A Comparison of Biologic Content in Three Elementary-School Science Curriculum Projects: ESS, S-APA, SCIS

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ATTENTION TO elementary-school science education in the United States was first encouraged during the early part of this century, but not until the early 1960s did our profession initiate the first large, concerted effort in this direction (Hurd 1968). Millions of dollars were spent in bringing together outstanding scientists, psychologists, and educators to create several curricula. Today, three prominent curriculum projects have emerged, to influence either directly or indirectly the direction of science education in elementary schools across the country. They are Elementary Science Study (ESS), Science—A Process Approach (S-APA), and Science Curriculum Improvement Study (SCIS).

Needless to say, the products of the past decade are of great significance to biology teachers and science educators at all levels. Those who teach in elementary schools are no doubt very interested in the wealth of activities that relate to biology and how the three programs compare. Secondary teachers who are familiar with elementary-science curricula can not only be more sensitive to the backgrounds of incoming students but can also glean from these programs a multitude of creative ideas central to the teaching of biology. Indeed, some of the most sophisticated and exciting pedagogy found anywhere lies in these three programs. College teachers in biology, likewise, should be familiar with the content and processes of these elementary curricula. Thousands of prospective elementary teachers pass through college biology courses each year. These future teachers develop interests, attitudes, and perceptions that directly influence how they handle biology in their own classrooms. If they learn biology as a static body of facts, from which the memorizing of descriptive terms is rewarded, they probably will remember biology in this fashion. Furthermore, they may find it exceedingly difficult to relate detailed mechanisms, such as the Krebs cycle, to the theory and spirit of their elementary curriculum. They may also find that memorizing the bones and muscles of the human body has little to do with a second-grader getting "turned on" in science. College biology teachers who teach elementary-education majors could significantly improve the appropriateness of their course content by becoming familiar with these three major elementary-science projects.

General Features of the Programs

Table 1 presents a brief comparison of various features of the three programs and their differences. It is important to note that all three programs emphasize (i) discovery of fundamental concepts in science, (ii) development of scientific processes, and (iii) stimulation of interest and curiosity in science. All three programs are activity-based and inquiry-oriented. Comparatively speaking, ESS tends to give highest priority to activities that stimulate interest and curiosity. S-APA can be characterized by its emphasis on process skill development. SCIS contains activities designed to allow for the exploration, invention, and discovery of major concepts in the physical and life sciences while providing evaluational tools for affective and process achievement (Karplus and Thier 1967). Table 1 also includes a brief comparison of instructional strategies, the primary role of the teacher, sequencing, materials available for teachers and students, and an approximate percentage of the program dealing with biologic principles.

Biologic Content of the Programs

Each program contains a wide variety of activities in the biologic sciences. In the following discussion, the programs will be considered in turn.

Elementary Science Study

Table 2 exhibits the 19 topics from the total of 58 that deal with life science in the ESS program.

Table 1. Comparison of major features of ESS, S-APA, and SCIS.

Feature	*ESS*	*S-APA*	*SCIS*
Grade levels	K–9	K–6	1–6
Primary goals	To stimulate scientific curiosity and investigation	To develop scientific skills and processes	Understanding of basic concepts in science
Instructional strategy	Open-ended investigation	Activities designed for development of basic competencies	Exploration, invention, and discovery
Role of teacher	Student-centered (least dominant)	Teacher-centered (most dominant)	Varies with type of activity
Unit sequencing	Independent units (nongraded)	Hierarchically* sequenced by grade and process	Structured by grade levels only
Teacher materials	Teacher guides for each activity	Set of teacher texts and background reading	Teacher guides for each activity
Student materials	Lab materials, occasional worksheets, few readers	Lab materials, few supplementary readers, many worksheets	Lab materials, student exercise and record books
Biologic content	Approximately one-third	Approximately one-fourth†	Approximately one-half

*Revised edition will include more flexibility. †Revised edition will increase biologic content.

The ESS teacher has a considerable choice of units to work with, each year. ESS developers felt that teachers or students in different parts of the country might possess distinct preferences based on interest and availability of local plants and animals. Activities in ESS have been designed to promote curiosity and subsequent investigation of classic problems in biology.

The ESS curriculum attempts to expose children at a young age to the central themes of biology and to provide opportunities for these ideas to grow into meaningful concepts as the students accumulate additional experience. What begins as "messing around" will end up, ESS teachers hope, as self-disciplined probing and creative experimentation. Children are not fed facts to memorize; rather, they are taught to appreciate facts as they relate to a big idea. In one ESS unit, Behavior of Mealworms, children are stimulated to ask questions about the observable behavior of an unfamiliar animal. They ask questions such as these: Can a mealworm see? How do mealworms follow walls? How do they find a pile of bran? In the pupils' attempt to solve these problems, they devise experiments, observe, measure, keep records, design and build equipment, and draw conclusions.

Table 2. Life-science topics in Elementary Science Study (ESS).

Growing seeds (K–3)	Mosquitoes (3–9)
Life of beans and peas (K–4)	Bones (4–6)
Butterflies (K–5)	Small things (4–6)
Eggs and tadpoles (K–6)	Tracks (4–6)
Animals in the classroom (K–9)	Crayfish (4–6)
Brine shrimp (1–4)	Budding twigs (4–6)
Changes (1–4)	Animal activity (4–6)
Pond water (1–7)	Earthworms (4–6)
Starting from seeds (3–7)	Microgardening (4–7)
	Behavior of mealworms (4–8)

The units depicted in table 2 are not equal in length; therefore, determining the percentage of coverage of each topic is difficult. Because some of the physical-science units are lengthy, it may not be accurate to conclude that 34% (19 of 58 units) of ESS deals with the life sciences.

Science—A Process Approach

Of the three programs, S-APA is perhaps the most drastic departure from traditional science. The development of specific competencies and skills are stressed, rather than knowing facts. Instead of studying "birds" or "ecology," students are given tasks in which "observing," "classifying," and "predicting" are the behavioral objectives. Table 3 lists the major processes that students are exposed to in this program. Children will eventually synthesize their own concepts about basic biologic mechanisms; meanwhile, the *method* of gathering the information characterizes this program.

Biologic content is represented in all of the processes listed in table 3. While students learn how to control variables and interpret data, they necessarily are exposed to the primary functions of life. In one S-APA exercise the objectives deal with constructing and demonstrating the use of a simple classification system. To do this the students classify the living and nonliving materials in an aquarium. Although the lesson is labeled Classifying—not "biology"—they nevertheless learn about the plants and animals in this system.

Because it is difficult to assess the exact percentage of activities that deal with life-science concepts, estimates have been made; they range from 18% to 37%. By my interpretation, 50 of the total of 159 exercises examined contained life-science coverage, in part, and could be considered "biology." However, many of these exercises have only one activity, among four or five, that deals with biologic phenomena. Seven additional exercises were open to interpretation as to whether they were "biology" or not.

The American Association for the Advancement of Science has recently prepared a new edition of S-APA. It contains additional modules dealing with biologic content at the ecologic level. Revised modules on pollution and environment will be available in the fall of 1974. In fact, all exercises have been revised into modules, which can now be purchased as single or clustered units. This feature increases greatly the flexibility of S-APA and provides school systems with options toward purchasable material.

Table 3. Life-science topics in Science—A Process Approach (S-APA).

Basic processes (K–3)	*Integrated processes (4–6)*
Observing	Controlling variables
Using space–time relationships	Interpreting data
Using numbers	Defining operationally
Measuring	Formulating hypotheses
Classifying	Experimenting
Communicating	
Predicting	
Inferring	

Science Curriculum Improvement Study

The central theme of the SCIS program is interaction, and development of the concept "ecosystem" represents the major direction of the content. The primary content of SCIS is shown in table 4. Microecosystems in the form of aquaria and terraria are used first, to help students discover interrelationships and interactions. Later, the children's observations and discoveries go beyond classroom models to outdoor ecosystems. Students observe organisms, learn their habits, and discover the unique roles of each species. In the SCIS program, teachers provide children with direct physical contact with the natural world. After the teacher invents key concepts, such as "habitat," "life cycle," and "food chain," students apply these concepts to new situations.

Systems of objects and interactions among objects within systems are emphasized in SCIS units. In one SCIS activity, students record the kinds and numbers of organisms in the vicinity of their school. This exercise serves as an exploratory activity for the "invention" of the population concept. Later, they predict variables that may result in an increase or decrease in the size of a population.

In SCIS, each year builds on the experiences of the previous year. Writers of the SCIS program hope that, by providing the younger student with a tangible biologic framework in which to operate, they will be better able to analyze the more complex and precise processes of life in their secondary-science course.

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Comparison of Content

Both functions and levels of organization where activities within the three programs are found are depicted in table 5. Obviously, many activities do not easily fit into this classification scheme. This is particularly true of S-APA. However, I did solicit confirmation from the curriculum headquarters of the three projects. Table 5 represents a consensus established between the author and each of the three representatives he communicated with. This schema, however, should not be viewed as a final analysis, because any unit of content can be viewed in a variety of ways. Also, some functions (for example, "internal transport") do not fit all levels of organization.

Table 4. Life-science topics in Science Curriculum Improvement Study (SCIS)

Organisms—Level 1		
Organism	Death	Food web
Birth	Habitat	Detritus
Life cycles—Level 2		
Growth	Genetic identity	Plant and animal
Development	Generation	Metamorphosis
Life cycle	Biotic potential	
Populations—Level 3		
Population	Community	Food chain
Predator	Plant-eater	Food web
Prey	Animal-eater	
Environments—Level 4		
Environment	Range	
Environmental factor	Optimum range	
Communities—Level 5		
Producer	Photosynthesis	Food transfer
Consumer	Community	Raw material
Decomposer		
Ecosystems—Level 6		
Ecosystem	Oxygen – carbon dioxide cycle	
Water cycle	Pollutant	
	Food–mineral cycle	

Table 5. Biologic functions and levels of organization covered by ESS, S-APA, and SCIS.

Function	*Cellular level*			*Organismic level*			*Population and community level*		
History and philosophy	ESS				S-APA				
Energetics (respiration and photosynthesis)		S-APA		ESS	S-APA	SCIS		S-APA*	SCIS
Structure and function	ESS	S-APA		ESS	S-APA	SCIS			
Nutrition	ESS			ESS	S-APA	SCIS	ESS	S-APA*	SCIS
Gas exchange				ESS	S-APA	SCIS		S-APA*	SCIS
Internal transport				ESS	S-APA	SCIS			
Regulation of fluids		S-APA			S-APA				
Chemical control					S-APA				
Nervous system				ESS	S-APA				
Skeletal system				ESS	S-APA				
Muscular system (and movement)				ESS	S-APA				
Behavior		S-APA		ESS	S-APA		ESS		SCIS
Reproduction				ESS	S-APA	SCIS	ESS	S-APA*	SCIS
Genetics					S-APA	SCIS		S-APA	
Growth and development		S-APA		ESS	S-APA	SCIS	ESS		SCIS
Evolution									
Interaction (ecologic relationships)			SCIS	ESS	S-APA*	SCIS	ESS	S-APA*	SCIS
Taxonomy			SCIS	ESS	S-APA	SCIS	ESS		SCIS

*Will be in revised edition.

Perhaps the most striking feature of this delineation is the lack of activities designed to represent functions at the cellular level. Maybe this is not surprising, given the influence of psychologists on the writing teams and the functioning level of elementary-school students. Another striking observation is that ESS and S-APA thoroughly cover the organismic functions in life and that SCIS emphasizes ecologic principles. Space does not permit a more specific breakdown, but it is quite obvious that ESS activities focus primarily on functions relating largely to nutritional procurement, structure and function, behavior, reproduction, and growth and development. Activities dealing with animal behavior are particularly sophisticated in ESS. The noticeable emphasis in "content" in S-APA is physiologic. Practically all of the major organismic functions are dealt with, in the course of activities centering on nutrition and energetics, transport systems, behavior, genetics, development, and taxonomy (classification).

In looking at the SCIS activities, it is easy to recognize the unique shift, compared with ESS and S-APA, to living functions at the population and community levels. The SCIS units, moreover, have been expressly designed to lead toward developing an understanding of the final unit, which has to do with principles inherent in "ecosystems." Emphasis on ecologic phenomena consistent with current nationwide interest is missing to some extent in ESS and to a greater extent in S-APA. (The current S-APA revision has sought to remedy this somewhat.)

All three programs deal adequately with the major organismic functions of life. ESS allows students, in an open-ended and unstructured manner, to investigate microorganisms, plants, and animals and to learn, by direct observation, the major happenings in life. S-APA uses biologic phenomena to develop fundamental skills and processes requisite to scientific study. While investigating the basic functions of organisms, elementary students learn to use such processes as observing, measuring, classifying, predicting, controlling variables, and experimenting. Through exploration, invention, and discovery, students in the SCIS program spend approximately half their time pursuing big ideas central to life science, culminating in the discovery of many of the most fundamental concepts in ecology.

Never before has there been such a monumental effort to illuminate the study of life science for consumption by the younger learner. Perhaps never again in our lifetime will we see three programs for elementary students with such sophistication of content and pedagogic design. Secondary-school and college biology teachers should join their elementary-education colleagues in assessing what these programs offer.

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