The Life Science Program of the Science Curriculum Improvement Study

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The author, a biologist from Michigan State University, has had a long history of interest and production in the improvement of the science curriculum. The SCIS project described here is supported by NSF.

The Science Curriculum Improvement Study life science program had its inception in September 1966. At that time the program existed only as an idea or two in the minds of the few of us who were primarily concerned with its development. One of these ideas was that we would teach biology by using living organisms. A second idea was that we would start with whatever ideas the children had concerning life and build from there, using the childrens' own observations as a foundation for the development of biological concepts. A third idea was the assumption that learning involves (1) attention directed to some undifferentiated whole, (2) the differentiation of the whole through the identification of the parts, (3) the invention of a pattern by which the parts are interrelated (this frequently is a cause-effect pattern), (4) testing the invented pattern to see if it applies, and (5) use of the new pattern in other similar instances. A fourth idea was that the concept of the ecosystem would be a useful guide to help us select suitable experiences for the children. Micro-ecosystems in the form of aquaria and terraria could be brought into the classroom. The aquarium or the terrarium would be the whole that could be differentiated into its parts, and by discovering the interrelationships of those parts all of biology could eventually be revealed. The depth of analysis and synthesis of the ecosystem probably would not be very great for the first grader, but for the sixth grader it might be quite respectable, particularly if we extended the children's observations beyond the classroom models of ecosystems to the real ecosystems outdoors.

In developing the life science program we followed the basic strategy employed in developing the physical science portion of the SCIS program. This consisted first of laboratory testing of our proposed material, so that we would have some idea of what would happen in the aquaria and terraria. Second, we brought the materials into a first grade class to see what the reactions of the children would be. On the basis of the children's responses we designed a program, which we tested in other classes.

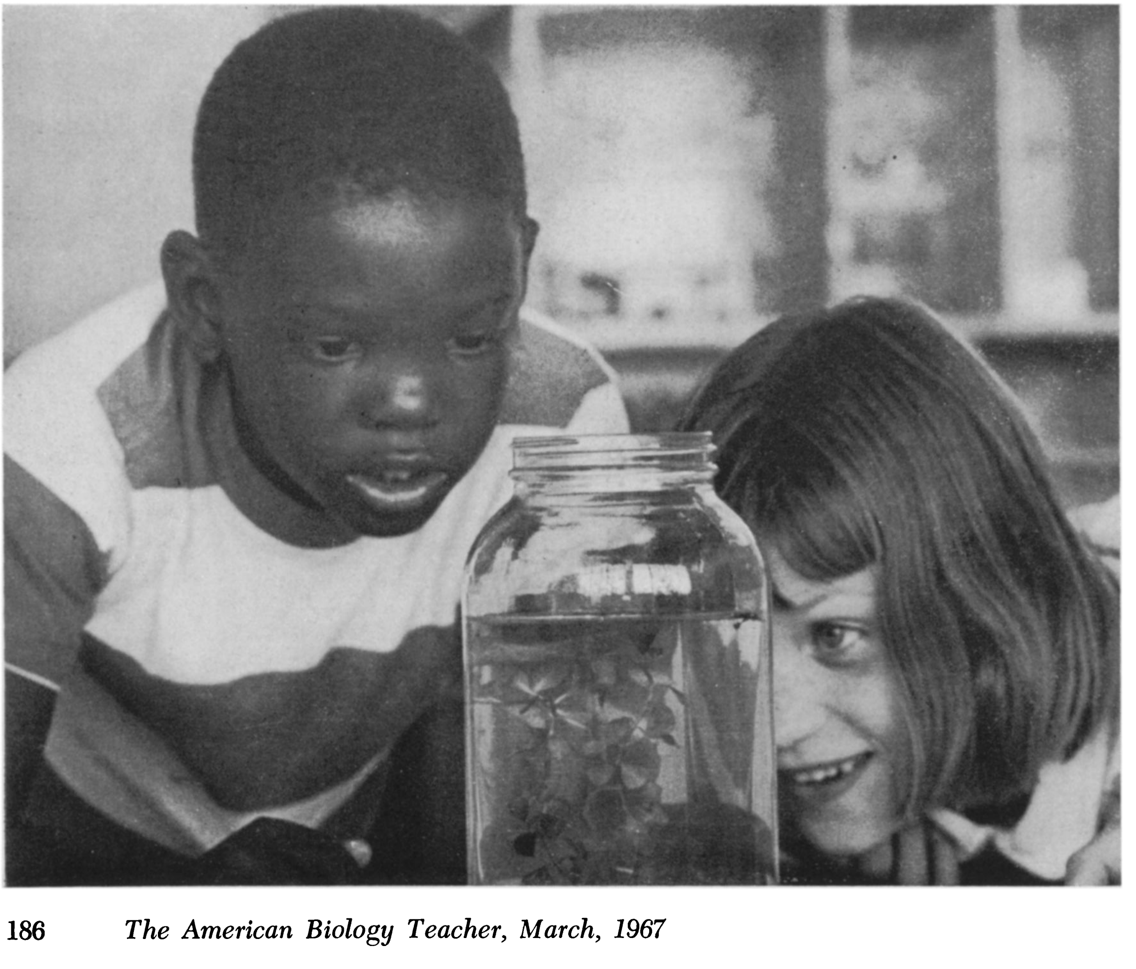
In our initial explorations with first graders we brought six half-gallon jar aquaria into the classroom. Each contained several guppies of both sexes, a few snails, and some aquatic plants. The bottom of each aquarium was covered to a depth of about one inch with fine white sand.

Our initial objectives were modest. We expected that some of the guppies would produce young and that this would permit the children to observe birth. We hoped that the young guppies would grow so that this basic phenomenon of living organisms could be observed. Living things inevitably die; so if this happened another characteristic of life could be demonstrated. Perhaps if the dead organism were left in the aquarium decomposition might be observed and questions could be raised concerning what happens to organisms after death. Movement attracts attention and we thought that by watching the fish and the snails the children might get some idea that organisms are sensitive to factors in their environment and behave in certain ways. To encourage this possibility we planned to have the children take care of feeding the fish so that they could observe feeding behavior.

These, then, were our initial objectives: to have the children observe a few basic life processes upon which we could build more detailed and more comprehensive understandings. But we planned without regard to the children. We didn't, perhaps we couldn't, anticipate the children's reactions to the aquaria. However, we did respond to their reactions and as a result built a far better first grade program than initially we had thought was possible.

The children's first reactions were as anticipated. They clustered about the aquaria, observed the fish, snails, and plants and commented about what they saw. After about fifteen minutes of this the teacher collected the children around her and asked them to report on what they had observed. After a few comments about the fish and the snails one child asked, "What is on the bottom of the aquarium?" We hadn't anticipated this question. It was the first of several surprises that we took advantage of to develop our program.

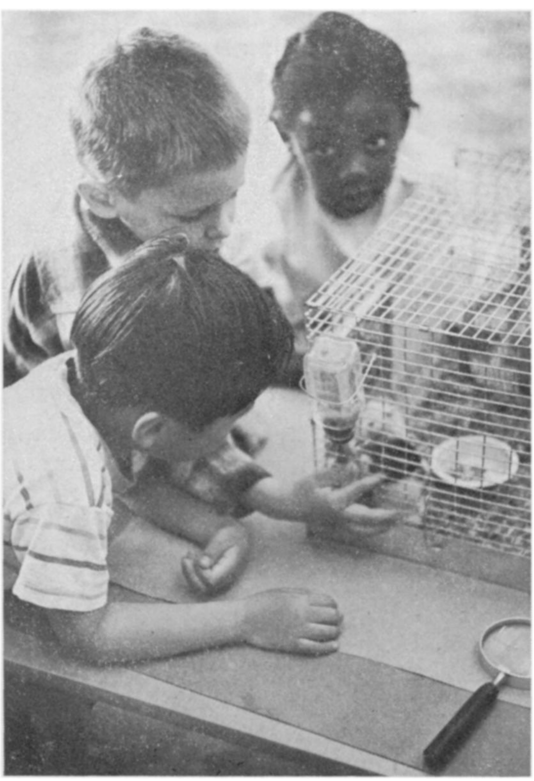
The teacher did not answer the question directly. Instead she asked if any of the other children had any ideas about the identity of the stuff on the bottom of the aquarium. One child did say it was sand, but there were



other ideas including salt, sugar, chopped up glass, and a sponge.

The process of differentiation of the whole, the aquarium, had begun with the recognition of the known parts—the fish, the snails, and the water plants. It now continued with an observable but unidentified element. The teacher could have satisfied the children by acting as an authority and telling them that the stuff was sand, but this would have violated one of the premises upon which we hoped to build our program. We wanted the children to discover as much as possible by their own resources—by suggesting their own ideas (hypotheses) and by testing these ideas by their own observations. To permit this the teacher scooped some of the sand out of the aquarium, placed it in a shallow dish and set it aside for further observation by the children.

The next day the teacher returned to class with clearly labelled packages of sand, sugar and salt. After showing the labelled packages to the children she poured some of each into separate dishes which she labelled and placed beside the sample of the stuff taken from the aquarium. The children compared



the samples ending up with a "taste test" and the decision that the stuff from the aquarium must be sand.

The teacher then took four empty half-gallon jars. Into one she added a sample of salt, into another sugar, into another some sand. She left the fourth jar empty. She then filled all four jars about two-thirds full of water and stirred. The children watched and noticed that the salt and sugar disappeared but that the sand did not. This reinforced their conclusion that the stuff on the bottom of the aquarium was sand.

But that was not all. The children tasted the water and discovered the difference between salt water and fresh water, and that the aquaria they had in the classroom contained fresh water.

The teacher then asked if any animals and plants could live in salt water. In this class some of the children knew that the ocean contained salt water and that some organisms lived in it. But even if they had not known the way was open for the introduction of a marine aquarium.

The addition of the marine aquarium caused much excitement, observations of different organisms, and new questions. For example, "Could the fish in the fresh water aquarium live in the salt water?" On the basis of the discussion that followed the teacher introduced the concept of habitat. She told the children that the fresh water aquarium was an example of a fresh water habitat, that the marine aquarium was an example of a salt water habitat, and that a habitat was a place where organisms lived. She then asked the children if they could think of any other habitats.

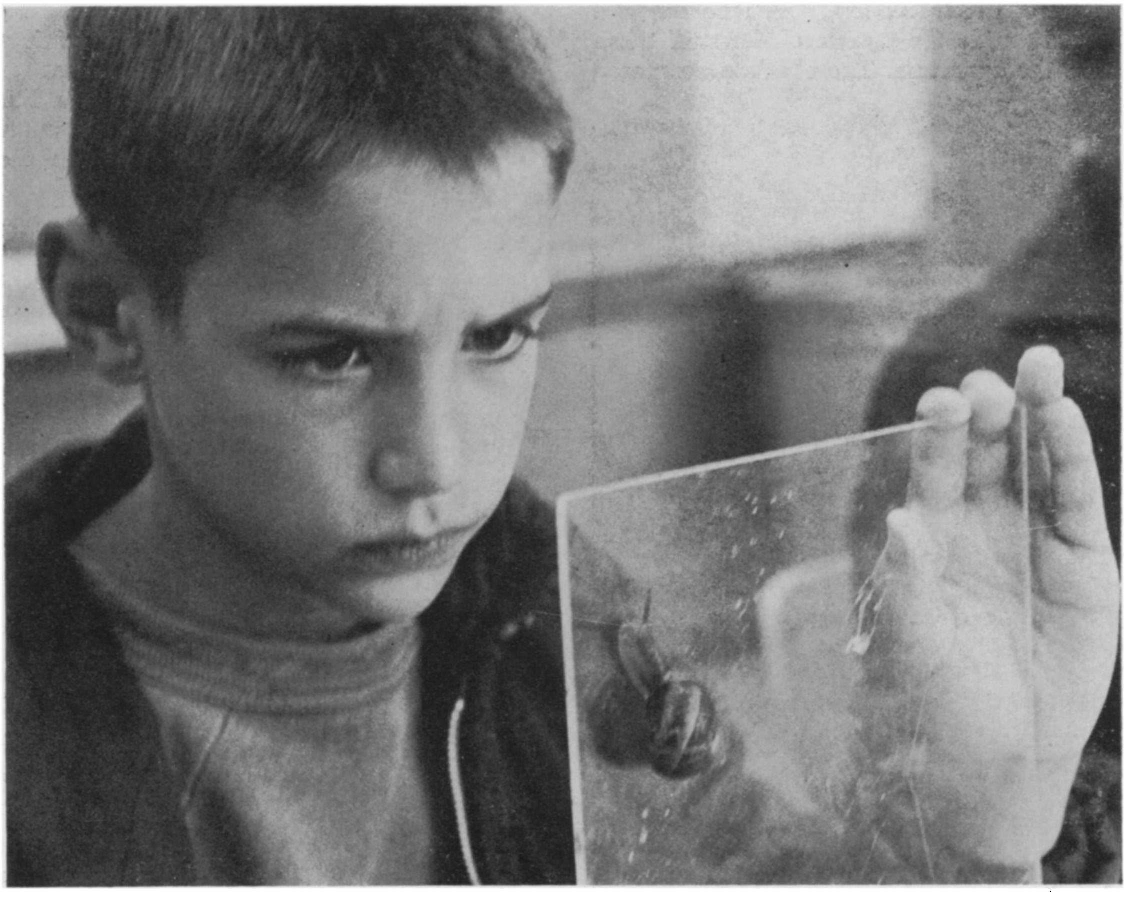
On the day she asked the question the response was negative, but the next day the children bubbled over with habitats of all kinds. The teacher suggested that they take their crayons and draw their habitats. The various drawings included the sea, a stream, the air with birds, a barn with a rabbit, the Steinhart Aquarium, a forest with "Christmas trees and a tiger," "grass with a snake, caterpillars, and a long worm."

As time went on two other observations of the children led to questions that were used to introduce other concepts. One of these was occasioned by the development of an algae bloom in the aquaria that had been placed near the windows. The children noticd the "green water," and wanted to know what caused it. Following up the question we introduced Algae, Daphnia, the major anatomical features of Daphnia with particular emphasis on the digestive tract, Daphnia eating algae and excreting feces. By feeding Daphnia to guppies we introduced the concept of the food chain—algae, Daphnia, guppies.

The second observation of particular significance was the accumulation of organic detritus on the sand of the aquaria. Again the children observed it and wanted to know what "that black stuff" was. Again the teacher did not tell them what it was but used their previous observations of feces from Daphnia and one or two fish that had died to enable the children to discover the source of the detritus.

After the discovery of the source of the detritus the teacher prepared a demonstration experiment that she hoped would prepare the way for the introduction of the concept of soil fertility. She removed the sand plus the detritus from one of the aquaria and placed it in a plastic dish. She then filled a similar dish with sand alone, added the same amount of grass seed to both and watered. More plants grew in the sand and detritus mixture; they were taller and had a darker green color. From these differences it was possible to relate organic material having its origin from dead animals and plants and animal feces with plant growth.

The entire first year program did not depend on the questions that children asked. The teacher gave the children seeds to compare and to plant in soil where they could germinate. Nothing specific or directive was made of the observations of the seedlings. The children observed growth and some of the differences among a variety of common garden plants. In the second year program a more detailed study of plants is planned to lead to the concept of life cycle.



Another part of the program contributed by the teacher was the study of diversity. After the work on habitats the teacher prepared and brought into the classroom some new freshwater aquaria containing different kinds of fish, snails, and aquatic plants from those in the original aquaria. Drawings of the organisms were passed out and the children were asked to cut out the drawings that were similar to the organisms in the aquaria and then to sort the drawings into groups on the basis of similarity.

In addition the children were asked to paste the different animal and plant cutouts on a sheet of paper containing an outline of an aquarium according to the relative position within the aquarium the organisms were observed. For example, catfish were usually on the bottom while the guppies tended to swim somewhere closer to the surface.

Three other events were observed by the children but not followed up. These were the birth of guppies, the appearance of snail eggs, and the death of fish. The study of reproduction and death and decomposition will be followed up in later grades.

The first-year program included some experience with each of the biological concepts listed below. For some of the concepts the experience was minimal, for others it was more extensive, but each experience was intended as a beginning to be followed by further growth in later grades. The concepts were:

Birth
Growth of animals
Seed germination and plant growth
Death
Habitat
Diversity of organisms
Microorganisms (Algae and Daphnia)
Anatomy of Daphnia (primarily the digestive system)
Feeding, digesting, excreting in Daphnia
Food chain (Algae, Daphnia, guppies)
Detritus
Soil fertility

The success of the life science program depends not only on the living material which the children observe but also on the responses the teacher gives to the children. She must not act as an authoritative source of answers for all the questions. Instead she must stimulate the children to suggest possible answers and then guide them in making new observations or experiments from which they can obtain answers. She must be alert to the moments when it is fruitful to introduce a new concept. The children can explore and investigate up to a point, but they cannot be expected to invent the major concepts of biology.

In addition, the teacher should encourage the children to discuss their observations and ideas and to argue among themselves. Discussion and argument stimulate the children's interest and give them practice in reasoning.

A general pattern of teaching that we have followed with some variations we have called *exploration, invention,* and *discovery*. By explorations we mean the initial direct physical and mental contact with the natural world. This experience is essential if something more than verbal behavior is to be learned. If real understanding is to be achieved, real contact with the world has to be provided. An example of exploration was described above. It was the observation of fresh water and marine aquaria, the investigation of the stuff on the bottom of the aquarium and the resultant recognition that some organisms live in fresh water and others in salt water. After this the teacher invented the concept "habitat." Sometimes after the invention of a new concept the teacher presents new and different instances of the concept. These are discovery lessons. From the new examples the child is expected to recognize that the new concept has applications to situations other than the initial example. The discovery experiences reinforce, refine, and enlarge upon the content of the concept.

In the case of the habitat invention no new examples were presented by the teacher. Instead she asked the children to recall examples from their past experiences. Thus the discovery lesson served to organize a variety of past experiences under the new concept habitat.

The second-year program is in process of development. The third, fourth, fifth, and sixth year programs will follow. Each year will build on the experiences of the previous year. We hope that at the end of the sixth year the children will have some idea of an ecosystem including the function of physical factors, the nature of communities, of populations, reproduction, heredity, food production of plants, food chains, behavior, prey and predators, etc. We may or may not include cells and their relations to biological processes, but we are certain we will not mention biochemical processes. We hope that by creating a framework of ideas that relate observable organisms with each other and with the earth, the air, and the sun, the more detailed analysis in later years of processes within individual organisms will be more meaningful.

The Swamp Stompers

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Although the Swamp Stompers program was developed for junior and senior high school students, it would also be appropriate for students in the upper elementary grades, and, with some modifications, for those in the lower grades as well. The author formerly taught at New London High School, New London, Ohio and read this paper at the AAAS-NABT-ANSS meeting in Cleveland.

The Swamp Stompers began, over five years ago, with five or ten of my better sophomore biology students who accompanied me one Saturday on a trip into the field. The students were quite enthusiastic and asked when we were going out and stomp the swamps again. It was from this question that the group took its name. Since that Saturday, the program has grown to over 40 students.

At about this time, I met George Linn, a graduate geologist, teaching earth science at another of the county schools. After discussing the program with him and finding that our objectives concerning students were similar, we decided to expand the Swamp Stomper program to include not only the bios of the area but also the geos. Thus, we felt, a more complete understanding of the relationship of the organism to its environment might be made available to the students. The following year, George Linn joined the New London staff, and the program started to pick up in earnest.

After spending the Fall Saturdays in the field, we spent most of our spare time that winter formulating our objectives, preparing field guides and keys, and also planning the sequence of the areas to be visited. We also felt that some of the other local teachers might like to participate along with some of their students, and invitations to them were sent out. Our county superintendent suggested making this program available to elementary teachers. At an evening meeting, we explained the program and objectives to the elementary teachers, and then held a very successful teacher Stomp.

At first, our response from county schools was practically nil. Fortunately, those who did come were impressed enough to mention the program to others. Slowly, others have joined, so that now it is necessary to travel caravan style, with identifying streamers flying from car aerials, to make it easier for the trailing cars to keep contact with those ahead.

Linn and I have written a book, "A Field Manual for Swamp Stompers," including the type of information needed by teachers who may want to direct similar programs. The manual contains methods of identifying rocks and how they came to be, identification keys for insects, frogs, toads, trees, and