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ABSTRACT

Alternatives for working within a regionally adopted framework for selecting an elementary school science program are considered in this paper. The alternatives are ranked on a scale from 0 to 5 in increasing levels of modifying a set instructional pattern: Level 0, typified by indifference to any consistent program in science; Level 1, a complete adherence to established conceptual scope, sequence, and instructional methods; Level 2, prescribed concepts and investigations are re-evaluated and re-structured against the pragmatism and parochialism of classroom experience; Level 3, prescribed conceptual systems and instructional strategies are evaluated against classroom experience and current conceptions of curriculum structure and cognitive development, involving, perhaps, the reordering of the conceptual sequence along a Gagnean hierarchy; Level 4, similar to Level 3, except having additional flexibility by the structure being used as a basis for selecting activities which have been shown to represent valid ways of involving children; and Level 5, choice is maximized by instructional decisions being based, in part, on the general tone of the adopted framework or criteria statement rather than a text's prescribed content or methodologies. (Author/PR)

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What Are Some Alternatives for Working Within a Regionally Adopted Science Framework?

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Over the past ten years, a score or more of commercially produced elementary text series have been published; also a similar number of project materials evolved approaches which were given the bittersweet test of classroom trial, evaluation, and subsequent revision. Although most series and projects proclaim internal integrity, the composite appears as a partially assembled jigsaw puzzle of concepts and strategies, sharing only similar philosophical commitments as to how children should be involved in the study of science. Perhaps this is as it should be in that many alternative sources are provided.

Periodically, regional and professional organizations grapple with the need to establish coherency through explicating position statements on the composition of science curriculum and modes by which science should be taught. These sets of criteria represent ideational matrices which are intended to be used in selecting or organizing specific instructional programs. At times, in their zeal to regionally assure that a framework is implemented, decision making bodies have selected a commercially developed text series. This seemingly expeditious move is perceived as an assurance that science will have a significant place in the elementary classroom, is taught in ways described in the framework, and provides a sequential development of concepts and conceptual systems. In addition, accompanying guides provide remediate background for those teachers who sense they are inadequately prepared in content and methodology.

Text series are developed independently of criteria statements; as a consequence, the selection process involves a search for the "best fit," permitting possibly a selection which is considerably out of phase with the framework. Ironically, out of the zeal to assure implementation of a framework through textbook prescription can evolve an imminent need to consider alternative approaches to organizing the curriculum and instruction.

Consider the criteria statement adopted by the California Curriculum Commission[1] in 1964: "Texts selected shall:"

> "develop scientific inquiry through process approach"
>
> "provide concepts and reading levels appropriate to varying ability levels"
>
> "be appropriate for interest and aptitude of children at various developmental levels and from different cultural backgrounds"
>
> "stress the open-ended nature of science and tentativeness of conclusions"
>
> "provide tested activities which involve experimentation, observation, discussion, problem solving which lead to concepts and generalizations"
>
> "arouse curiosity, stimulate inquiry, and invite hypothesizing"

Compare and contrast these criteria with examples drawn from the single prescribed text series[2] supplied to all elementary schools in the state. The following represents the investigative format in the series, a selection from the fifth grade text. A problem is posed, "An investigation into whether soaked seeds produced carbon dioxide." A sequence of directives follows, "Put a layer of cotton ... Put in soaked lima beans ... Cap tightly ... make a tight fitting hole ... Squeeze the sides of the carton ... to force the gas into limewater." Along with these directions is a series of three colored photographs showing not only the arrangement of the apparatus, but "what happened in one trial" --a "successful" trial I might add. Obviously, not only are children denied some modicum of uncertainty in the context of the activity, but on the page preceding the investigation is the statement "Lima bean seeds make carbon dioxide!"

Second grade children throughout the state are supposedly to study:

> "There is a relationship between changes in termperature and the motion of molecules." "There is a relationship between the motion of molecules and changes in the state of matter." Evolution of life in sea to life on land."

In the sixth grade:

> "Change is the result of unbalanced forces, e.g., gravitational, electromagnetic, and nuclear." "The characteristics of living things are laid down in a genetic code." "Genetic changes preceded changes in structure of living things." "Nuclear reactions produce the radiant energy of stars, and consequent change."

Oh cry Piaget for our children suffer! Recall the noble concern for ability levels; for providing a program for children from divergent cultural backgrounds; for providing investigations which foster inquiry, stress the open-endedness of science, encourage a process approach. Where, in fact, have they been implemented?

Teachers immersed in the reality of working with confused and frustrated children stumbling through an inappropriate program, soon question the credibility of the existing curriculum--and possibly, whether science should be taught at all in the elementary classroom beyond the incidental approach. In a recent survey on science textbook utilization conducted by the California State Department of Education, teachers' reactions to the state's program suggest antithetical criteria were implemented: reading level is much too high; investigations are too theoretical, technical, and closed; too much material to cover, certainly raising serious scope and sequence problems as children move through the grades; and concepts and subconcepts are too abstract and difficult for elementary school children.

Administratively a single text adoption which meets the criteria has much expeditious appeal to implementating a framework. However, should a framework prescribe specific instructional activities and concepts which are crassly imposed across a region as diverse as California in student abilities and cultural background?

What then are some alternatives for working within a regionally adopted framework? Consider these as being ranked along a scale of increasing "Levels" of modifying a set instructional pattern. At the origin, Level 0, are those reactions typified by instructional indifference to any consistent program in science. At the other extreme, Level 5, instructional decisions do not follow those set in a prescribed program or adopted text series, but represent variations on the tone of a position statement, framework, or criteria. At this level, optimum flexibility in choosing instructional strategies is evidenced.

Levels 1 through 4 include approaches to implementing a prescribed program. Level 1 represents complete adherence to established conceptual scope, sequence, and instructional methods. A regionally adopted text series becomes a linear instructional program. It is well to point out that at best, the structure of content and pedagogy of elementary science series represents hunches, buttressed by experience, about cognitive capacities of children and modes of facilitating their cognitive growth. At worst, the organizational patterns are influenced by untested boundaries of tradition and current political pressures often irrelevant to both enhancing a child's understanding of his environment and providing him with skills for further intellectual development.

Level 2. Prescribed concepts and investigations are re-evaluated and re-structured against the pragmatism and parochialism of classroom experience. Those aspects of a program with which teachers experênce success would remain:

a model of molecular motion to conceptualize "how sounds are produced," found in a prescribed third grade text[2] would be dropped due to children's inability to utilize the model; but the activities for "making sound" would be retained. Likewise, second grade children would study the phenomena of evaporation and condensation, but would not be expected to explain the events using a model of the molecular structure of water.

Level 3. Prescribed conceptual systems and instructional strategies are evaluated against classroom experience and current conceptions of curriculum structure and cognitive development. A reordering of a conceptual sequence along a Gagnéan[3] hierarchy might be undertaken, i.e., concepts arranged in terms of increasing complexity. To illustrate, the following concepts could be sequentially subsumed under the scheme, Living things are interdependent with one another and with their environment

3. Living things are adapted by structure and function to their environment.

2. There are characteristic environments, each with its characteristic life.

1. There are different forms of living things.[4]

Level 4. As in Level 3, this level includes an evaluation and possible restructuring of a prescribed conceptual sequence against current conceptions of learning and curriculum structure. Unlike Level 3, the structure is used as a basis for selecting activities which have been shown to represent valid ways of involving children. The extended experimental development of projects as Science Curriculum Improvement Study (SCIS),[5] Elementary Science Study (ESS),[6] and Science - A Process Approach (SAPA)[7] strongly supports the validity of their instructional strategies; in turn, they offer rich activity resources. Methods common to these projects include:

1. Provisions for an observational base from which children, guided by a teacher, can invent concepts, constructs, and generalizations through induction.

2. Involvement of children in such ways that they seek and test explanations in the environment of activities.

3. Activities which are open enough to involve children in the dilemma of considering alternative interpretations or explanations of observational data.

4. Incorporate elements of scientific processes including observing, classifying, inferring, interpreting data, experimenting.

To illustrate this approach, three generalizations were drawn from a sequence in the California series. Around each are clustered some examples drawn from project units.

There are different forms of living things. Observing, classifying, and communicating are processes integral to activities which center on this "first grade" theme. SAPA and SCIS include activities in which children work with different kinds of organisms, selected from both the plant and animal kingdoms. Information gathered only through the senses is to be used to describe the organisms and then group them in various ways according to similarities and differences. In both projects, children develop acquaria. As objects and organisms are added, students group them according to categories as "living" and "nonliving;" living forms on the basis of easily observed similarities and differences; and subsequently demonstrating the place of new organisms in a class developed classification scheme.

Another scheme, appearing in the third grade text, Living things are adapted by structure and function to their environment, might lead to the following project selections: From ESS, the unit Bones would involve children in exploration of the form and shape of bones in relationship to their function; Tracks, in which children explore evidence suggested by animal tracks, e.g., eating, walking, size, and habitat; Earthworms and Mealworms in which children study living organisms, observe and speculate about their structures and functions. In SCIS, the unit Populations, organisms are studied in terms of their functional relationship within an ecosystem, e.g., predator, prey, plant and animal eaters, etc.

From the fifth grade text, Energy must be applied to produce a force which results in change in motion: From SAPA, Communicating 13, Force and Motion, Using carts, pulleys, various masses, etc., children analyze forces which are acting on a cart at rest, when it is changing speed, and the effect of increasing or decreasing a force upon the motion of a cart. From ESS, Mobiles, children construct mobiles in which they gain experience with some laws and problems of balance, balance systems, and symmetry by constructing and hanging simple mobile systems. From SCIS, Energy Sources, students work with a "rotoplane" to provide experimental background for the development of, or "invention", of concepts as energy transfer, energy sources, and energy receiver. They apply these new concepts to situations in which motion or temperature change provides evidence of energy transfer, using "stopper poppers," rolling and colliding spheres, etc.

Certainly a multitude of other project activities cluster around this conceptual scheme: ESS, Spinning Tables and Stream Tables (experiences with moving water on model landforms), Structures, Sink or Float, Pendulums, Senior Balancing; from SAPA, Predicting: Describing the Motion of a Bouncing Ball, Using Space/Time Relationships: Rate of Change of Position, etc.

Level 5. Unlike the other levels, curriculum and instructional decisions are based, in part, on the general tone of the adopted framework or criteria statement rather than a text's prescribed content or methodologies. Although the latitude of choice is maximized, making decisions at this level can be most complicated. Instructional decisions should arise from deliberation of alternatives. Such a procedure may appear chaotic and confused. The soundness of the decision maker's choices is dependent not only on his defense of each but the extent of his knowledge about alternatives. To illustrate decision points for devising alternatives at Level 5, I shall describe several permutations within the criteria statement adopted by the California Curriculum Commission in 1964. To review, teaching materials selected were to: a) be process oriented; b) include tested activities and materials which excite and interest children; c) present open-ended activities which would invite experimentation; and d) be structured around a sequential arrangement of content, though no specific concepts were listed.

Logistically, the most direct approach to selecting alternatives within the cast of the framework, is to choose a program which meets all criteria statements. While three commercially available projects, e.g., ESS, SAPA, SCIS, meet the requirements of process involvement and tested ways for involving children, only SCIS includes an explicit graded conceptual sequence, e.g., Organisms, Life Cycles, Populations, Environments, Communities, Ecosystems, and an interdependent scope, e.g., the second level in the sequence centers on the theme of change: in the physical sciences, change as a consequence of interactions; in the life sciences, change in terms of development of organisms.

SAPA lays claim to a sequence of "processes," e.g., observing, classifying, inferring. The content/phenomena components are claimed to be vehicles for developing the hierarchially sequenced processes. If a mandate requires a conceptually framed program, the task is clear. The content/phenomena focii need to be analyzed to explicate, if possible, a sequential pattern.

As a consequence of the "process" focus, the project has provided fodder for the rhetorical debates about sacrificing content for process. But let's compare some themes which reoccur in SAPA with a sequence from a text series claimed to be organized around a conceptual framework. In SAPA, Part A, activities are primarily perceptual in character, cluster around a theme so familiar to the primary teachers, i.e., we describe our environment and objects within it by observations, e.g., color, shape, odor, texture, temperature, etc.; and Part C includes activities centering on changes as in position, rate, physical state, products of interactions, and a result of separations. Contrast this to a sequence from a "conceptually sequenced" series[2]: A change in the state of matter is determined by molecular motion (Grade 2); Matter consists of atoms and molecules (Grade 3); In chemical change, atoms react to produce change in the molecules; (Grade 4). Can it be concluded that this sequence is more appropriate than the other SAPA.

ESS lays neither direct claim to a sequence of process nor content. However, in each of the 55+ units, an approximate grade range at which the units had been successfully taught is provided, e.g., Grades K - 3, Light and Shadows, Growing Seeds, Match and Measure; Grades 3 - 6, Rocks and Charts, Starting from Seed, Where is the Moon? In some units, correlations of two or more units are suggested, e.g., Clay Boats and Sink or Float.

If the regional framework requires a conceptual sequence, a local ESS adoption would necessitate development of a framework and an analysis of the units to determine how they might fit the conceptual matrix. For example, the theme, "There is an interdependence between structure and function," used in conjunction with ESS grade placement recommendations would support the following unit clusters: primary grades, Brine Shrimp, Life of Beans and Peas, Growing Seeds; in the intermediate grades, Bones, Mosquitos, Crayfish, Behavior of Mealworms. In each of these units, children study directly structural elements and their functions.

Another approach to implementing the tone of a framework yet drawing upon tested activities, is to mesh project activities in such a way that several investigations from different programs cluster around a theme. In so doing, provisions can be made for a) broader experience with phenomena incorporated in the concept, b) alternatives which meet vagaries of student interest and material availability, c) enrichment variations, and d) different strategies which may be more appropriate for some children than others. ESS places, for example, a high stress on a direction which evolve from children's explorations and inquisitiveness. SCIS includes an exploratory phase in addition to a more formal sequence in which teachers introduce a concept and children discover its application.

SAPA does permit early exploration, but the structure of the exercises provides a much tigher sequence than either ESS or SCIS.

Let me illustrate. SCIS Life Cycles includes the study of both plant and animal cycles, e.g., fruit flies, frogs, mealworms and several angio-sperm plants. Integral to the unit are the concepts of growth, development, generation, metamorphosis, and biotic potential. In several ESS units, experiences with the development of other animals are provided in addition to some interesting adjuncts. Mosquitos, Earthworms, Butterflies, Crayfish, and Mealworms include additional studies of behavior. Crayfish, for example, involves children in the study of dominance; Mealworms, in terms of behavior in a stimulus-response model.

SCIS, Relative Position and Motion includes reference object, reference frame, relative position, relative motion. ESS units, Daytime Astronomy and Where is the Moon implicates these concepts in astronomical observations and interpretations.

SCIS, Models of Electric and Magnetic Interaction can be amplified with ESS selections from Batteries and Bulbs in which children further explore batteries, bulbs, circuits, magnets, and compasses; or SAPA, Part E, in which additional variations on the same concepts are provided.

The possible intercorrelations of project materials is extensive. In the context of a regionally adopted position, I believe the advantages in this approach to providing a program of experiences sensitive to children's proclivities outweighs the disadvantages in apparent dismemberment of a project.

In summary, the levels presented represent different gradations of working within a regionally adopted framework or criteria statement. The experience in California raises very serious questions about prescribing a specific program for an entire region in efforts to implement a regions philosophy. Ironically, for elementary teachers in California to approach the criteria statement, they must digress markedly from a text series selected in the premise that it represented the regional position statement. Several local reactions were suggested: two in which a prescribed text series is reevaluated; two in which experimentally tested project materials are liberally implemented either within a restructured conceptual framework, or selected only in terms of the general philosophy about science education.

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