken to publish a series of articles designed to answer the many questions in a more comprehensive form than would be possible through the medium of numerous individual letters.

The series of articles will present a description of three programs sponsored in part or in whole by the National Science Foundation—the Elementary Science Study (ESS), the Science Curriculum Improvement Study (SCIS), and Science—A Process Approach (AAAS). These three programs have been selected on the basis of the frequency of requests for information about them and the extent of the use of the materials on a national basis.

Information for writing the articles has come from three major sources:

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1. Documents housed at the ERIC Center for Science Education.
2. Documents received from the projects' staffs and others who work with the project materials, and
3. Materials obtained by searching libraries and making special contacts (telephone, etc.) with a wide variety of people (workshop leaders, etc.) who have worked with the projects in some capacity.

Six areas are generally covered for each of the three programs: (1) nature of the program; (2) instructional materials; (3) use of materials; (4) implementation and teacher programs; (5) evaluation; and (6) the role of the teacher.

INTRODUCTION

The last decade and a half has witnessed curriculum improvement projects in a number of subjects. Not the least among these has been in the area of science. First there were projects in secondary science: physics, biology, and chemistry. Then in the early sixties efforts of a large scale were undertaken to upgrade science instruction in the elementary school. Several projects involving scientists and educators were initiated. The Elementary Science Study (ESS) is one such project.[1]

ESS is one of the many curriculum programs under preparation at the Education Development Center (EDC) in Newton, Massachusetts. EDC, a nonprofit organization incorporating the Institute for Educational Innovation and Educational Services Incorporated, began in 1958 as a parent organization to the Physical Science Study Committee. One of EDC's largest endeavors, claiming approximately 10 percent of the total EDC budget in 1968, is the elementary science program being developed by ESS.

In 1960, ESS began on a small scale developing materials for teaching science from kindergarten through eighth grade. Since then, more than a hundred scientists and educators have been involved in the conception and design of ESS materials. These staff developers have received considerable help from staff specialists in the design of equipment, making of films, and producing printed materials.

Nature of ESS Program

In order to understand the nature of ESS materials, it is essential to know how the ESS staff has gone about developing those materials. Significantly, the materials are not based on a specific theory of how children learn, or on the logical structure of science, or any concept of the needs of society. This is not to say, however, that what children do with ESS materials is psychologically unsound and scientifically trivial. Considering the composition of the development staff (educators and scientists) this is hardly the case. Nevertheless, ESS's approach has been largely intuitive, rather than theoretical, particularly in the beginning.

Of course, ESS personnel have some ideas about what constitutes good science for children. Philip Morrison, one of the prime movers of ESS, has provided a clue to what ESS considers important when children and science meet:

> One mandate is imperative for our style of work: there must be personal involvement. The child must work with his own hands, mind and heart (20, p. 70).[2]

Indeed getting children totally involved in working with materials is what gives direction to the development of ESS materials. And this involvement criterion is determined to a large extent not by theoretical assumptions about what interests children but by how children actually respond to materials during the developmental process. If the materials fail to turn children on, affectively and cognitively, the idea under consideration is discarded and others are pursued. As is readily seen, this approach to developing instructional materials relies heavily upon feedback from teachers, classroom observers, and administrators.

The ESS Development Process

In its final form, a phenomenon dealt with by ESS staff developers becomes an instructional unit.[3] The development of a unit can be thought of as progressing in stages, as described below.

1. *"Gleans" and Hunches.* A staff member has an idea that he thinks has potential for being developed into a unit.
2. *Early Development.* Staff members work out an opening series of lessons which are taught by a staff member and observed by other staff members in a local (Newton, Massachusetts and vicinity) classroom. Classroom work is followed by evaluation. If the idea still seems workable, the development process proceeds to the next stage. If not workable, the idea is discarded.
3. *Advanced Development.* Local teachers try out the unit. A teacher's guide is written and prototypic equipment is perfected.
4. *Trial Teaching.* The unit is tested against a wide background of teachers and classrooms. Trial teaching feedback may lead to changes in the Teacher's Guide, equipment design, and, sometimes, content.
5. *Preparation for Commercial Release.* Feedback from trial teaching is further analyzed and on the basis of this feedback necessary changes are made in written materials and equipment. Staff members work with commercial publishers in production.

The ESS Staff is primarily concerned with developing instructional materials that are, in ESS terms, appropriate for children's science learning (8). One aspect of what is appropriate is the concrete; that is, children

[1] The sources of information for writing this article have consisted primarily of documents held at the ERIC Center for Science Education and unpublished information supplied by the ESS director and staff members. Some information has been obtained from other assorted sources. Most information came from ESS publications, articles written about ESS by staff members, and various other articles pertaining to the program.

[2] Numerals in parentheses refer to references listed at the end of the article.

[3] The development process described here is an abbreviated version of the process described in a communication received from ESS.

work with things, not ideas (2). This predilection for working with things is based partly on what motivates children to explore and partly on how children learn. Thus ESS does not teach concepts such as "living forms are orderly and complex," "matter is electrical in nature," or "energy is conserved." Rather, in the words of former ESS Director Randolph Brown:

> . . . ESS finds it more profitable to help children explore the hatching and growth of tadpoles, the habits of mealworms, and the ways of lighting bulbs with batteries . . . ESS feels that "things" encourage children to ask great questions and find their own answers (2, p. 33).

Appropriate also means that the materials must be of such a nature that they stimulate children to raise questions, as well as being conducive to yielding answers. One of the questions that children invariably ask when they are working with the unit *Behavior of Mealworms* is "How do mealworms find food?" The children are encouraged to have the mealworm "answer" the question for them by designing some investigations that inquire about the mealworm's sense of smell, sight, and so on.

Furthermore ESS has some definite ideas about how its materials should be used in the classroom. Eleanor Duckworth has described ESS's approach in the following manner:

> There are two main characteristics which we keep in mind. One is that children use materials themselves, individually or in small groups, often raising the question themselves, answering them in their own way, using the materials in ways the teacher had not anticipated, and coming to their own conclusions. . . . The other is that we try to create situations where the children are called upon to talk to each other (8, p. 242).

David Hawkins (10), a former Director of ESS, has emphasized the importance of allowing children to "mess about" with materials in the early phase of a unit, the rationale being that preliminary free and unstructured experience (messing about) with the materials "produces the early and indispensable autonomy and diversity" that serves to give meaning and direction to children's questions and activities. This approach permits children to learn different things and to learn at different rates.

The ESS Approach and Psychology of Learning

Although no specific efforts have been made by ESS to base its approach on a particular psychology of learning, resulting materials do turn out to have a sound psychological basis, as Eleanor Duckworth, a psychologist who has worked with ESS, has observed (8). Two important aspects of ESS materials, using concrete things and children's active involvement in learning, are supported by Piaget's ideas on intellectual development (21). The notion that children should have free and unhurried periods of exploration during the early phases of learning has been stressed by Bruner (3), Hunt (14), Berlyne (1), Dewey (7), and John Holt (12). Moreover, Susan Isaacs (15), an outstanding leader in child growth and development in England, and Robert Sears (24), an American psychologist, have emphasized that children derive the greatest pleasure from those things (either animate or inanimate objects) that respond to their manipulations.

Allowing children to follow their own inclinations as they explore materials is obviously important to ESS's approach to children's learning. The thinking behind this is that children learn more when they are doing what they want to do instead of what someone else wants them to do. Furthermore, such self-directed learning has more meaning for them. Hunt (14), Hull (13), Hein (11), Hawkins (10), Dewey (7), Holt (12), and Isaacs (15) have emphasized the importance of allowing children to follow their own bent as they interact with their environment.[4]

Motivation

While the wide variety of units developed by ESS allow all combinations of formal and informal, sequenced and unsequenced, large-group and small-group instruction, all units are designed to motivate children to explore, speculate, and try things, for as Philip Morrison and Charles Walcott have observed:

> . . . a major aim of a project such as this one [ESS] is to encourage children to examine the world around them and to acquire the desire, interest, and ability to *continue* to analyze, relate, and understand it as they go through life (18, p. 49).

According to Morrison, when speaking of the work of ESS:

> The complex thing we call motivation or attitude, the affective side of learning, is perhaps above all the human attribute which we hope to evoke (19, p. 65).

If these remarks are representative of the views of other ESS personnel, and the authors have no reason to believe that they are not, then one is led to conclude that above all else ESS materials are intended to motivate children to explore the world around them.

Scope and Sequence

Scope and sequence of content are factors that frequently draw considerable attention from curriculum makers. Nevertheless, ESS does not seem at all concerned about these factors believing that there is no way of knowing whether in fact the content of science that is important now will be important in the first half of the twenty-first century, the period in which our present elementary school children are to live most of their lives (22). ESS has given two reasons for not developing a sequential science program for the ele-

[4] According to the *Plowden Report* (Her Majesty's Stationery Office, London. 1967), one-third of the primary schools in England happily and successfully operate from this rationale.

mentary school. First, since learning theorists do not fully understand just which sequences of experiences lead to the kind of changes in children ESS would like to see, it would indeed be presumptuous to develop a sequential program (18). Secondly, ESS believes in any case that it is both the prerogative and responsibility of each school system to work out its own sequence with its own objective in mind (22). While ESS is willing to consult with school systems on such matters, it does not wish to dictate a certain sequential order in which its materials are to be used. This, in ESS's view, would be tantamount to making its materials a textbook or textbook series, a curriculum pitfall it wishes to avoid. Although, as has been indicated, ESS units are not designed in a way that requires that they be taught in a certain order, many schools have constructed a complete science program around them including a locally determined sequential order in which the units are to be taught.

Instructional Materials

As of the fall of 1969, ESS has in commercial form 50 units for use in grades K-8. The majority of the units are concentrated in grades four, five, and six. There are, however, at least sixteen units that are suitable for K-3 and twelve for grades seven and eight. The variety of units produced by ESS can be used to provide a wide range of learning experiences. Some units are designed to develop fundamental skills in graphing, weighing, and measuring. Other units are oriented more toward content development; still others are concerned primarily with developing thinking skills. Most units, in fact, provide a combination of all these experiences. The *Growing Seeds* unit, for example, includes activities that call upon the children to graph, to measure, and to seek ways of finding answers to their questions. At the same time pupils learn something about the conditions favorable to germination and growth of plants, about rates of growth of different plants, and about the structures of seeds and plants.

The basic instructional materials for a unit consist of a teacher's guide and a pupil kit. The teacher's guide contains background information about the content of the unit, as well as suggestions for its use, and is not written as a prescription to be followed blindly by the teacher. Rather it respects the judgment, imagination, and individuality of the teacher and encourages him to exercise these qualities. The pupil kit contains all the equipment that the children will need to carry out the ideas suggested in the teacher's guide. If encouraged to do so, the children will find other ways to use the equipment as they explore their own ideas.

In addition to the basic materials, worksheets, pictures, supplementary booklets, film loops, and 8mm films accompany some units. The film loops are each three or four minutes long and are designed to provide children with learning experiences that could not be readily obtained directly, yet contribute to children's understanding of important phenomena related to a unit. An example of such a film loop is one entitled the "Black Swallowtail Butterfly: Egg, Hatching, and Larvae." It is very difficult to raise butterflies through the stages of their life cycle in the classroom.[5] Direct observation being impractical, ESS developed a film in order that children can nevertheless have an "experience" with the life cycle of a butterfly.

It should be noted that ESS worksheets are not the traditional fill-in-the-blank variety. Some are designed to facilitate keeping of records and are usually based on children's observations of their own manipulations of materials. Others may be in the form of "prediction sheets" that call upon the children to make predictions on the basis of previous experiences in the unit. Frequently, these prediction problems are in the form of diagrams, as is the case with a prediction sheet in the *Batteries and Bulbs* unit. On this sheet several diagrams of wire connections betwen bulbs and batteries are shown and the child is asked to predict in which arrangements the bulb would light.

Some units are designed to be used by an entire class at the same time. These units frequently consist of student worksheets and film loops as well as teacher's guides and pupil kits. Such units can be accommodated in a typical classroom without major alterations of schedules or class organization. Units that fall in this category are listed below:

GASES AND "AIRS"
BATTERIES AND BULBS
MICROGARDENING
BALANCING
GROWING SEEDS
HEATING AND COOLING
ICE CUBES
PENDULUMS
BALLOONS
KITCHEN PHYSICS
COLORED SOLUTIONS
OPTICS
SLIPS AND SLIDES
SINK OR FLOAT
ROCKS AND CHARTS
SMALL THINGS

Other units are less definitive and may include only a teacher's guide which suggests activities and simple materials that are obtainable locally or are available from equipment-supply houses. Units of this type may involve the whole class or part of the class and may or may not be taught in a series of connected lessons. The teacher's guides for these units are less structured, more open-ended, and require more teacher initiative. A list of units in this category is below:

BONES
MEALWORMS
MYSTERY POWDERS
EGGS AND TADPOLES
POND WATER
MOSQUITOES
BRINE SHRIMP
STRUCTURES
WHERE IS THE MOON?

[5] ESS staff has spent considerable time and money on this problem and has succeeded in rearing the "carrot" butterfly, but commercial production has not been worked out. *ESS Newsletter*, No. 11.

ANIMAL BOOK
LIGHT AND SHADOWS
CHANGES
MAPPING
MATCH AND MEASURE
MUSICAL INSTRUMENT RECIPE BOOK
CLAY BOATS
STARTING FROM SEEDS
LIFE OF BEANS AND PEAS
BUTTERFLIES
DAYTIME ASTRONOMY
TRACKS
PEAS AND PARTICLES
MOBILES

A third category of units is designed for individual or small group work. These units lend themselves well to meeting individual needs and interests of different children. The design of these units demand an informal and flexible classroom organization where individuals or groups of students can work at different units at the same time. Working with these units can, in an organizational sense, be thought of as project work. Units in this category are listed below:

ATTRIBUTE GAMES AND PROBLEMS
GEO BLOCKS
PATTERN BLOCKS
TANGRAMS
SAND
ANIMAL ACTIVITY
BATTERIES AND BULBS II
SPINNING TABLES
MIRROR CARDS
BALANCE BOOK
MOBILES
PRINTING PRESS
DROPS, STREAMS, AND CONTAINERS

All ESS units have gone through trial stages during the course of their development. One of the reasons for testing the materials is to determine the grade levels at which the units are most appropriate. Frequently, in trial classrooms a unit is found to work well with children in several grades. For example, *Batteries and Bulbs* has been used successfully with grades four, five, and six. The unit *Changes* has been used with children K-4. Perhaps the unstructured nature of the ESS program accounts for the appropriateness of the materials for children in different stages of intellectual development. While one child explores the materials in one direction, another child explores the same phenomenon in another direction and at a different level of understanding. Children work at their own level and pace.

From its inception one of the requisites established for ESS materials was that they should be inexpensive (8). This requisite has been met with the materials of many but not all units. For the unit *Growing Seeds*, for example, the cost of materials, including teacher's guide, for a class of 30 children comes to only $16.50. On the other hand the cost of materials, excluding films, for *Small Things* amounts to $171. It is worth noting that much of the equipment for the more expensive units can be used with other science topics. Moreover, with some effort a teacher, or school, can develop a basic supply of equipment that could be used with a number of units, and which would preclude the necessity of purchasing packaged equipment whenever a new unit is introduced to the classroom.[6] Furthermore, when ordering from the publisher, it is not necessary that one order the whole packaged kit. The components of a kit are itemized in the publisher's catalog.

It has been roughly estimated that a government-supported program, such as ESS, will cost at least three times as much to *introduce* in an elementary school as it does to introduce a traditional program that is essentially textbook centered (4). (No estimations have been made on cost comparison over the long run.) But a school or teacher need not make a commitment to the whole ESS program. If one had to be extremely cost-conscious, the less expensive, yet successful units such as *Behavior of Mealworms, Peas and Particles, Crayfish, Starting from Seeds, Mirror Cards, and Changes* could be utilized at minimal cost.

Use of Materials

According to the *Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments* (25) over 7,500 teachers and 225,000 children were using ESS materials as of January, 1968. These estimates were arrived at by using sales figures received from McGraw-Hill Book Company, the chief commercial distributor of ESS materials. In a recent communication to the writers, ESS stated that approximately 40,000 teachers used ESS materials during the school year 1968-69. The ESS staff further predicts that approximately 53,000 teachers and 1,300,000 children will be using ESS materials during the school year 1969-70. All these figures were calculated from commercial sales information and from trial editions distributed by ESS. The numbers for children are calculated on the basis of 25 children per class.

There are a number of school systems throughout the country that use ESS materials almost exclusively for their science program. However, the largest number of schools using ESS materials use them with a few teachers who are by "disposition and inclination" attracted to the ESS approach.

ESS materials are also being used in some foreign countries. The Republic of South Korea and the province of British Columbia have adopted ESS materials and mandated their use throughout their respective elementary schools. ESS has worked with Peace Corps trainees who later adapted the materials for use in places such as Ethiopia, the Philippines, and Colombia, South America. Some of the units developed by the African Primary Science Program (an EDC project) are adapted versions of ESS units.

ESS materials are also used in preservice methods courses and inservice workshops for elementary teachers. This appears to be done for one or both of the following reasons: In the first place, course instructors

[6] The Elementary Science Advisory Center at the University of Colorado in Boulder has prepared a booklet entitled *Science Equipment in the Elementary School* that may offer considerable assistance to those who wish to establish a basic supply of science equipment in their school.

and workshop leaders consider it important that elementary teachers become acquainted with some of the new elementary science projects, such as ESS. Secondly, ESS materials provide a vehicle for conveying concepts of teaching (e.g. children learn science from their own exploration of concrete materials) central to science education today.

Implementation and Teacher Programs

For a number of years ESS has held workshops for a variety of educational personnel, including teachers, supervisors, consultants, team-teaching leaders, master teachers, school administrators, and personnel from colleges and universities. The duration of these workshops varies considerably, from a day for school administrators to six weeks for college students.

A significant part of the ESS implementation program is conducting workshops at Newton to prepare participants for leadership positions in regional workshops. In this workshop program, the participants usually spend about four weeks at Newton before going out to conduct regional workshops for teachers and to assist schools within the region in the implementation process. During the summer of 1968, 32 educators attended the workshop at Newton. After the Newton workshop, these 32 implementation specialists conducted six regional workshops,[7] which involved a total of 283 teachers and administrators.

It is interesting to note that the Newton workshop included a four-day intensive sensitivity training session involving workshop staff and participants. As used in education, sensitivity training refers to a range of laboratory and workshop efforts that are designed to help teachers reconceive their role in working with children. Cultivation of the heightened awareness of children as growing, self-actualizing (fulfilling one's potentialites) individuals is the focus of such training. Sensitivity training has received much of its impetus from the work of perceptual psychologists such as Combs (6), Kelly (16), Rogers (23), and Maslow (17). It is the contention of ESS that viewing children as growing, self-actualizing individuals is consonant with its approach to children's learning science. At the end of the Newton workshop, many participants indicated that the sensitivity training had caused them to "change their procedures" during the workshop. Two of the regional teams also included sensitivity training in their area workshops.

Another important aspect of both the Newton and regional workshops is the opportunity for participants to teach with ESS materials and methods by working with small groups of children. ESS imposes two conditions of participation upon each school district that sends a teacher to the regional workshops. These conditions are: (1) the district must commit $400 to the teacher for the purpose of purchasing materials, and (2) the teacher must be released at least part time during the school year to work with teachers in his district. ESS feels that these conditions are essential in order that each school district benefit fully from the teacher's workshop experience.

[7] Regional centers were: Rochester, N.Y.; Philadelphia, Pa.; Minneapolis, Minn.; Long Island, N.Y.; Waco, Texas.

During the summer of 1969, ESS conducted a second Summer Implementation Workshop involving 40 participants, who in turn conducted regional workshops.

Although ESS has directed its major thrust at inservice education, it is beginning to move more toward preservice education. It has, for example, made an arrangement with Wheelock College [8] (Boston) whereby some 30 freshmen students spend their six-week winter term half-time at ESS.

Through its workshops and preservice programs, ESS is actively involved in numerous teacher education activities. Furthermore, it is not merely concerned with preparing teachers to teach ESS materials. It is equally concerned with the important task of informing and acquainting supportive personnel (principals, supervisors, college instructors, and so on) with the ESS materials and ESS approach to educating children.

Evaluation

ESS is first and foremost an organization that exists for the purpose of developing instructional materials. It is very much concerned with making sure that the materials developed are in fact appropriate for children's science learning and that the materials are being used as they were intended. Hence, a great deal of attention is given to the development process and to teacher programs.

ESS is, of course, concerned with evaluating children's learning. But the kinds of learning outcomes—interests, motivation, curiosity, attitudes, inquiry skills—it considers important are indeed difficult to measure. Some attempts have been made to assess the impact of ESS materials on children by tape-recording their responses to questions about provocative film loops they had just viewed. The purpose of the assessment was to see if children who had been exposed to ESS materials differed from non-exposed children (control group) in their pattern of response. The results were inconclusive.

ESS contends that while objective, quantified testing is one way to evaluate learning outcomes, the subjective impressions of teachers and administrators are also valid forms of assessment. According to ESS, the feedback gathered from teachers and administrators indicates that children who use ESS materials "like science, ask more questions, ask more perceptive questions, are more observant about things outside of school, and actively initiate projects" (22).

One of the most satisfying experiences ESS has had has been with the children involved in its Cardozo Project [9] in Washington, D. C.'s ghetto area. ESS reports that many of the Cardozo children who are "nonverbal" and generally unsuccessful in school have begun

[8] Wheelock is a private college for women that is devoted entirely to the preparation of elementary school teachers.

[9] See Mary Lee Sherburne, *A Peach Tree Grown on T Street*, EDC, 1967, for an informative account of the Project.

to read better and perform better in many of their school tasks (25). ESS attributes this improvement to the change in the child's view of himself; he has a healthier self-image, which gives him a greater sense of his own potential and power, not only with science but with other areas as well. If indeed this is a correct interpretation of this phenomenon, educators would do well to take a very close look at ESS materials, for a number of studies, including the Coleman Report (5), have found the state of a child's self-concept to be a variable significantly related to achievement.

The Role of the Teacher

To teach ESS materials as intended demands a certain view of teaching, of the learner, and of the learning process. The teacher's role in an ESS classroom is one of consultant, guide, and catalyst. The teacher advises, listens, diagnoses, and in Hawkins' terms, acts as an external loop, doing things for the child that he cannot do for himself (9). For this reason, the teacher must see the child as having an extraordinary capacity for learning and believe that he learns best from his own activity. Teachers who already have this view of teaching, learning, and children are well suited to use ESS materials in their classroom, while others who do not share it might be persuaded to reconceive their role as teachers through sensitivity training, workshops, and reading.

Besides conceptualizing this role, the teacher needs to know how to operationalize it. He needs to see what an ESS type classroom looks like: how the teacher attends to the details of classroom management, the mechanics of distributing and storing materials, and how the teacher works with a whole class, small groups, and individual children. Participating in an ESS workshop, viewing ESS teaching films, observing existing ESS classes, reading or viewing documentation [10] of how some teachers have developed their own style in teaching ESS materials are all ways of learning how to operationalize ESS concepts of teaching.

It is very difficult for an isolated teacher to go it alone in an innovative endeavor, irrespective of his commitment to the innovation. He needs the continued philosophical and material support of his superintendent, principal, and supervisor, as well as the good will of his teaching colleagues. Real and lasting curriculum change comes only when it proceeds on a broad front and when personnel at all levels are actively committed to the same goals.

Summary Statement

ESS has so far directed its major efforts at developing instructional materials, acquainting an assortment of educational personnel with the materials, and preparing teachers to use them. ESS has not proceeded in its development of instructional materials within the framework of a particular philosophy of education. Implicit in its approach to developing materials is a concern for the *development of the whole child.* ESS emphases—active involvement, freedom to pursue one's interests, imagination, individually—are aimed at developing self-directing, autonomous, and self-actualizing individuals. The materials include a great deal that is related to learning science concepts and developing intellectual skills. Intuitive as well as analytical thinking are cultivated. Thus, the cognitive domain is served well.

In the area of the psychomotor domain, ESS's emphasis upon children's manipulating concrete materials helps develop motor skills. But ESS's greatest strength is, perhaps, its contribution to the effective development of children. Children derive satisfaction from exploring, in their own individual ways, interesting materials, finding not only answers and solutions but also that they have the ability to learn for themselves. Perhaps, too, children who find satisfaction in exploring will in time come to value and commit themselves to it.

[10] *An Interview with Dorothy Welch* (EDC, 1969) is one such documentation.

References Cited

1. Berlyne, David. "Conflict and Arousal." **Scientific American.** August 1966.
2. Brown, Randolph. "Elementary Science Study." **Education Development Center Annual Report 1968.** Newton, Massachusetts. 1968.
3. Bruner, Jerome S. **Toward A Theory of Instruction.** W. W. Norton & Company, New York City, 1968.
4. Butts, David P. "The Price of Change." **Science and Children.** April 1969.
5. Coleman, James S., et al. **Equality of Educational Opportunity.** U.S. Government Printing Office, Washington, D. C. 1966.
6. Combs, Arthur W. "A Perceptual View of the Adequate Personality." **Perceiving, Behaving, Becoming.** Association for Supervision and Curriculum Development, Washington, D. C. Yearbook, 1962.
7. Dewey, John. **Democracy in Education.** The Macmillan Company, New York City. 1916.
8. Duckworth, Eleanor. "The Elementary Science Study Branch of Educational Services Incorporated." **Journal of Research in Science Teaching.** September 1964.
9. Hawkins, David. "I, Thou, It." Elementary Science Study. Newton, Massachusetts. 1967.
10. Hawkins, David. "Messing About in Science." **Science and Children.** February 1965.
11. Hein, George E. "Children's Science is Another Culture." **Technology Review.** December 1968.
12. Holt, John. **How Children Learn.** Pitman Publishing Corporation, New York City. 1967.
13. Hull, William. Quoted in **The Prepared Environment** by Margaret Howard Loeffler. Casady School, Oklahoma City. 1967.
14. Hunt, J. McV. **Intelligence and Experience.** Ronald Press, New York City. 1961.
15. Isaacs, Susan. **Intellectual Growth in Young Children.** Shocken Books, New York City. 1966.
16. Kelly, Earl C. "The Fully Functioning Self." **Perceiving, Behaving, Becoming.** Association for Supervision and Curriculum Development, Washington, D. C. Yearbook, 1962.
17. Maslow, Abraham H. "Some Basic Propositions of a Growth and Self-actualizing Psychology." **Perceiving, Behaving, Becoming.** Association for Supervision and Curriculum Development, Washington, D. C. Yearbook, 1962.
18. Morrison, Philip, and Charles Walcott. "Enlightened Opportunism: An Informal Account of the Elementary Science Summer Study of 1962." **Journal of Research in Science Teaching.** March 1963.
19. Morrison, Philip. "Experimenters in the Schoolroom." **ESI Quarterly Report.** Winter-Spring 1964.

20. Morrison, Philip. "The Curriculum Triangle and Its Style." **ESI Quarterly Report.** Summer-Fall 1964.
21. Piaget, Jean. "Development and Learning." **Journal of Research in Science Teaching.** September 1964.
22. Personal Communication from ESS. June 23, 1969.
23. Rogers, Carl R. "Toward Becoming a Fully Functioning Person." **Perceiving, Behaving, Becoming.** Association for Supervision and Curriculum Development, Washington, D. C. Yearbook, 1962.
24. Sears, Robert. "Process Pleasure," in **Learning About Learning,** ed. Jerome S. Bruner. U.S. Government Printing Office, Washington, D. C. 1966.
25. **Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments.** Under the editorship of J. David Lockard. Science Teaching Center, University of Maryland, College Park. 1968.

Other References

Education Development Center. "An Interview with Dorothy Welch." Newton, Massachusetts. 1969.

Elementary Science Advisory Center. "Science Equipment in the Elementary School." University of Colorado. 1967.

Elgammal, Attia. "Elementary Science Study at Macomb County: Students' and Teachers' Reaction." Macomb Intermediate School District, Mount Clemens, Michigan. 1969.

Finley, Gilbert. "The Elementary Science Study." **Elementary School Science Bulletin.** February 1963.

Hartley, Mary Lou. "Evaluation and Reflection after Attending the Elementary Science Study Summer School." **ESI Quarterly Report.** Winter-Spring 1964.

Hawkins, David. "ESI Elementary Science Activities Project." **Science Education.** February 1964.

Hawkins, David. "Laboratory Science in Elementary Schools." **American Journal of Physics,** November 1964.

Hawkins, David. "The Informed Vision: An Essay on Science Education." **Daedalus.** Summer 1965.

Hawkins, David. "The Stuff from Which Questions Are Shaped." **Nature and Science** (Teacher's Edition), April 17, 1964.

Leodas, C. J. "The Elementary Science Study." **ESI Quarterly Report.** Winter-Spring 1964.

Moss, Penrod. "An Elementary Science Study Report from California." **ESI Quarterly Report.** Winter-Spring 1964.

Nichols, Benjamin. "Elementary Science Study—Two Years Later." **Journal of Research in Science Teaching.** December 1964.

Walcott, Charles. "Elementary Science Study." **Science Education News,** AAAS Miscellaneous Publication. December 1962.

Webster, David. "How To Help Children Make Mistakes." **Science and Children.** May 1964.

Webster, David. "Making a Chicken Skeleton." **Nature and Science.** May 1964.

Zacharias, Jerrold R. "Learning By Teaching." **Instructor.** January 1966.

Zacharias, Jerrold R. "What's Ahead in Elementary Science." **Instructor.** January 1967.

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