DOCUMENT RESUME

ED 111 655 SE 019 523

| | |
|---|---|
| AUTHOR | Smith, Edward L.; McClain, Janis J. |
| TITLE | Content Analysis of Selected Primary Level Units of the Science Curriculum Improvement Study. |
| INSTITUTION | Southwest Regional Laboratory for Educational Research and Development, Los Alamitos, Calif. |
| REPORT NO | SWRL-TN-2-72-58 |
| PUB DATE | 7 Dec 72 |
| NOTE | 72p. |
| EDRS PRICE | MF-$0.76 HC-$3.32 Plus Postage |
| DESCRIPTORS | Biological Sciences; *Content Analysis; *Curriculum Evaluation; Elementary Education; *Elementary School Science; *Instructional Materials; *Science Course Improvement Project; Science Education |
| IDENTIFIERS | *Science Curriculum Improvement Study; SCIS |

ABSTRACT

To evaluate a method of content analysis, and as a step toward the specification of a conceptual domain for primary level science, extant instructional programs were analyzed. This paper reports an analysis of the introductory unit and three biological science units of the Science Curriculum Improvement Study (SCIS). The background of the program and the procedures for the analysis are described. The conceptual content is summarized. Problems encountered in the analysis and their implications for subsequent analyses are discussed. (Author/EB)

SWRL SOUTHWEST REGIONAL LABORATORY
TECHNICAL NOTE

DATE: December 7, 1972

NO: TN-2-72-58

# CONTENT ANALYSIS OF SELECTED PRIMARY LEVEL UNITS OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY

Edward L. Smith and Janis McClain

ABSTRACT

To evaluate a method of content analysis, and as a step toward the specification of a conceptual domain for primary level science, extant instructional programs were analyzed. This paper reports an analysis of the introductory unit and three biological science units of the Science Curriculum Improvement Study. The background of the program and the procedures for the analysis are described. The conceptual content is summarized. Problems encountered in the analysis and their implications for subsequent analyses are discussed.

# CONTENT ANALYSIS OF SELECTED PRIMARY LEVEL UNITS OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY

Edward L. Smith and Janis McClain

Approximate specification of conceptual domains in important subject matter areas is required as a basis for research on problems in conceptual instruction at the primary school level. In addition, methods for analysis of conceptual content may be refined on the basis of difficulties revealed in such preliminary analyses, thus facilitating subsequent examination of concepts in the primary curriculum.

A proposed method of content analysis based largely on the mathematical theory of sets was used to examine the content of selected extant instructional programs in primary level science. The purposes of these analyses were:

1. To provide a basis for evaluation and revision of the scheme for categorizing conceptual content.
2. To provide a source from which components of a preliminary domain of science concepts might be selected.
3. To provide a basis for establishing the content validity of selections for the domain.

This paper reports the results of an analysis of the content of four primary level units of the Science Curriculum Improvement Study (SCIS, 1966, 1968a, 1968b, 1968c).

## THE SCIS SCIENCE PROGRAM

The materials of SCIS were selected for analysis because of the reliance of this program on an explicit conceptual framework.

The SCIS program is divided into physical science and biological science units. All three biological science units intended for use at the primary level were analyzed to allow examination of the longitudinal development of the conceptual framework. Since physical science units of other programs are to be analyzed, only the first SCIS physical science unit was analyzed at this time. That unit introduces several concepts which are further developed in the biological science units.

SCIS is the result of a curriculum materials project supported by the National Science Foundation. Like other major elementary science curriculum projects of the last decade, SCIS replaced heavy reliance on textbook reading with a strong emphasis on first-hand observation and manipulation of objects and materials. A major goal of the program is the development of "scientific literacy," the ability "to use information obtained by others, to benefit from the reading of textbooks and other references that present information in abstract form" (Karplus & Their, 1967). As a basis for these abilities, the program attempts to develop a framework of basic concepts.

The conceptual framework for the primary level units of the SCIS program is built upon a set of basic analytic concepts: object, property, interaction, and system. Other, more specialized concepts are also introduced including organism, life cycle, and population in the biological science units, and material, relative position and relative motion in the physical science units. These concepts are presented in "invention" lessons and then developed through utilization in the investigation of

objects and phenomena in "discovery" lessons. Additional concepts are introduced in the context of these objects and phenomena. Many of the concepts refer to particular classes of objects, systems or organisms, or to particular properties, etc.

Another major national elementary science curriculum, the Conceptually Oriented Program in Elementary Science (COPES, 1967), shares the emphasis on concepts noted in SCIS. SCIS differs, however, in its greater emphasis on concept utilization through exploration and investigation of materials and phenomena. Also, the COPES program places less stress on analytic concepts.

As in the case with *Science: A Process Approach* (Xerox, 1967, 1968), children in the SCIS program are expected to acquire skill in observation, measurement, and other science processes. However, while *Science: A Process Approach* is organized almost exclusively around specific science processes, SCIS does not give special emphasis to these apart from the development and utilization of concepts with which they are associated. Of course, *Science: A Process Approach* is not devoid of concepts. However, the introduction and development of concepts plays a subservient role to the development of mastery of the science processes.

## PROCEDURES FOR CONTENT ANALYSIS

Conventions for analyzing the outcomes of K-3 curriculum areas have been described (Smith & Van Horn, 1971) and employed in analyses of science (McClain & Smith, 1971; Smith, 1971) and music (Fink, Piper, & Smith, 1971) outcomes. These conventions defined a set of components

(elements, variable names, values, etc.) in terms of which the tasks required of children can be defined. The components also provide a basis for organizing content upon which the tasks are carried out. The examples of each component can be listed, and the relevant interactions among them indicated. In the music analysis, for example, sets of values for each variable were defined and grouped under headings indicating the classes of elements for which they were applicable.

From a conceptual point of view, the components mentioned above provide a basis for defining classes of concepts. Thus, some concepts are variable or dimensional concepts, and others are value concepts. Specific classes of elements are the referents of class concepts. Still other concepts refer to relations between examples of the other kinds of concepts, e.g., correlational concepts refer to the relation between two or more variables. Distinctions among these types of concepts are based on differences in the kind of representation which would be required in a set-theoretic formalization of the concepts. The mathematical theory of sets was used as a foundation for the present approach although the notational mechanism was not employed. The present analysis was conducted employing the following concept classes and definitions:

Class concepts. These concepts refer to a set of elements grouped on the basis of shared features or attributes. They usually have a standard label which can function as a name for the elements. The membership of the set of elements can be defined in terms of criterial values for a set of relevant variables, e.g., horse, predator, holiday.

Descriptive value concepts. These concepts refer to a particular attribute of elements rather than to elements as such. They often have standard labels. These are the pieces of information in terms of which class concepts are defined, e.g., long, carnivorous, expensive.

Variable (dimension) concepts. These concepts refer to an aspect or characteristic of elements which can vary from element to element. They are intimately related to sets of values. The values for a variable represent possible manifestations or states for that aspect or characteristic. The values are logically mutually exclusive. The values for some variables correspond to descriptive value concepts while these for other variables correspond to class concepts, e.g., length, cost, shape.

Relational concepts. These are concepts which explicity involve the relationship between two or more concepts of the above types. They are subdivided on the basis of the types of concepts related.

Comparative concepts. These relate values for different elements on the same variable. They can be qualitative, e.g., same, different; or quantitative, e.g., greater, less.

Correlational concepts. These relate values of different variables for the same element, e.g., X is proportional to Y.

Class-Class relation concepts. These relate membership in one class to membership in another, e.g., all A's are B's.

Class-value relation concepts. These relate class membership to a value or values, e.g., some A's are Y.

Appendix A contains a listing of the specific information sought for cases of each class of concepts as they were encountered in the analysis.

The four selected SCIS units, "Material Objects," "Organisms," "Life Cycles," and "Populations," were analyzed chapter by chapter. As a concept occurred in a chapter, it was categorized and listed, along with other relevant information (cross-referencing, chapter, etc.) as outlined in Appendix A. In the course of analysis, two new classes, Event Class Concepts and Student-Teacher Action Concepts, to be described later, were added to the system.

For each unit, summary tables were formed from the above lists. These tables were organized in the following way:

Table 1: Class concept and class variable concept information. Class concepts were organized into gross categories (e.g., plant concepts, material concepts, etc.). Within these categories, mutually exclusive parallel subsets were grouped together. Class concepts employed as values were indicated by listing variable names reflecting that usage.

Table 2: Event concepts.

Table 3: Descriptive variable and descriptive value concepts, organized into categories of qualitative and quantitative variables.

Table 4: Comparative (Intradimensional) concepts, organized into categories of comparisons between elements vs. comparisons over time (same element) and qualitative vs. quantitative comparisons.

Table 5: Correlational (Interdimensional) concepts.

Table 6: Class-class relational concepts.

Table 7: Student/teacher action concepts.

# RESULTS

## DISTRIBUTION OF CONCEPTS

A summary of the frequency of occurrence of the various categories of concepts is presented in Table 1. Such a summary provides a superficial characterization of the kind of conceptual content found in a program. It should be noted that these figures represent the number of distinct concepts identified and not the frequency of recurrence of particular concepts. The most striking features of this information are the relatively large number of class and descriptive concepts, and the relatively small number of relational concepts. The primary level SCIS units emphasize the description, comparison, and classification of objects and "systems," in terms of their properties. This emphasis is reflected in Table 1. No correlational concepts were explicitly introduced in the units analyzed and few examples of such concepts were found. Another interesting aspect of SCIS revealed in Table 1 is that the number of descriptive values and variables decreased in the higher level units. This decrease probably reflects an assumption that skill with descriptive concepts had been acquired in prior units, as well as the nature of the content in the later units.

## THE CONCEPTUAL CONTENT OF THE SCIS UNITS

In general, a program like SCIS, geared toward discovery, is at a disadvantage and is perhaps somewhat misrepresented in a content analysis such as this. There is more content in SCIS than meets the eye, at least judging from the number of concepts indicated in Table 1.

TABLE 1

NUMBER OF CONCEPTS IDENTIFIED

| | Material Objects | Organisms | Life Cycles | Populations |
|---|---|---|---|---|
| *Class Concepts (total) | 60 | 68 | 51 | 68 |
| class value concepts | 53 | 56 | 40 | 50 |
| others | 7 | 12 | 11 | 18 |
| Event Concepts | 4 | 8 | 7 | 2 |
| Class Variable Concepts | 18 | 15 | 14 | 18 |
| Descriptive Variable Concepts | 27 | 16 | 12 | 11 |
| **Descriptive Value Concepts (total) | 48 | 31 | 15 | 20 |
| regular values | 45 | 28 | 14 | 17 |
| specific comparative values | 3 | 3 | 1 | 3 |
| Correlational Concepts | 9 | 4 | 8 | 5 |
| General Comparative Concepts | 7 | 3 | 3 | 5 |
| Class-Class Relational Concepts | 1 | 3 | 5 | 8 |
| Student-Teacher Action Concepts | 9 | 6 | 6 | 5 |
| | 183 | 154 | 121 | 142 |

*Where sets of unspecified examples of classes were bracketed in Table 1, each set was counted once.

**Where sets of numbers [1, ..,n] were included as values, each set was counted once; includes one count for each case in which a variable is specified, but no particular values are indicated.

This table represents classes, variables, values, etc., that are made explicit in the units. In a program like SCIS, there is likely to be much that is not made explicit.

For example, one SCIS chapter is designed to differentiate between plants and animals. Where another, more expository science program might explicitly point out variables upon which plants and animals differ, there are no such variables mentioned in the SCIS chapter--it is the children themselves, in the context of a class discussion, who come up with the variables. Thus, even though there is likely to be a significant number of variables and values utilized in the chapter, none of them appear in the tables.

The failure of the analysis to inventory some implicit conceptual content should not be regarded as a defect in the method of analysis, per se, but of the procedure of relying exclusively on published program materials. Further applications of the method of analysis can be supplemented by classroom observations, where that is deemed useful.

Class Variable and Class Value Concepts

Several class variables played an important role in several different chapters and/or units, although in many cases, the specific class values changed.

Kind of organism: Plant, animal

Kind of plant

Kind of animal

Part of plant: stem, leaf, root, flower, seed

Part of animal

(Stage of development): egg, adult, seed, flower

Kind of material

Kind of habitat: land, water

Sex of organism: male, female

(Role in food relation): predator, prey, source

Other class concepts playing an important role in several units or chapters were:

Parents

Offspring

Food

Food chain/web

Life cycle

Population

The remaining concepts in Table 1 in Appendix B occurred less frequently and derive their importance from being values or examples for the concepts listed above or from the relations into which they enter as reflected in Table 6.

Certain concepts developed in the SCIS units seem to have particularly general applicability, certainly well beyond the limits of natural science. These have been listed separately in Table 1 (Appendix B) under the heading Analytic Concepts.

Frequency of explicit use of these concepts varies considerably across units. However, this seems to reflect instructional procedures more than applicability. In many cases, their application was apparantly

assumed by program developers. All of the analytic concepts seem to have rather general applicability to the content areas of the units reviewed.

Part

Group

Property

Experiment

Evidence

System

The concept of stage, although never made explicit in the program, seems to have sufficient application to warrant its addition to the list. This is evidenced by its frequent occurrence as a part of the various names supplied by the reviewer in organizing the values used in the units. The concept of event might also prove useful, at least for the purpose of developing the concept of stage.

Descriptive Variables and Values

Many of the descriptive variables identified were based on other, more fundamental ones. For example, number of population, number of deaths in a population, etc., are all based on the variable of number. The following variables and values are either underlying several more particular ones or occur frequently as listed.

Size--large, -er
small, -er

Height--tall, -er
short, -er

Length--long, -er
short, -er

Amount--some, none

Number--more, less; counting numbers

Change--increase, decrease; comparative values of specific variables

Rate--fast, -er
slow, -er

Color--colorless, yellow, green, brown, black

Shape--

Motion--moves (of own accord)

Direction--up, down

Illumination--light, dark

As pointed out above, the students are expected to supply the descriptive variables and values in the later units. The following variables and values occurred explicitly only in the material objects unit but appear to apply to the biological units.

Texture--rough, -er
smooth, -er

Temperature--cold, -er

Type of covering--furry, no fur

Comparative Concepts

The qualitative concepts same and different, and the quantitative concepts more than and less than were used quite consistently throughout. The concepts most and least were not found in later units. A similar pattern was found in the comparative version of the quantitative descriptive values, i.e., the -er forms appeared frequently in later units while the -est forms did not. The concepts of increase and decrease referring to comparisons

over time were introduced in the later units. However, the -er forms of descriptive values and more than and less than were also adapted for this purpose, e.g., by use of the expression "get bigger."

Correlational Concepts

Methods of analysis of correlational concepts have not been developed beyond the point of defining the variables and type of variables correlated. Both qualitative and quantitative variables were employed in the correlations in each unit. Over half of the correlations involved either temporal ordering of stages in events or change in the size of populations. Temporal aspects of these concepts provide additional reasons for including event and stage as basic analytic concepts.

Interclass Relational Concepts

The number of interclass relational concepts identified increased from unit to unit. The eating relation between classes of organisms and the development relation between stages in the life cycles of organisms occurred most frequently. The distinction between one stage of an organism's life cycle developing from another stage and a product or substance deriving from a source is not reflected in the terms used. If both develops from and comes from are to be used, the former might better be used only for the life cycle relation. The later units involve multiple steps or chain relations and repeating or cycling relations.

Event Concepts

Most of the event concepts related to the life cycles of organisms. Birth, germination, growth, death, and decay were included as well as the more specialized concepts, metamorphosis and molting. The only function concept included was defecation. (Note, however, that "eats" was included as an interclass relational concept.) The concept of change was explicitly employed in two units. The concept of change would seem to be useful in defining many of the more specialized event concepts, especially in conjunction with specific variable concepts related to the events, e.g., the variable concept size and the event concept growth.

Student/Teacher Action Concepts

These concepts refer to the intervention of the observer or experimenter into the situation being studied. Some refer to scientific or logical processes and other to physical manipulation. The process concepts observation, description, comparison, and sorting occurred consistently throughout. Counting was added in the later units.

DEVELOPMENT OF THE BASIC SCIS CONCEPTS

In the course of the analysis certain features of the organization and the development of the main concepts in the SCIS materials were noted. Most of the concepts represent examples or sets of examples of the analytic concepts made explicit in the program description and rationale. In this sense, the program's content is accurately reflected in these descriptions.

It was observed that the concept of property, defined as "a characteristic of an object," was used ambiguously in SCIS. It was applied both to value labels and to variable names; for example red and color were both at various times identified as properties. This sort of ambiguity no doubt results in some confusion among children; when asked to name properties of objects, it is unclear whether the value or variable label is being elicited.

The definition of population used in SCIS also seemed unclear; it was defined as "the total number of organisms of one kind living in a particular area." From the definition it was not clear whether population was a Class Concept or a Variable Concept i.e., whether it referred to the group of organisms or the number of them. It was used subsequently only to refer to the group.

It was noted that some previously learned analytic concepts were not extensively used in the later SCIS units. For example, the concepts of object, property, system, and interaction, each taught prior to the third-grade Populations unit, seldom appear explicitly in that unit despite their frequent applicability. Utilization of these concepts by teachers and/or students may have been assumed by the program developers.

## MODIFICATIONS OF METHOD OF ANALYSIS

In the course of analysis, two types of concepts were identified, each of which had certain common features which seemed unique enough to warrant classification in a distinct category. Both of the following classes of concepts were added to the system and used in the present analysis.

Event Class Concepts

These concepts refer to sets of particular kinds of events, i.e., time-sequenced occurrences, as distinct from the sets of objects and locations included in the Class Concept category. Like the latter, the membership of the set of elements (in this case, the particular examples of the event) can be defined in terms of criterial values of relevant variables (e.g., the event class "growth" involves an increase in size). Inclusion of these in the class concept category was awkward due to the kinds of information required.

Student-Teacher Action Concepts

These concepts refer to a special type of active relationship where the student or teacher (the "doer") acts upon an element or elements (the object of the "doing") in some special way. Some of these actions are basically logical in nature, e.g., describing, observing, while others refer directly to substantial changes in the elements, e.g., planting, mixing.

An additional modification involved the omission of certain of the information requirements for concept classes listed in Appendix A. In most cases it was felt that the resource requirements for those specifications omitted (indicated by asterisks) were too great, or that the kind of information required in the specifications was duplicated elsewhere.

PROBLEMS IN METHOD OF ANALYSIS

In addition to the modifications in the procedures described above, certain concepts presented problems which were not resolved or were resolved arbitrarily in the present analysis. These kinds of problems require further study to achieve more rigor in the method of analysis.

Class vs. Descriptive Value Concepts

Additional clarification is needed in the distinctions between class variable/value concepts and descriptive variable/value concepts. In practice, their distinction tended to be linguistic: Class Concepts and Class Value Concepts were nouns; Descriptive Values were adjectives or adverbs (or adjectival or adverbial phrases). However, there are some problems with this sort of distinction:

1) In theory, the definition of class concepts (i.e., sets of elements grouped together on the basis of shared attributes) is more inclusive than the actual SCIS listing of class concepts. In the SCIS analysis, only those class concepts which were identified by a name, in noun form, were listed. Those classes identified by a descriptive word or phrase rather than a name were not included on the SCIS class concept list. However, such classes can be generated from the "Classes described or referred to "column of the Descriptive Variables/Values tables. For example, the class "animals that are furry" can be generated by the value, "furry," and the class referenced, "animals". Other classes which do not appear on the class concept list include classes which are unnamed--there are cases where, for example, snails are classified into different kinds, but the types are not named. The existence of such a

class is reflected in this analysis by the class variable, e.g., kind of snail. These cases suggest a revision of the class concept definition to include only those classes given a name. There was some arbitrariness in cases where variable names were not made explicit in the unit; it was often possible to construe both the variable and its values in such a way that they could be classified as either descriptive or class types. For example, in Life Cycles, children are supposed to notice the sequence of developmental changes that occur in germination (roots, stem, and leaves appear). This could be represented as:

| Descriptive Variable | Descriptive Value |
|---|---|
| (Kind of change in germination) | roots appear |
| | stem appears |
| | leaves appear |

or

| Class Variable | Class Value |
|---|---|
| (Developmental stage in germination) | roots |
| | stem |
| | leaves |

If there is any meaningful distinction between class and descriptive variables and values, it seems lost in cases like these.

Event Concepts

Another point of fuzziness exists over the distinction between event concepts and descriptive value concepts: "(growth), grows," for

example, was listed as an event, but "moves" was listed as a value. Both are action-type verbs, both involve change, and more specifications are needed to classify them.

Action Concepts

Some of the concepts in the Student-Teacher Action list are illustrative of the general problem of a lack of criterion for deciding what is and what is not science content. In the SCIS analysis we include as "content" the processes of science, e.g., observing, describing. Also included were such physical manipulations as "planting," "watering," "pushing," "pulling," some of which seem to be more general than strictly scientific.

Relational Concepts

Classification of relational concepts seemed arbitrary in some cases, particularly with respect to relations between class concepts. Review of the results produced further distinctions among these concepts. These distinctions are summarized below.

Set-subset relations. These are relations of the form "A's are B's." This asserts dual class membership for each of a subset of elements. These relations are reflected (but not differentiated) in the class concept-class variable information in Table 1 in the Appendix, e.g., "Guppies are organisms." Both "guppies" and "organisms" are listed as class concepts. The relation is reflected in the inclusion of "guppies" as a "kind of organism."

Inter-element relations. These are relations between individual elements from one class and different elements from another class, e.g., "Wolves eat rabbits." Such relations are reflected in the class variables

and associated values in Table 1 (e.g., under "animals preyed upon") and/or in the class-class relations in Table 4 (e.g., as "A's eat B's"). These relations should not be confused with comparisons of values of a variable for one element or class of elements with those for another, e.g., "A's are taller than B's."

Whole-part relations. This type of class-class relation is reflected in Table 1, e.g., the class concepts "leaves," "flowers," etc. are listed under the class variable, "parts of plants." In terms of the above distinctions this could be classified as an instance of either inter-element or set-subset relations. Since the elements in the set of wholes are technically different elements from the elements in the set of parts, this can be judged an inter-element relation. Alternatively, a set reflecting the class of wholes can be defined with the sets of parts forming subsets, e.g., plant parts-leaves. Since this creates a new set (plant parts) and does not make the inter-element aspect explicit, the inter-element classification seems more appropriate.

Class-value relations. These are relations between an entire class and a value (as opposed to an individual element and a value, see next paragraph). Definitional (or criterial) values for a class are examples of this type of relation, but there may also be associated values. Associated values are incidentally characteristic of a class, but are not definitional (i.e., the absence of the characteristic does not deny class membership). For example, there are no female presidents of the United States at present, but there is no definitional requirement of this effect. These relations are reflected (but not differentiated) in Table 3 where the element classes characterized by the value of descriptive variables are listed.

Element-value relations. These are distinguished from the class-value relations in that only a particular element (indicated by gesture etc.) is involved in an assertion, e.g., "This is red." These relations are also reflected in Table 3.

Element-class relations. These relations are similar to the element-value relations in that the assertion applies only to an individual element. Class membership is asserted, however, rather than applicability of a descriptive value, e.g., "This is a plant." These relations are reflected in Table 1.

Complex Constructs

Another difficulty that was encountered involved the classification of complex constructs such as "food chain," a construct which had features of class concepts but also embodied within itself a series of relationships between other class concepts (e.g., "food chain" involves the relation "A's eat B's eat C's"). It was determined that a complex concept such as this should be categorized as a class concept; as such, it refers to a set of elements, where the elements themselves are ordered sets. For example, "hydra, daphnia, algae" and "owl, mouse, corn" are two sample elements of food chains.

## RESOURCE REQUIREMENTS

The resources for conducting the analysis reported were as follows:

1) Initial analysis. This includes time spent on categorizing and listing, dealing with categorization problems and deciding upon modifications. Time required (AMPS), approximately an hour per chapter or a total of 80 man hours.

2) Summary and organization of materials. Time required (AMPS) Approximately 10 hours per unit or a total of 40 man hours.

3) Consultation. Time required (MPS and AMPS), 10 man hours.

4) Drafting of report. Time required (MPS and AMPS), 60 man hours.

## CONCLUSIONS

The results indicate that analysis based on the notions, if not the notation, of mathematical set theory is a useful approach to take in specifying the conceptual content of an instructional program. While some problems in the method were revealed which further study will be required to work out, the method did yield a good indication of what the SCIS program is about, how the program content is organized, and where difficulties may arise in the program resulting from inadequate organization in the development and use of concepts. Nothing was revealed in the present analysis which would suggest any fundamental defect in the set theoretic approach.

The value of this particular analysis as a source of candidates for a primary level domain of science concepts or as evidence for validity of selections for such a domain depends upon the adequacy of the program analyzed. The program is based on a systematic scheme of analytic concepts. As such, it achieves a degree of "construct validity" as applied to curriculum (Bessemer, 1971). In addition, the program has had the benefit of a quantity and quality of expertise not applied to such undertakings prior to the advent of the curriculum projects of the last decade. Our analysis indicates that the concepts actually in the program fit the scheme which

were purported to underlie it. These points suggest that the content identified should be of considerable value for the stated purposed of the analysis. However, certain cautionary notes should be made.

1) Without ourselves making an extensive and detailed analysis of the major concepts included, we cannot be certain that all of the important component concepts required have been included in the program and our lists. Thus, we have not assessed the completeness of the conceptual domain described.

2) No distinction has been made between those concepts which are necessary and those whose inclusion is advantageous or simply arbitrary. The analytic concepts identified above may in fact be the only necessary concepts.

3) The goals selected for the program provide an essential basis for the judgment of content validity. Apart from the goals established for the program and the conceptual scheme devised as a basis for their attainment, the individual items may have very little validity.

# APPENDIX A

## RELEVANT INFORMATION FOR EACH CONCEPT CLASS

Class Concepts

1) List each class concept label, grouping those which represent mutually exclusive parallel subsets of a larger set of elements (e.g., plants and animals).
2) If a superordinate class is named, so indicate and include it in the list and cross-reference it.*
3) If a subordinate class is named, so indicate and include it in the list and cross-reference it.*
4) Where value concepts are employed in describing or defining the class, so indicate and cross-reference the values and variable name (if one is used).*
5) List the example elements employed and indicate the mode of presentation, e.g., pictoral, verbal, actual, etc.*
6) If class concept labels are employed as modifiers of other class concepts, include an appropriate name in the class variable list and cross-reference the class concept labels so employed. For example, for daphnia population put "species of organism" on variable list and cross-reference it to population and daphnia.

---

*These specifications were omitted because they required excessive resources or because the kind of information required was duplicated elsewhere.

Variable (Dimension) Concepts

1) List each variable name employed. If the values are descriptive values, list it under descriptive variables. If they are class concepts, list it under class variables.

2) Cross-reference any value labels employed.

3) List any elements characterized with the variable.

4) Cross-reference any classes defined or described with the variable.

5) List observation/measurement procedures employed for the variable cross-referencing any values so assigned.*

6) Cross-reference any class concepts employed as values.

Value Concepts

1) List all values grouping them by variable. Separate alternative sets.

2) If variable is named, cross-reference to variable name. If not, make up an appropriate variable name and add it to the variable list.

3) List observation/measurement procedure used to assign values, if any, unless it is listed under the variable name.*

Relational Concepts

Class-class relations

1) List relational term or phrase or specify sentence form.

2) Cross-reference classes so related.

Variable-Variable or Correlation (value-value relations across variables)

1) List relational term or phrase or specify sentence form.

2) Cross-reference variables (or values) so related.

Class-Variable Relations

1) List sentence forms employing any unusual syntax or quantitative terms.*

2) Cross-reference class and variable.*

Value-Value Comparative Relations (for same variable)

1) List relational term or phrase.

2) Cross-reference variable.

3) Classify as quantitative (indicating an order) or qualitative.

# APPENDIX B

## CONCEPTUAL CONTENT OF SCIS UNITS

In general, the terms included in the following lists were explicitly used in the teacher and/or student materials for the corresponding units and reflect, in the judgment of the reviewer, probable usage with the students. Terms enclosed in parentheses were selected by the reviewer to indicate the implicit usage of concepts as reflected in the usage of associated terms. In most instances, the terms enclosed in parentheses are variable names selected to reflect usage of associated terms as values, i.e., as characterizations of elements or classes of elements. The phrases "kind of _____" and "part of _____" were frequently employed in the teacher's guide. These phrases were used, therefore, whenever the class variable names required them whether or not they were explicitly used in the program materials in each individual case.

The use of a slash (/) between variable names indicates that the corresponding values were employed for both variables or that the reviewer was unable to determine which of the alternatives was most likely to be employed by the teacher.

In some cases, examples of certain classes (objects, organisms, foods), were not listed separately as class concepts in the summary, but were bracketed as, for example, [examples of common discrete objects]. This occurred 1) when the examples were not further studied, and were used only to illustrate the concept (e.g., a paper clip serving as an example of an object), or 2) when the actual examples were not specified.

A "Chapter" column appears in each table. The approximate frequency of usage of each concept listed is reflected in the number of chapters

in which it occurs. The number of chapters, of course, is not an actual measure of frequency of usage, since some concepts appear only once in a chapter while others are used several times.

TABLE 1A

CLASS/CLASS VARIABLE CONCEPTS

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| MATERIAL OBJECTS UNIT | | |
| Object Concepts | | |
| object | | 1-30 |
| [Examples of common discrete objects from classroom, playground. etc; material samples] | kind of object | 1-30 |
| [Examples of parts of common discrete objects] | part of object | |
| line drawings of plane figures | kind of object | 22,24 |
| mortar | kind of object | 25,27 |
| pestle | kind of object | 25,27 |
| medicine dropper | kind of object | 27 |
| syringe | kind of object | 29,30 |
| magnifier | kind of object | 8,10,11,12,14,16, 23,25,27 |
| rock | kind of object/rock (rock subclasses unnamed) | 16,17,24 |
| animal | kind of object | 5 |
| plant | kind of object | 4 |
| Animal Concepts | | |
| [Examples of common zoo animals] | kind of object/animal | 5 |
| shell | kind of object/part of animal | 23 |
| tail | kind of object/part of animal | 5 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| ear | kind of object/part of animal | 5 |
| eye | kind of object/part of animal | 5 |
| fur | kind of object/part of animal | 5 |
| **Plant Concepts** | | |
| [Examples of common plants] | kind of object/plant | 4 |
| leaf | kind of object/part of plant | 4 |
| flower | kind of object/part of plant | 4 |
| stem | kind of object/part of plant | 4 |
| **Material Concepts** | | |
| material | | 9,10,11,12,13,14, 15,16,17,18,25 |
| solid | form of iodine/water | 19,27 |
| wood | kind of material | 8,10,12,13,14,15, 24 |
| metal | kind of material | 8,10,11,15 |
| plastic | kind of material | 8,10 |
| piece | form of word/metal/plastic | 13,14,25 |
| dust | form of wood | 13,14 |
| shaving | form of wood | 14 |
| birch | kind of material/wood | 12 |
| walnut | kind of material/wood | 12,14,15 |
| oak | kind of material/wood | 12,14,15 |
| pine | kind of material/wood | 12,14,15 |
| balsa | kind of material/wood | 13,15 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| lead | kind of material/metal | 11,15 |
| brass | kind of material/metal | 11,15 |
| steel | kind of material/metal | 11,15 |
| aluminum | kind of material/metal | 11,15,24 |
| liquid | form of water | 18,26,27,28 |
| oil | kind of material/liquid | 18,26 |
| glycerin | kind of material/liquid | 18,26 |
| starch | kind of material/liquid | 18,26 |
| water | kind of material/liquid/ (habitat) | 5,18,26,27,28, 30 |
| salt water | kind of liquid | 28 |
| gas | form of iodine | 19 |
| air | kind of material/gas | 19,29,30 |
| Freon | kind of material/gas | 19 |
| iodine | kind of material/gas | 19 |
| crystal | form of iodine | 19 |
| ice | kind of material/form of water | 27 |
| sugar | kind of material | 25 |
| lump sugar | kind of material/sugar | 25 |
| rock candy | kind of material/sugar | 25 |
| mixture | | 25 |
| Location Concepts | | |
| land | (habitat) | 5 |
| Analytic Concepts | | |
| group | | 8,9,10,11,12, 14,17,18 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| property | | 1-30 |
| evidence | | 4,5,12,14,18,24 25,27,28 |
| part | | 4,5,9,25 |

TABLE 1B

CLASS/CLASS VARIABLE CONCEPTS

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| ORGANISMS UNIT | | |
| Organism Concepts | | |
| organism | | 1-23 |
| animal | kind of organism | 1,7,9,12,13,21 |
| plant | kind of organism | 1,5,6,7,8,9,12,13,14, 21,22,23 |
| food | | 20,21 |
| food web | | 21 |
| Animal Concepts | | |
| fish | kind of organism/animal | 1,2,3,7,8,9,13,14,22 |
| crab | kind or organism/animal | 1,2,3,7,8,9,13,14,22 |
| sea star | kind of organism/animal | 1,2,3,7,8,9,13,14,22 |
| sea anemone | kind of organism/animal | 1,2,3,7,8,9,13,14,22 |
| mussel | kind of organism/animal | 1,2,3,7,8,9,13,14,22 |
| oyster | kind of organism/animal | 1,2,3,7,8,9,13,14,22 |
| guppy | kind of organism/animal /fish | 1,2,3,15,20,21 |
| goldfish | kind of organism/animal /fish | 7 |
| catfish | kind of organism/animal /fish | 7 |
| daphnia | kind of organism/animal | 17,18,19,20,21 |
| snail | kind of organism/animal /snail (snail subclasses unnamed) | 1,2,8,9,11,13,14,16 |
| egg | (stage in development of organism) | 2 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| young | (stage in development of organism) | 2 |
| adult | (stage in development of organism) | 2 |
| antenna | part of animal | 19 |
| mouth | part of animal | 19 |
| anus | part of animal | 19 |
| intestine | part of animal | 19 |
| leg | part of animal | 19 |
| eye | part of animal | 19 |
| carapace | part of animal | 19 |
| mother | (parent) | 3 |
| father | (parent) | 3 |
| male | (sex) | 3,7 |
| female | (sex) | 3,7 |
| Plant Concepts | | |
| marigold | kind of organism/ plant/seed | 5,6 |
| ryegrass | kind of organism/ plant/seed | 5,6,14 |
| pumpkin | kind of organism/ plant/seed | 5,6 |
| dwarf pea | kind of organism/ plant/seed | 5,6 |
| mustard | kind or organism/ plant/seed | 5,6,23 |
| algae | kind of organism/ plant | 14,15,16,17,18,19,20,21 |
| volvox | kind of algae | 15,16 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| eudoria | kind of algae | 15,16 |
| chlamydomonas | kind of algae | 16 |
| oedogonium | kind of algae | 16 |
| seaweed | kind of algae | 16 |
| seed | | 5,14,23 |
| leaf | part of plant | 6,22 |
| stem | part of plant | 6 |
| root | part of plant | 6,14 |
| Material Concepts | | |
| material | | 10,15,16,19,22,23 |
| sugar | kind of material | 10 |
| salt | kind of material | 10 |
| sand | kind of material | 10,13,14,23 |
| detritus | kind of material | 22,23 |
| feces | kind of material | 5,14,23 |
| water | kind of material/ habitat | 13,14,15,16,21 |
| saltwater | kind of water/habitat | 11,13 |
| freshwater | kind of water/habitat | 10,11,13 |
| Location Concepts | | |
| habitat | | 13,16,21 |
| desert | kind of habitat | 21 |
| forest | kind of habitat | 21 |
| pond | kind of habitat | 13,17 |
| lake | kind of habitat | 13,17 |
| stream | kind of habitat | 13 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| ocean | kind of habitat | 13 |
| land | kind of habitat | 21 |
| Object Concepts | | |
| aquarium | | 1,2,3,4,7,8,9,10,11,13, 14,15,16,17,22 |
| magnifier | | 1,2,5,15,16,17,18,19 |
| Analytic Concepts | | |
| part | | 6,18,19 |
| group | | 21 |
| property | | 10 |
| experiment | | 10,14,15,17,22 |

TABLE 1C

CLASS/CLASS VARIABLE CONCEPTS

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| LIFE CYCLES UNIT | | |
| Organism Concepts | | |
| organism | | 12 |
| animal | kind of organism | 9,11,12 |
| plant | kind of organism | 3,4,10,11,12 |
| [examples of common organisms] | kind of organism/object | 13 |
| offspring | | 9,10 |
| life cycle | | 6,7,8 |
| generation | | 6,7,9,10 |
| Animal Concepts | | |
| fruit fly | kind of animal | 6 |
| moth | kind of animal | 6 |
| frog | kind of animal | 7,9 |
| mealworm | kind of animal | 8 |
| [examples of unspecified animals--dog, guppy, etc.] | kind of animal | 12 |
| egg | (stage in life cycle of fruit fly/frog/mealworm) | 6,7 |
| larva | (stage in life cycle of fruit fly/mealworm) | 6,8 |
| pupa | (stage in life cycle of fruit fly/mealworm) | 6,8 |
| adult | (stage in life cycle of fruit fly/mealworm/frog) | 6,8 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| tadpole | (stage in life cycle of frog) | 7 |
| leg | part of animal | 7 |
| tail | part of animal | 7 |
| body | part of animal | 7 |
| skin | part of animal | 8 |
| male | (sex) | 9 |
| female | (sex) | 9 |
| Plant Concepts | | |
| pea | kind of plant/seed | 4 |
| bean | kind of plant/seed | 4,10 |
| [examples of unspecified common plants--carrots, grass, etc.] | kind of plant | 12 |
| squash | kind of plant/seed | 2,11 |
| marigold | kind of plant/seed | 2,11 |
| corn | kind of plant/seed | 2,11 |
| sunflower | kind of plant/seed | 2,11 |
| root | part of plant, (developmental stage in germination of plant) | 3 |
| stem | part of plant, (developmental stage in germination of plant) | 3,4 |
| leaf | part of plant, (developmental stage in germination of plant) | 3,4 |
| seed coat | part of plant | 3 |
| seed leaf (cotyledon) | part of plant | 3 |
| tendril | part of plant | 4 |
| fruit | part of plant | 1 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| flower | part of plant, (developmental stage in life cycle of pea plant) | 4 |
| pod | part of plant, (developmental stage in life cycle of pea plant) | 4 |
| seed | part of plant, (developmental stage in life cycle of pea plant) | 1,2,3,4,5,10,11 |
| seedling | part of plant, (developmental stage in life cycle of pea plant) | 3,4 |
| [examples of unspecified common fruits--apples, tomatoes] | kind of fruit | 1 |
| [examples of seeds from unspecified common fruits] | kind of seed | 1 |
| **Material Concepts** | | |
| soil | | 2,4 |
| water | | 2,3,4 |
| **Object Concepts** | | |
| object | | 13 |
| [examples of common nonliving objects] | kind of object | 13 |
| magnifier | | 2,6,7,8 |
| **Analytic Concepts** | | |
| property | | 6,12,13 |
| part | | 3,4,5,7,8,12 |
| experiment | | 5 |

TABLE 1D

CLASS/CLASS VARIABLE CONCEPTS

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| POPULATIONS UNIT | | |
| Organism Concepts | | |
| organism | | 1-17 |
| animal | kind of organism/population/ origin of food | 2,7,9,10,12,13,14,15,16,17 |
| plant | kind of organism/population/ origin of food | 2,8,9,10,11,12,14,15,16,17 |
| offspring | | 8,17 |
| population | | 1-17 |
| community | | 16 |
| food | | 7,9,10,14,16 |
| [examples of common human foods] | kind of food | 10 |
| food chain | | 14,15,16 |
| food web | | 15,16 |
| (life cycle) | | 11,17 |
| Animal Concepts | | |
| human | kind of organism/animal | 9,10 |
| chameleon | kind of organism/animal/ population | 13,17 |
| cricket | kind of organism/animal/egg/ population | 12,13,17 |
| snail | kind of organism/animal/egg/ population | 1,2,4,9,12,13 |
| planaria | kind of organism/animal/ population | 7,9 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| daphnia | kind of organism/animal/ population | 1,2,3,4,5,6,9 |
| gammarus | kind of organism/animal/ population | 4,9 |
| dragonfly nymph | kind of organism/animal/ population | 7,9 |
| guppy | kind of organism/animal/ population | 7,9 |
| hydra | kind of organism/animal/ population | 4,6,9 |
| buffalo | kind of organism/animal/ population | 2 |
| [examples of common farm pond animals] | kind of organism/animal/ population | 9,13,15,16 |
| [examples of common forest animals] | kind of organism/animal/ population | 4,15,16 |
| [examples of common school ground animals] | kind of organism/animal/ population | 2,16 |
| egg | (stage in life cycle of cricket) | 17 |
| nymph | (stage in life cycle of cricket) | 17 |
| adult | (stage in life cycle of cricket) | 17 |
| tentacle | part of animal (hydra) | 4 |
| body | part of animal (hydra) | 4 |
| tongue | (part of animal used in catching prey) | 13 |
| claw | (part of animal used in catching prey) | 13 |
| female | (sex) | 11,17 |
| (male) | (sex) | 11,17 |
| predator | (role in eating relation between animals) | 6,7,13,16 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| prey | (role in eating relation between animals) | 6,7,13,16 |
| plant eater | (kind of food source) | 9,12,13,14,16 |
| animal eater | (kind of food source) | 9,12,13,14,16 |
| plant and animal eater | (kind of food source) | 9 |
| **Plant Concepts** | | |
| elodea | kind of organism/plant/ population | 1,2,4,8 |
| duckweed plant | kind of organism/plant/ population | 1,2,4,8,9 |
| algae | kind of organism/plant/ population | 1,2,3,4,9 |
| clover | kind of organism/plant/seed | 12,17 |
| grass | kind of organism/plant/seed | 12,17 |
| [examples of common farm pond plants] | kind of organism/plant/ population | 9,15,16 |
| [examples of common forest plants | kind of organism/plant/ population | 14,15,16 |
| [examples of common school ground plants] | kind or organism/plant/ population | 2,16 |
| seed | (stage in life cycle of plant) | 11 |
| flower | (stage in life cycle of plant) | 11 |
| plant | (stage in life cycle of plant) | 11 |
| leaf | part of plant | 11 |
| stem | part of plant | 11 |
| root | part of plant | 11 |
| **Location Concepts** | | |
| habitat | | 11 |
| terrarium | kind of habitat | 11,12,13,14,17 |

| Class Concepts | Class Variable Concepts | Chapter |
|---|---|---|
| aquarium | kind of habitat | 1,2,4,5,6,7,8,16;19 |
| farm pond | kind of habitat/community | 9,13,15,16 |
| forest | kind of habitat/community | 4,15,16 |
| school ground | kind of habitat/community | 2,16 |
| **Material Concepts** | | |
| soil | | 11 |
| sand | | 1 |
| water | | 1,13 |
| **Object Concepts** | | |
| reservoir | | 11 |
| magnifier | | 1,6 |
| **Analytic Concepts** | | |
| part | | 11 |
| experiment | | 5,8 |
| group | | 2 |
| system | | 16 |

TABLE 2A

EVENT CONCEPTS

| Event Concepts | Specified Variables Involved | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| MATERIAL OBJECTS UNIT | | | |
| growth, to grow | | plants | 4 |
| change | form of wood/sugar/water | wood, sugar, water, mixtures of liquids | 13,25,26, 27 |
| (melting), to melt | form of water | ice | 27 |
| (evaporation) | form of iodine | iodine crystals | 19 |

TABLE 2B

EVENT CONCEPTS

| Event Concepts | Specified Variables Involved | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| ORGANISMS UNIT | | | |
| (growth), to grow | size | plants, animals | 2,6,14,23 |
| (birth, reproduction), is born | | animals | 2 |
| (death), to die | | organisms | 4 |
| (decay) | | organisms | 4,22 |
| (germination), to sprout | | plants | 6 |
| (evaporation) | | water | 10,15 |
| (dissolution), to dissolve | form of sugar | material samples (sugar, salt) | 10 |
| (defecation), to defecate | | animals (daphnia) | 19 |

TABLE 2C

EVENT CONCEPTS

| Event Concepts | Specified Variables Involved | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| LIFE CYCLES UNIT | | | |
| growth, to grow | size | animals, plants | 3,4,6,7,8,11 |
| (germination) | | seeds | 3,10 |
| development, to develop | | parts of plants, parts of animals | 4,6,7 |
| metamorphosis | stage in life cycle of fruit fly/moth/mealworms | mealworms, fruit flies | 6,8 |
| (molting), to molt | | mealworms | 8 |
| death, to die | | animals, plants | 9,10,13 |
| change, to change | | animals, plants | 12,13 |

TABLE 2D

EVENT CONCEPTS

| Event Concepts | Specified Variables Involved | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| POPULATIONS UNIT | | | |
| growth, to grow | size | grass, clover, crickets | 11,17 |
| (death), to die | | crickets | 17 |

TABLE 3A

DESCRIPTIVE VARIABLE/VALUE CONCEPTS

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| MATERIAL OBJECTS UNIT | | | |
| Quantitative Variables | | | |
| texture | rough<br>smooth | objects, materials | 1,2,20,23,24 |
| size | large, -er, bigger<br>small | objects, materials, plants, animals | 1,2,6,22,23, 24,25,27 |
| weight | heavy<br>light | objects | 1,24 |
| shininess | shiny<br>dull | objects, materials | 2,20,24 |
| order in which pictures were taken | first, second, etc. | states of plant growth/ iodine evaporating/ sugar being ground/ice melting | 4,19,25,27 |
| time (point in time) | | balloons/states of plant growth/iodine evaporating/ sugar being ground/ice melting | 4,19,25,27 |
| number of different kinds of wood | 1, ...n | wood | 14 |
| (intensity of color of gas formed from iodine crystals) | | iodine crystals | 19 |
| (rate of fall) | | balloons filled with different gases | 19 |
| (brightness of color) | light<br>dark | objects, materials | 20,22,23,24, 26 |
| (bounciness) | bouncy | objects | 20 |
| length | long, -est<br>short, -est | objects | 21,22,24 |
| grain (amount of) | | wood | 12,24 |
| number of corners | 1, ...n | line drawings | 24 |

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| amount of liquid | | liquids | 26 |
| (opacity) | opaque | materials (liquids) | 26 |
| (temperature) | cold | water | 27 |
| (buoyancy) | floats | objects | 28 |
| Quantitative Variables | | | |
| (compressibility) | can be squeezed | air | 29 |
| (position of plunger of syringe) | pulled out<br>pushed in | plunger of syringe | 30 |
| Qualitative Variables | | | |
| color | red<br>blue<br>green<br>brown<br>purple<br>colorless | objects, materials | 1,2,6,8,22<br>29 |
| shape | | objects | 1,29 |
| (origin of object) | (man-made)<br>(not man-made) | objects | 3 |
| (type of covering) | furry<br>no fur | animals | 5 |
| (homogeneity of material) | contains one material<br>contains more than one material | objects | 9,10,16,17,<br>18 |
| (mode of viewing) | is seen through magnifier<br>is not seen through magnifier | wood (pictures) | 12 |
| (whether mixture is stirred or unstirred) | stirred<br>unstirred | liquids | 26 |

TABLE 3B

DESCRIPTIVE VARIABLE/VALUE CONCEPTS

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| ORGANISMS UNIT | | | |
| Quantitative Variables | | | |
| size | large, -er<br>small, -er | animals, parts of animals, plants | 2,3,8,17,23 |
| change in size | increase | guppies | 2 |
| (rate of growth) | sprouts first<br>grows faster | plants | 6 |
| (height) | tall, -er<br>short | plants | 14 |
| (illumination) | light<br>dark | (areas where plants are growing) | 14,17 |
| (length) | long | roots | 14 |
| (number of ___) | 1, ...n | daphnia | 17 |
| (change in number of ___) | increase | daphnia | 17 |
| soil fertility | (makes plants grow larger, etc.) | detritus | 23 |
| (amount of detritus in sand) | is detritus in sand<br>no detritus in sand | detritus | 23 |
| Qualitative Variables | | | |
| color | (colorful)<br>colorless, clear<br>yellow<br>green<br>brown<br>black | organisms, parts of organisms, materials | 3,7,14,15,16,17,19,22 |
| (alive or dead) | dead<br>live/alive | organisms | 4 |
| body shape | | animals, e.g., goldfish | 7 |

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| view (of organism) | unspecified, e.g., front, side | organisms | 8,9 |
| location | bottom of aquarium, etc. | organisms and materials in aquarium | 9,10,18,22 |
| form of ___ | (dissolved) (undissolved) | sugar, salt | 10 |

TABLE 3C

DESCRIPTIVE VARIABLE/VALUE CONCEPTS

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|---|
| LIFE CYCLES UNIT | | | |
| Quantitative Variables | | | |
| number of ___ | 1, ...n | seeds, eggs, mealworms, frogs, plants | 1,8,9,10,11 |
| (order of stages in germination of plant) | first, second, etc. | plants, e.g., marigold | 3 |
| size | | pea plants, frogs | 4,7 |
| (order of stages in life cycle of ___) | first, second, etc. | frogs, fruit flies, pea plants, mealworms | 4,6,7,8 |
| (motion) | moves | fruit fly pupae | 6 |
| (change in size) | increase, bigger | frogs | 7 |
| (biotic potential-number of offspring an organism can produce) | 1, ...n | plants, e.g., beans; animals, e.g., frogs | 9,10 |
| (amount of change in population size) | | plants, e.g., beans; animals, e.g., frogs | 9,10 |
| (number of deaths in population) | 1, ...n | plants, e.g., beans; animals, e.g., frogs | 9,10 |
| Qualitative Variables | | | |
| (direction of growth of parts of seedling) | downward<br>upward | roots, stems of plants | 3 |
| body shape | | frogs | 7 |
| (whether object is living or non-living) | living<br>non-living | objects, organisms | 13 |

TABLE 3D

DESCRIPTIVE VARIABLE/VALUE CONCEPTS

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described or referred to | Chapter |
|---|---|---|---|
| POPULATIONS UNIT | | | |
| Quantitative Variables | | | |
| number of ____ population (population size) | 1, ...n | plants, e.g., duckweed; animals, e.g., daphnia | 2,3,4,5, 7,8,12,13, 17 |
| number of different populations | 1, ...n | plants, animals | 2,11 |
| change in population size | larger increase<br>more decrease<br>less | plants, e.g., grass; animals, e.g., crickets | 3,4,5,7, 8,12,13,17 |
| (biotic potential--number of offspring an organism can produce) | 1, ...n | crickets, daphnia | 3,17 |
| (amount of food supply) | (plentiful) | planaria | 7 |
| size | small, -er<br>large, -er | plants, vials of algae-water | 3,8 |
| (number of deaths in population) | | crickets | 17 |
| (amount of change in population size) | | crickets | 17 |
| Qualitative Variables | | | |
| (living conditions) | (large vial of algae-water)<br>(small vial of algae-water) | daphnia | 3 |

| Descriptive Variable Concepts | Descriptive Value Concepts | Classes Described or Referred To | Chapter |
|---|---|---|---|
| (presence of animal feeding on organism) | there is an animal feeding on organism | planaria | 7 |
| way of escaping predators | flying<br>jumping | bird, frog | 13 |

TABLE 4A.

COMPARATIVE (INTRADIMENSIONAL) CONCEPTS

| Comparative Concepts | Descriptive Or Class Variable Upon Which Based | Classes Referred To | Chapter |
|---|---|---|---|
| MATERIAL OBJECTS | | | |
| Comparisons between Elements | | | |
| Qualitative Comparisons | | | |
| similarity, same, alike | kind of metal, kind of material, (other unspecified common variables) | objects, plants, animals material samples | 2,3,4,5,6, 8,9,11,12, 13,14,15, 17,19,21, 23,25 |
| difference, different | time, kind of material, form of material, (other unspecified common variables) | objects, plants, animals, material samples | 2,4,5,6,8, 9,11,12,13, 14,15,17, 18,19,21, 23,25 |
| Quantitative Comparisons | | | |
| more than, (value + -er), > | bounciness, shininess size (larger), length, "grain," brightness or darkness, number of corners | objects, material samples | 20,21,22,23, 24 |
| most, (value + -est) | length (longest) | objects, material samples | 21,22,23 |
| less than, (value + -est), < | "texture," brightness or darkness, size, shininess, weight | objects, material samples | 20,21,22,23, 29 |
| least, (value + -est) | length (shortest) | objects, material samples | 21,22,23 |
| equal to, = | (unspecified variables, e.g., length) | objects, e.g., line drawings | 22 |

TABLE 4B

COMPARATIVE (INTRADIMENSIONAL) CONCEPTS

| Comparative Concepts | Descriptive Or Class Variable Upon Which Based | Classes Referred To | Chapter |
|---|---|---|---|
| ORGANISMS UNIT | | | |
| Comparisons Between Elements | | | |
| Qualitative Comparisons | | | |
| similarity, similar, same, alike | kind of habitat, kind of organism, (other unspecified common variables) | organisms, seeds | 3,5,7,8,21 |
| difference, different | size (of organism), view (of organism), (other unspecified common variables) | organisms, aquaria, seeds | 3,5,7,8,21, 22,23 |
| Quantitative Comparisons | | | |
| (value + -er) | size (larger) height (taller) size (smaller) | guppies, daphnia, plants | 3,14,17 |

TABLE 4C

COMPARATIVE (INTRADIMENSIONAL) CONCEPTS

| Comparative Concepts | Descriptive Or Class Variable Upon Which Based | Classes Referred To | Chapter |
|---|---|---|---|
| LIFE CYCLES UNIT | | | |
| Comparisons Between Elements | | | |
| Qualitative Comparisons | | | |
| similarity, alike, same | (unspecified common variables) | seeds, plants, animals | 1,2,12 |
| difference, differ | (unspecified common variables) | seeds, plants, animals | 1,2,12 |
| Comparisons Over Time (Same Element) | | | |
| Quantitative Comparisons | | | |
| increase, (value + -er) | size (bigger) | frogs, plants | 4,7 |

TABLE 4D

COMPARATIVE (INTRADIMENSIONAL) CONCEPTS

| Comparative Concepts | Descriptive Or Class Variable Upon Which Based | Classes Referred To | Chapter |
|---|---|---|---|
| POPULATIONS UNIT | | | |
| Comparisons Between Elements | | | |
| Qualitative Comparisons | | | |
| same | size, habitat | plants, animals | 2,8 |
| different | kind of population, size of vials | populations, vials of algae-water | 2,3 |
| Quantitative Comparisons | | | |
| less than, (value + -er) | size (smaller) | plants | 8 |
| Comparisons Over Time (Same Element) | | | |
| Quantitative Comparisons | | | |
| increase, more than, (value + -er) | population size (larger) | plants, animals | 3,7,8,12,17 |
| decrease, less than, (value + -er) | population size | plants, animals | 3,4,5,12,13 |

TABLE 5A

CORRELATIONAL (INTERDIMENSIONAL) CONCEPTS

| Related Variables | | Classes Referred To | Chapter |
|---|---|---|---|
| MATERIAL OBJECTS UNIT, | | | |
| order in which pictures were taken | (size of plant-photographed) | plants | 4 |
| (mode of viewing wood sample) | (amount of grain) | wood | 12 |
| order in which pictures were taken | (intensity of color of gas formed from iodine crystals-photographed) | iodine | 19 |
| kind of gas in balloon | (rate of fall of balloon) | gases (air, Freon) | 19 |
| order in which pictures were taken | (size of crystals/pieces of sugar/rock candy-photographed) | sugar | 25 |
| order in which pictures were taken | (size of melting ice cube-photographed) | ice | 27 |
| (size of ice cube) | (size of puddle of melted water ice cube makes) | ice/water | 27 |
| (buoyancy of object) | (kind of liquid in which object is placed) | objects | 28 |
| (position of left plunger of connected syringes) | (position of right plunger of connected syringes) | connected syringes | 30 |

TABLE 5B

CORRELATIONAL (INTERDIMENSIONAL) CONCEPTS

| Related Variables | | Classes Referred To | Chapter |
|---|---|---|---|
| ORGANISMS UNIT | | | |
| (illumination of area where plant is growing) | (size of plant) | plants | 14 |
| (illumination of area where plant is growing) | (color of plant) | plants | 14 |
| (illumination of area where plant is growing) | (size/length of roots) | plants | 14 |
| (presence of detritus in soil) | soil fertility | detritus/ plants | 23 |

TABLE 5C

CORRELATIONAL (INTERDIMENSIONAL) CONCEPTS

| Related Variables | | Classes Referred To To | Chapter |
|---|---|---|---|
| LIFE CYCLES UNIT | | | |
| (developmental stage in germination of plant) | (order of stages in germination of plant) | plants, e.g., marigold | 3 |
| (developmental stage in life cycle of pea plant) | (order of stages in life cycle of plant) | pea plant | 4 |
| (developmental stage in life of fruit fly) | (order of stages in life cycle of fruit fly) | fruit fly | 6 |
| (developmental stage in life cycle of frog) | (order of stages in life cycle of frog) | frog | 7 |
| (amount of change in population size) | (biotic potential of population) | plants, e.g., bean; animals, e.g., frog | 9,10 |
| (amount of change in population size) | (number of deaths in population) | plants, e.g., bean; animals, e.g., frog | 9,10 |
| number of seeds | number of plants grown from seeds | plants, e.g., sunflower; | 11 |
| kind of seed | kind of plants grown from seed | plants, e.g., squash | 11 |

TABLE 5D

CORRELATIONAL (INTERDIMENSIONAL) CONCEPTS

| Related Variables | | Classes Referred To | Chapter |
|---|---|---|---|
| POPULATIONS UNIT | | | |
| (amount of change in population size) | (living conditions) | daphnia | 3 |
| (change in population size) | (amount of food supply) | planaria | 7 |
| (change in population size) | (presence of animal feeding on organism) | planaria | 7 |
| (amount of change in population size) | (biotic potential) | cricket | 17 |
| (amount of change in population size) | (number of deaths in population) | cricket | 17 |

TABLE 6A

CLASS/CLASS RELATIONAL CONCEPTS

| Class-Class Relational Concepts | Classes Referred To | Chapter |
|---|---|---|
| MATERIAL OBJECTS UNIT | | |
| A matches B | A- blocks of different materials<br>B- blocks of different materials<br><br>A- samples of different kinds of rocks<br>B- pictures of different kinds of rocks | 7,15,16 |

TABLE 6B

CLASS/CLASS RELATIONAL CONCEPTS

| Class-Class Relational Concepts | Classes Referred To | Chapter |
|---|---|---|
| ORGANISMS UNIT | | |
| A eats B | A- daphnia<br>B- algae | 17,19,20,21 |
| | A- guppy<br>B- daphnia | |
| A comes from B | A- detritus | 6,22 |
| | B- feces, leaves, dead fish, snails | |
| | A- plants<br>B- seeds | |
| A "have" B;<br>A do not have B | A- females<br>B- babies | 3 |
| | A- males<br>B- babies | |

TABLE 6C

CLASS/CLASS RELATIONAL CONCEPTS

| Class-Class Relational Concepts | Classes Referred To | Chapter |
|---|---|---|
| LIFE CYCLES | | |
| A comes from B | A- seeds<br>B- fruits | 1 |
| A develops B | A- plant<br>B- parts | 4,7 |
| A develops from B develops from C... develops from A (life cycle relationship) | A- seed<br>B- pod<br>C- flower<br>D- seedling | 4 |
| A comes from B comes from C... comes from A (life cycle relationship) | A- adult<br>B- pupa<br>C- larva<br>D- egg | 6,8 |
| A allows for B | A- molting<br>B- growth (of mealworm) | 8 |

TABLE 6D

CLASS/CLASS RELATIONAL CONCEPTS

| Class-Class Relational Concepts | Classes Referred To | Chapter |
|---|---|---|
| POPULATIONS UNIT | | |
| A eats B | A- animals, e.g., hydra<br>B- plants or animals, e.g., daphnia | 6,7,12,13,14, 15,16,17 |
| A catches B | A- predators, e.g., frog<br>B- prey, e.g., insect | 6,13 |
| A escapes B | A- prey, e.g., bird<br>B- predators, e.g., fox | 13 |
| competition for food between A and B | A- animals, e.g., hydra<br>B- animals, e.g., dragonfly | 7 |
| A comes from B comes from C comes from A (life cycle relationship) | A- flower<br>B- plant<br>C- seed<br><br>A- adult<br>B- nymph<br>C- egg | 11,17 |
| A eat B eat C (linear food chain relationship) | A- animal eater<br>B- plant eater<br>C- plants | 14 |
| All A start with B | A- food chains<br>B- plants | 14 |
| interaction between A and B | A- organisms, e.g., owl<br>B- organisms, e.g., snake | 16 |

TABLE 7A

STUDENT/TEACHER ACTION CONCEPTS

| Student-Teacher Action Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|
| MATERIAL OBJECTS UNIT | | |
| Scientific Processes | | |
| (observation), to observe | objects, plants, animals, material samples, events | 1-30 |
| (description), to describe | objects, plants, animals, material samples, events | 1-30 |
| (comparison), to compare | objects, plants, animals material samples | 8,9,13,18,20,21, 22,23,24,25,26, 29 |
| (sorting), to sort, to group | objects, animals, material samples | 2,3,5,6,7,8,9,10, 11,12,14,15,17, 18 |
| Physical Manipulations | | |
| (mixing), to mix | material samples | 25 |
| (grinding), to grind | material samples | 25 |
| (stirring), to stir | liquids | 26 |
| (pushing), to push | plunger of syringe | 29,30 |
| (pulling), to pull | plunger of syringe | 29,30 |

TABLE 7B

STUDENT/TEACHER ACTION CONCEPTS

| Student-Teacher Action Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|
| ORGANISMS UNIT | | |
| Scientific Processes | | |
| (observation), to observe | organisms, objects, material samples, events | 1-23 |
| (description), to describe | organisms, objects, material samples, events | 1-23 |
| (comparison), to compare | organisms, objects, material samples, events | 6,7,8,9,10,14,16 17,18,19,22,23 |
| (sorting), to sort, to group | organisms | 8,21 |
| Physical Manipulations | | |
| (planting), to plant | seeds | 5,23 |
| (filtration), to filter | algae | 15 |

TABLE 7C

STUDENT/TEACHER ACTION CONCEPTS

| Student-Teacher Action Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|
| LIFE CYCLES UNIT | | |
| Scientific Processes | | |
| (observation), to observe | objects, plants, animals, events | 1-13 |
| (description), to describe | objects, plants, animals events | 1-13 |
| (comparison), to compare | plants, animals, seeds | 2,8,11,12 |
| (counting), to count | plants, animals, seeds, eggs | 1,8,10 |
| Physical Manipulations | | |
| (planting), to plant | seeds | 2,3,4,11 |
| (watering), to water | plants | 3,4,11 |

TABLE 7D

STUDENT/TEACHER ACTION CONCEPTS

| Student-Teacher Action Concepts | Classes Described Or Referred To | Chapter |
|---|---|---|
| POPULATIONS UNIT | | |
| Scientific Processes | | |
| (observation), to observe | plants, animals, materials, objects, events | 1-17 |
| (description), to describe | plants, animals, materials, objects, events | 1-17 |
| (counting), to count | plants, animals | 3,4,8,13 |
| (comparison), to compare | aquarium communities, plants | 4,8 |
| (sorting), to sort | foods (by origin) | 10 |

# REFERENCES

Bessemer, D. W. Concepts and language in K-1 instruction. Technical Note No. TN-2-72-07, 1972, Southwest Regional Laboratory, Los Alamitos, California.

Commission on Science Education, American Association for the Advancment of Science. *Science--a process approach.* New York: Xerox Education Group, 1967, 1968.

Fink, M., Piper, R., & Smith, E. Multivariable analysis of the outcomes of the SWRL music program. Technical Note No. TN-3-71-23, 1971, Southwest Regional Laboratory, Los Alamitos, California.

Karplus, R., & Thier, H. D. *A new look at elementary school science.* Chicago: Rand McNally, 1967.

McClain, J., & Smith, E. Outcomes of the SCIS unit, *material objects.* Technical Note No. TN-2-71-14, 1971, Southwest Regional Laboratory, Los Alamitos, California.

New York University Center for Field Research and School Services. *Conceptually oriented program in elementary science.* New York City: New York University, 1967.

*Science curriculum improvement study.* Boston: Heath, D. C., & Company, 1966, 1968.

Smith, E., & Van Horn, K. R. Conventions for analyzing skill areas in the K-3 curriculum. Technical Note No. TN-2-71-12, 1971, Southwest Regional Laboratory, Los Alamitos, California.

DISTRIBUTION

1 - Babikian

5 - CRC Heads - Design

5 - Directorate

1 - Lester (In the SWRL)

10 - Library

1 - Piper

9 - 202 Staff