ESCP: a Project in Transition

By WILLIAM D. ROMEY

The Earth Science Curriculum Project (ESCP) is one of the group of curriculum reform projects initiated with the support of the National Science Foundation during the 1960s—the decade of the big curriculum projects. Work on ESCP began in 1963 under the sponsorship of the American Geological Institute. The major objective of the project was said to be, broadly, the improvement of earth science education in the secondary schools.

Development of the Program

Need for a revision was clear. The number of students taking earth science in junior high school was increasing at a tremendous rate: from a few thousands in 1945 to a quarter of a million in 1963. Curricular materials available by 1958 included a small number of textbooks written primarily by secondary school teachers and requiring little more than rote learning of definitions. Classroom practice reflected the questions included in these books. The approach used almost universally involved lecturing, vocabulary drill, and multiple-choice tests. The model of learning in most classrooms was a didactic one (see fig. 1) characterized by a flow of information from teacher to pupil and by minimal student involvement.

In 1958 a small group of geologists, astronomers, meteorologists, oceanographers, geographers, and soil scientists assembled in Duluth, Minn., to prepare a *Geology and Earth Sciences Sourcebook* for teachers. From the Duluth conference came the inspiration for ESCP and the nucleus of writers who were to prepare the new curriculum. In the summer of 1963 the first planning conference was held; it led to hundreds of pages of outlines for prospective chapters in the book eventually called *Investigating the Earth.* During this conference a series of themes was chosen as a basis for the course. The three "behavioral themes" were science as inquiry; comprehension of scale; and prediction. Six "conceptual themes" were universality of change; flow of energy in the universe; adjustment to environmental change; conservation of mass and energy in the universe; earth systems in time and space; and uniformity of process: a key to interpreting the past. A further theme, historical development and presentation, was included to emphasize major discoveries, the people behind them, and the role of human intuition and chance in formulating explanations of earth configurations and phenomena.

In the summers of 1964, 1965, and 1966 major writing conferences were held in Boulder, Colo. For parts of this time ESCP writers shared the same building with BSCS summer staff and used the BSCS art staff. (Close contacts have been maintained between the full-time BSCS and ESCP staffs since the beginning of the earth science curriculum revision.) A total of 67 writers were involved: 17 geologists, 18 secondary school teachers, 6 oceanographers, 6 meteorologists, 6 geographers, 4 astronomers, 3 geophysicists, 3 science educators, 2 soil scientists, 1 geochemist, and 1 science writer. The reason for the blend of disciplines was to produce as nearly as possible a truly interdisciplinary course intended for ninth graders.

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This team achieved a considerable measure of success in avoiding mere juxtaposing of materials from the various disciplines: subject areas are well interwoven in many parts of the ESCP book. But because of the large number of authors, *Investigating the Earth* shares a common ailment of programs produced under NSF support during the 1960's: it gives the impression of having been produced by a committee.

Recognizing that a program developed primarily by a group of university scientists might not have achieved the right level for ninth graders (in spite of the efforts of the 18 secondary school teachers who aided in the writing and reviewed all manuscripts through a special "teacher's panel"), the project staff subjected the program to extensive field testing. During the 1964-65 academic year 75 teachers and about 7,500 students in 15 test centers helped evaluate the program, and this invaluable classroom feedback served as the basis for the extensive revision made during the summer of 1965. A second year of testing, 1965-66, involved about the same numbers of teachers and students and provided feedback on the 1965 revision. Many teachers outside of the official testing program also tried the program, and some sent in revision suggestions. Each test center included a college consultant who met weekly with five teachers to discuss problems and programs and to go over laboratory exercises scheduled for the coming week. Many of the centers suggested ideas for new investigations and for deletions, additions, and modifications. One of the most important aspects of the test centers was that they provided much-needed training of key teachers in the test areas and served as models for in-service programs that followed. The centers also planted the seeds of a major earth science teacher-preparation project, which is now developing.

The writing conference of the summer of 1966 was devoted to preparation of final copy for commercial publication of *Investigating the Earth* and its two-volume teacher's guide in 1967. Other publications and supporting materials produced by ESCP have included a series of reference pamphlets (*The ESCP Reference Series*) available from the American Geological Institute, several films, equipment packages to accompany the textbooks, the single-topic *ESCP Pamphlet Series* (to appear in January 1971), and a series of staff publications. A quarterly newsletter (free) and further information about these materials can be obtained from ESCP, P.O. Box 1559, Boulder, Colo. 80302. The basic program was being used during 1969-70 by over 300,000 students. Over 13,000 copies of the teacher's guide have been distributed—an indication many teachers who are not actually using *Investigating the Earth* are nevertheless familiar with the program. Many of these teachers have undoubtedly been affected by the ESCP program and have used some ESCP teaching ideas.

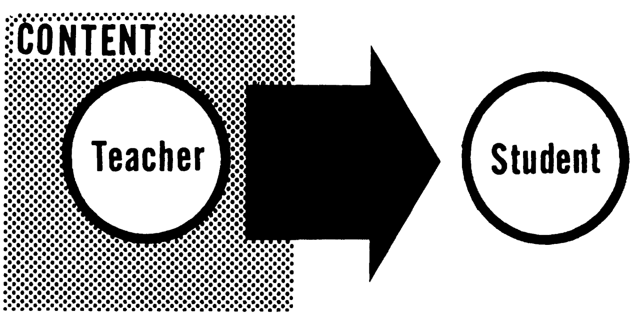

Fig 1: didactic model of teaching. Predetermined content is directed at the student. The teacher's responsibility is to be trained in content background. The student is a recipient of information. The teacher's role is to convey the predetermined content to the student. Importance is placed on Information.

Nature of the Program

One of the main goals of curriculum projects during the 1960s was to move away from the didactic model of teaching described earlier and pictured in fig. 1. Implicit in this model was the idea that everything worth knowing could be told by teachers and could be learned through listening. Scientists who wrote for the curriculum projects felt that students should become involved in the processes of science, and this gave rise to the phrase "process approach." ESCP went along philosophically with BSCS and the various physical science programs in working toward what was called directed discovery. Teachers, to use ESCP materials as intended, had to become managers rather than information dispensers. A model showing how the teacher was expected to behave with respect to his students in a process approach is shown in fig. 2—a "managerial" model.

In ESCP and the other major curriculum-revision programs the stress is on acquisition of behaviors. The rationale for this shift is that if students are involved on a psychomotor level—*doing* things the teacher has told them to do—they will retain the skills they practice and will also show greater cognitive gain than in a didactic situation, by virtue of using several of their senses at the same time. Thus each chapter of *Investigating the Earth* is written around a series of behavioral objectives. These state more or less explicitly what behavior students should be able to demonstrate when they have finished performing certain investigations and discussing certain questions. An interesting innovation in *Investigating the Earth* is that the approximately 50 investigations in the book are written into the text in such a manner that they *must* be done in order for succeeding parts of the chapter to make sense. Many of the problems to be investigated are stated only briefly—requiring students to set up their own experimental designs and allowing them to modify the problem to a greater or lesser degree. The more successful ESCP teachers do little or no lecturing and may have their students spend half or more of their class time doing investigations.

The ESCP teacher's guide emphasizes the importance of the structure of the chapters and investigations and suggests that the course be presented without rearrangement. A sample 180-day schedule shows teachers when they should be doing what, if they want to "cover" the course; furthermore, each chapter contains a suggested day-by-day schedule, or lesson plan, on how to cover the chapter. Included in the schedule and in the detailed instructions for setting up investigations and leading students in the direction of hoped-for discoveries are suggestions as to how many minutes to devote to pre-lab discussion, how long to let students work, how to help them, when to let them flounder, how to break off the laboratory work, how much time to give to post-lab discussion, and even what leading questions to ask.

Most of the more successful ESCP teachers have been able to develop flexibility within this rigid schedule and have not hesitated to depart from both the subject-matter organization and time requirements outlined in the teacher's guide. Nonetheless, much of the teacher-training effort and the very rigidity of the schedule compel even most "good ESCP teachers" to behave as strict managers and efficiency experts. Students do have the advantage of knowing what is expected of them, but they are managed so much of the time that they have few opportunities to make significant decisions, little time to learn from mistakes, and few opportunities to fail. Within the framework of investigations and discussions they have the opportunity to make many lower-level decisions; but even here they commonly are too much hurried to think through *what* they are doing, *how* they are doing it, and *why* they should be doing it—all three being essential factors in efficient and careful decision-making.

ESCP in Relation to Biology

Most of the more than one million students currently taking earth science in the U.S. do so in the eighth or ninth grade. Of these, probably at least one-quarter have either used *Investigating the Earth* or have been affected by ESCP through their teachers' knowledge of the program and its goals. Probably most of these students go on to take biology. What can biology teachers expect from these students?

There are three main characteristics of students that will be important for a high school biology

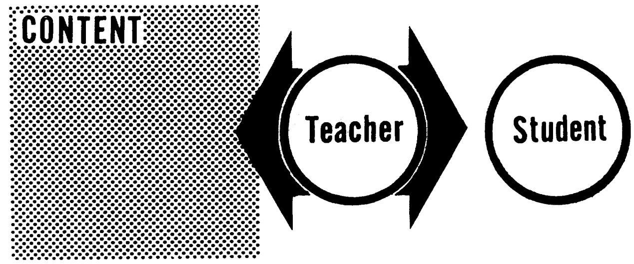

Fig. 2: managerial model of teaching. This approach focuses on the behavioral interaction between the student and predetermined content (commonly emphasizing concepts). The teacher's role is to focus on the behavioral interaction. The student is actively involved with investigating the curricular content.

teacher to look for and to consider in his relationships with students from ESCP classes: behavior, general knowledge, and attitude. Although generalizations are difficult to make because of the overriding effects of the particular teacher-student relationships that existed in a particular ESCP classroom, the program itself might produce at least certain expectations if the teacher had followed the general rules stated in the teacher's guide.

Students from ESCP classes should be used to handling laboratory equipment of many different kinds. They should be able to take problems stated in relatively general terms and plan investigations designed to solve these problems. They should be fairly competent in making systematic observations. They should be able to record quantitative data in a systematic way, graph their data, and make at least low-level generalizations that are compatible with the data. Ability to set up their own systems of classification and to use existing systems should be a normal outcome of a good ESCP course. Students ought to be used to working in small groups or alone on problems and will probably be fairly businesslike in their approach to laboratory work. They will be used to writing detailed laboratory reports. In classroom discussions they should be unwilling to accept authority without justification and supporting data. A device widely used in the BSCS program has been used in ESCP also: the invitation to inquiry. Students from ESCP should function well in this kind of discussion.

ESCP students who have "covered" the course may have gained general knowledge that will be useful to them in biology. They will have had some exposure to the following subjects, among others: processes of change through time in both living and nonliving things; the interface concept; problems of vegetation and soil conservation; structure of water; simplified information on atoms and molecules; abundance of various elements in nature; the earth's seasons; relationship of solar radiation to life; effects of the atmosphere on solar radiation and on life; temperature fields in relation to life; wind

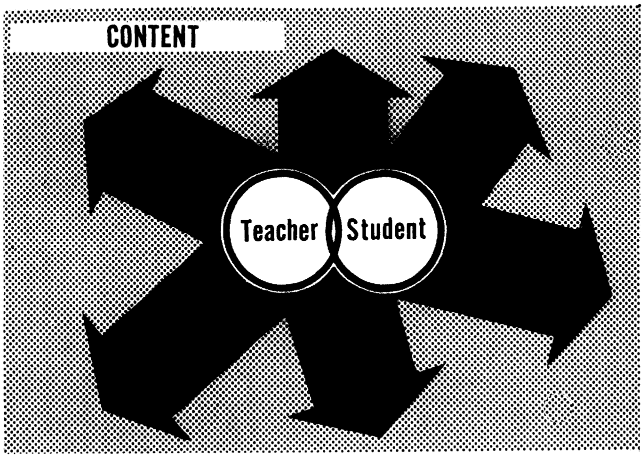

Fig. 3: intrinsic motivation model. The teacher's role is to work as a research coordinator for investigations chosen entirely or largely by the student. The student determines and investigates the content as it occurs in the learning environment that is available.

and water current circulation patterns; physical and biologic factors involved in the water cycle; plants and their effects on movement of water through soil; transpiration by plants; photosynthesis; vegetation and the water budget; chemistry of the oceans; climatic patterns and their effects on vegetation and life; chemical and physical effects of plants in weathering; evolution of soils and effects of plants; contributions by marine life to oceanic sediments; marine organisms; fossils as indicators of ancient conditions (paleoecology); formation of fossils; development of coral reefs; migration of elements through cycles of incorporation in living things, water, air, and rock; use of biologic features (tree rings, growth lines of shells) for estimating duration of time; dating of biologic materials by C^{14} methods; fossils as indicators of geologic time; the fossil record; the theory of evolution; zones where life exists; life and energy; interaction of organisms and chemical cycles; variation in populations of fossil organisms; and evidence in the rock record for natural selection. Eighteen of the 26 chapters in *Investigating the Earth* contain some biologic references and information. The sections on the oceans and on paleontology contain much biology. From a pure subject-matter point of view, biology teachers would be well advised to look through secondary school earth science books and investigations, especially those in the ESCP program, so that they can use these materials as building blocks rather than repeating what has been done already. ESCP and BSCS made no conscious efforts to integrate their materials, but a measure of integration has occurred spontaneously.

The attitudes of students who have had an ESCP course will depend to a large extent on the teacher. Teachers who have forced their students to cover the entire package may have developed "science-haters" because the dose was simply too large and too strong. In general, students who have been through our investigatively oriented package may be expected to like science better than students who have had a didactic approach, but both didactic and managerial types of courses are based upon a coercive pedagogy in which the teacher specifies all or most of the class activities. Substituting an emphasis on externally specified behavioral goals for an emphasis on externally specified factual information is probably an improvement. Students from a well-taught, investigatively based ESCP course probably will be more interested in science than will students from didactically oriented classes—but, of course, the teacher variable will be paramount.

Where Do We Go from Here?

The ESCP staff and many of the successful teachers we have identified feel strongly the need for improved teacher preparation along new lines. Having made the transition from didacticism to a managerial approach, we are seeking ways of stimulating a truly intrinsic motivation in students. From our observations and experience one thing is clear: we cannot expect students to find our materials intrinsically interesting if teachers impose a rigid structure in their classrooms. This indicates the following:

1. Teachers must be trained to take our program apart, rather than to go through it chapter by chapter. The rigid schedules we originally proposed are neither realistic nor pedagogically sound, in that they stress maximum coverage of externally imposed subjects rather than the intellectual growth of students.

2. Teachers must be willing to drop many parts of the program altogether. Different teachers should drop different parts for different students.

3. Teachers must be trained to allow individual students to make significant decisions about what is to be studied.

4. We must encourage teachers to be less concerned about maintaining artificial constraints and more concerned about their students as human beings.

In short, the ESCP staff would like to see *Investigating the Earth* considered henceforth as a resource for an earth science course, rather than as a unique program around which to structure a whole course.

A third model of teaching-learning relationships is emerging in science education. This might be called an intrinsic motivation model (fig 3). It recalls many of the ideas first proposed actively by John Dewey. The term intrinsic is used with reference to the student. In this model, students are allowed to decide for themselves which aspects of earth science they wish to study and to pursue them within the constraints imposed by the learning environment the school system and teachers can provide. Fortunately, one aspect of the learning environment available at very low cost for study of earth science has almost unlimited possibilities: the natural environment outside of the schoolroom. When a teacher is trained to tolerate in his classroom the freedom implicit in an intrinsic model he also has a good chance of establishing an environment of trust. This will even enable him to revert to didactic and managerial styles of teaching for short periods of time in order to "cover" an occasional concept that he feels needs exposure. Students will accept and probably will profit from this kind of intrusion by their teacher when they respect him sufficiently for his willingness to listen to *them* most of the time.

In order to implement this third model, the ESCP program as it now exists must simply be another element of the environment that teachers make available to their students. Such things as specific reading assignments, assigned questions, or having all of the students do a given investigation at the same time are out. It is still probably fair, occasionally, to choose some of the broader investigations in *Investigating the Earth* and convert them to sufficiently ambiguous assignments so that great divergence in student behaviors can be stimulated; but the teacher must be very sensitive to the difference between coercion and stimulation.

Recognizing the need to migrate from the level of a rigid, prescribed curriculum to a program that aims at an intrinsic model of learning, the ESCP staff has recently been funded for two major new projects: the Earth Science Teacher Preparation Project (ESTPP) and the Environmental Studies project (ES). Together, these make up the new Earth Science Educational Program (ESEP) of the American Geological Institute.

The goal of ESTPP is to make a comprehensive attack on the rigid qualities characteristic of teacher-preparation programs—qualities that are carried into secondary and elementary school classrooms by newly certified teachers. One of the primary targets is the college program for pre-service teacher education. It is not sufficient to change the education methods courses and educational psychology courses alone; even more important is the need to introduce into college science courses the same kind of intrinsic learning model we wish to see carried to the secondary and elementary schools. Teachers who have lived it will use it. The academic establishment may seem at first glance a tough nut to crack, but we have been gratified to learn about numerous attempts to open up the college classroom and to allow students to make more and more significant choices within the curriculum and, most important, within individual courses. The staff of ESTPP will hold a series of workshops for university faculty members who are ready to change and for teaching assistants—tomorrow's faculty members. Innovative programs will be encouraged and supported, and detailed information on these programs will be widely disseminated.

ESTPP also plans extensive efforts in the direction of encouraging and stimulating suitable changes in in-service, summer, and academic-year programs for teachers and school administrators. Workshops will stress the role of the teacher as a resource person and will aim at helping teachers become more sensitive to their students as people to be supported in their learning endeavor rather than as receptacles to be filled or machines to be programmed.

ES is a combined curriculum and teacher-preparation program aimed at urban students. Staff members and participating teachers are creating ways of helping to stimulate urban children to study their environment. Ambiguous assignments, such as "Go out and photograph evidence of change" and "Go out and make a photographic map of the neighborhood," invite widely divergent kinds of student activities. The interdisciplinary implications of this approach are clear, and we can expect biologic and ecologic aspects of the environment to attract as many students as do physical aspects of the environment. Preliminary materials for ES were developed under the ESCP Laboratory Blocks program. The new project is in full swing at the present time, with testing and development activities proceeding in 11 test centers in U.S. cities.

Implications for Biology Teachers

Given even modest success in the new endeavors, high school and university biology teachers can expect to find a radically different kind of student arriving in their classes—a student who has experienced true inquiry and worked in an environment that stimulates creative activity, but a student who may not have "covered" the traditional subjects. The challenge to you, the biology teacher, is this: are you prepared to continue the free environment leading to relevant, intrinsically based learning or will you again erect the walls of extrinsically determined objectives? Will your students be allowed to make their own decisions or will you reduce them again to playing *your* game? We feel that the intrinsic model we have proposed will come much closer than ever before to producing self-motivated, independent learning.

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