Proc. Natl. Sci. Counc. ROC(D)
Vol. 10, No. 2, 2000. pp.61-70

Organization of Biological Concepts in Elementary Science Textbooks

YUEH-SUEY SHIAO

Department of Elementary Education
Taitung Teachers College Taiwan, R. O.C.

(Received July 27, 1999; Accepted March 6, 2000)

Abstract

The purpose of this study was to examine how biological concepts are presented in elementary science textbooks in Taiwan. The concepts chiefly consisted of living things, animals, and plants presented in grades one through four. Fifteen units in the elementary science textbooks (1995) used by all school districts in Taiwan were chosen as the subject of investigation. The three major areas of interest were: (1) the attributes of the three relevant concepts, (2) the development of concepts in terms of content organization and the concepts' connections, repetition, and complexity, and (3) the pedagogical emphasis of the texts. Results indicate that the most commonly mentioned attributes are "habitat," "movement," "growth," "energy source," and "structure." The textbooks organize concepts from a very high-level concept (living things), to lower-level concepts (animals and plants), and then to more specific concepts (e.g., fish and silkworm). However, links among the concepts within a unit or across units are not adequately made. The textbooks present science as a way of thinking, but neglect the application of concepts and lack inquiry based on experiments and students' prior knowledge.

Key Words: concept development, textbook analysis, elementary science

I. Introduction

A growing body of research suggests that concept development is dependent on the content area involved (Carey, 1985; Driver & Easley, 1978). Achievement in science depends, to a great extent, on specific knowledge and prior experience rather than on general levels of cognitive structure (Driver & Easley, 1978).

Despite formal teaching in schools, alternative concepts have been found to be prevalent among students at various grade levels (Driver & Oldham, 1986; Shiao, 1995). Research indicates that the concepts of living things, animals and plants held by fourth grade children in Taiwan are quite different from those of biologists (Shiao, 1995). Students' alternative concepts and incoherent views of the three biological concepts reflect the degree of inadequacy of the current science curriculum and instruction. It is thus important for researchers to study how biological concepts are developed in textbooks, as well as concepts in other fields of science.

In Taiwan, textbooks play a very important role in science teaching and learning. Before 1996 each elementary grade had the same science textbook and fixed class periods, which teachers had to follow precisely. This centralized curriculum was changed in the fall semester of 1996, and first through fourth grade teachers can now choose among science textbook series from different publishers. All current science textbooks must follow the national science curriculum standards established by the Taiwanese government, however, and these standards designate constructivism as one of the major theoretical bases. Information concerning how students construct scientific concepts and how the concepts should be presented in science textbooks at different grade levels is important in the constructivism approach.

However, there is little research on elementary science textbooks available for use in textbook design and improvement. This study thus provides significant

information for the use of curriculum designers and teachers in organizing biological concepts in science textbooks.

II. Purpose

The purpose of this study was to examine how biological concepts are presented in elementary science textbooks in grades one to four in Taiwan. The study focused on the three biological concepts of living things, animals, and plants. Three research questions were asked:

1. Which attributes of concepts related to living things, animals, and plants are addressed in elementary science textbooks in grades one to four in Taiwan?
2. How are these concepts presented in elementary science textbooks?
3. What is the pedagogical emphasis of the elementary science textbooks?

III. Review of Relevant Literature

Researchers working from different perspectives have attempted to explain why children have difficulty understanding scientific concepts. Research on concept learning and science textbooks is reviewed below.

1. Concept Learning

Research shows that concept learning through examples plays an important role in conceptual development, especially in younger children. Kossan (1981) found that 7-year-olds learned more quickly under conditions that required close attention to specific examples than under conditions that required learning a rule for classifying new examples. In contrast, 10-year-olds learned well under both conditions. Since children may have difficulty when confronted with a totally new object, they must have some basis of comparison beyond a simple match. Siegler (1991) pointed out that children have to develop important features and relations to represent concepts. Representations of specific examples are involved in conceptual representation at all ages, but not all conceptual representations may be used at all ages.

Many categories are hierarchical. Typically, there are at least three levels; a general level (a superordinate level), a specific level (a subordinate level), and a level of middling generality (a basic level) (Rosch, Mervis, Gray, Johnson & Boyes-Braem, 1976). For example, “bird” is a basic-level category; “animal” is a superordinate one; and “robin” is a subordinate one.

How do children acquire concepts at different levels of generality? It is possible that children first learn concepts at an intermediate level of generality, later learn more specific terms through differentiation, and learn more general terms through hierarchic integration (Anglin, 1977). Basic-level categories play prominent roles in early conceptual development.

Abdullah and Lowell (1981) investigated the ability of elementary school students to generalize two science concepts, insect and animal, with and without instruction in the form of a mental set. It was found that the children in this study were more able to generalize the insect concept than the animal concept. Children, with age and instruction, were better able to master a less general concept, insect, than a more general one, animal. The study also showed that children were able to improve their ability to generalize a concept if instruction included a great number and a variety of instances and noninstances of the concept.

Investigations have revealed that children first learn category names for objects which are familiar and important to them in their daily lives, and later learn labels for less familiar and less important objects (Anglin, 1977). This seems to be consistent with the finding that frequency of occurrence is the determinant of the order of acquisition of category labels (Abdullah & Lowell, 1981).

Shiao (1995) investigated three biological concepts, living things, animals, and plants held by 24 fourth graders in Taiwan. That study found that most of the fourth graders’ concepts were different from those of biologists. The concept of living things was much more difficult to grasp than the animal or plant concept. Alternative concepts of living things, animals, and plants were prevalent. Animals were viewed as prototypes of living things. Insects were considered not to be a subgroup of animals but rather a group at an equal level to animals. In that study, several students did not even consider plants to be living things.

2. Research on Science Textbooks

Reviews of science textbooks have focused on concept development and pedagogical emphasis in elementary science textbooks.

Tull (1991) analyzed the development of botanical concepts presented in the elementary textbook series Silver Burdett Science, 1985. Concept maps for each unit were used to evaluate the development of concepts with regard to connections between concepts, the complexity of the text, and repetition of topics. Connections between concepts were generally made in the text. The concept maps in textbooks for upper

grades possessed a high degree of complexity. The number of hierarchical levels of concepts varied from two to ten. Unnecessary repetition of topics was found in the textbooks.

In Tull's study, children's botanical concepts were also compared with those presented in the textbooks. It was found that the children had poor understanding of many of the botanical concepts found in the textbooks and lacked scientific classification schemes. The concepts were related to reproduction and differences between living and nonliving things and between plants and animals.

The pedagogical emphasis of the textbooks consisted of the presentation of science as a body of facts rather than as a process, neglected human use of plants and social issues, and lacked inquiry-based experiments.

Staver and Bay (1989) examined the development of concepts in eleven science texts for kindergarten through third grade through concept maps. They found that concepts were developed differently in different texts. The concepts in some texts were more complex than those in others. Reasoning demands were often above the level of the children's cognitive development. While concept maps in some texts indicated that the concepts were not connected, in most texts the concepts were well defined.

The pedagogical emphasis in elementary science textbook series was analyzed based on the recommendations of Project Synthesis. Staver and Bay (1989) found that the texts placed emphasis on academic concept development and provided little coverage of careers in science or the relationship between science and society. Some texts covered the goal of personal needs for some topics. In addition, the texts placed little emphasis on activities and experiments, especially inquiry-based experiments.

Eichinger and Roth (1991) analyzed concept development in the elementary textbook series Silver Burdett & Ginn Science. They first analyzed the overall content organization based on its scope and sequences and then examined how particular topics were developed in and across the second-, third-, and fifth-grade texts. From their analysis of content organization, they found that the science curriculum was organized around topics in particular discipline, such as Life Science or Physical Science. Major topics were generally repeated in successive or alternate years.

Analysis of textbooks by university curriculum experts and elementary school teachers in Eichinger and Roth's study revealed problems in concept development. The textbook series lacked adequate connections among concepts, overemphasized memorization of isolated facts, especially at the upper grade levels, and did not encourage students to apply concepts to different contexts. Another problem was the lack of attention paid to students' prior knowledge.

Based on this review of previous literature, we concluded that most elementary science textbooks are not likely to help students develop a connected and useful understanding of science concepts. This is because the textbooks do not provide much support in linking ideas together, especially in linking science concepts with students' prior knowledge or with social issues.

IV. Method

The elementary science textbook series (1995) selected for this study was used in all elementary schools in Taiwan, with the exception of laboratory schools or classes experimenting with new science curricula. The textbooks were developed based on the standard science curriculum by the Taiwan government in 1974 and revised twice in 1985 and 1989.

A textbook review was conducted to examine how the three biological concepts of living things, animals, and plants were presented in the textbooks for grades one through four. This review had three major areas of interest: the attributes of concepts related to living things, animals, and plants; the development of the three biological concepts in the textbooks; and the pedagogical emphasis of the textbooks. In addition, based on Shiao's (1995) research findings, fourth graders' concepts of living things, animals, and plants were compared with the concepts presented in the elementary science textbooks.

1. Textbook Review Procedures

The textbook review procedure was a modified version of Tull's (1990) method. The topics of the units in the first through fourth grade textbooks connected with the three biological concepts and to their attributes (e.g., "habitat" and "structure") were documented. Attributes were categorized according to the 16 groups of attributes of living things (Table 1), which were developed by Shiao (1995) based on Carey's (1985) groups. Concept maps (Novak & Gowin, 1984) were drawn up for each of the units connected with the three concepts.

All descriptive statements and questions in the 15 units of the first through fourth grade textbooks connected with the three biological concepts were documented. The statements or questions were classified as the two categories of "fact" and "experiment."

Table 1. Categories of Attributes for Living Things

	Group	No.	Subgroup	Example
I	Biologically irrelevant	1	Use	A crayon is not living because it is for drawing.
		2	Fact	A doll is not living because it is a toy.
		3	Existence	The sun is living because it is a natural phenomenon.
		4	Other reasons	A mushroom is living because an encyclopedia said that.
II	Habitat	5	Habitat	The sun is not living because it is in the sky (not on earth).
III	Anthropomorphic trait	6	Anthropomorphic trait	Living things have faces and wisdom.
IV	Movement	7	Movement	A frog is living because it is can jump and swim.
		8	Autonomous movement	A doll is not living because it can not move by itself.
V	Biological characteristics	9	Have life (viability)	A boy is living because he has life.
		10	Growth	A tree is living because it can grow.
		11	Reproduction	A bird is living because it gives birth by bird parents.
		12	Energy source	A river is not living because it can not eat.
		13	Breath	A seed is living because it breaths.
		14	Can respond	A butterfly is living because it has life and can move and respond.
		15	Structure	A crayon is not living because it is made of chemical material.
		16	Member of a group	A bird is not living because it is an animal.

Note: Adopted from Shiao (1995).

Statements or questions that were connected with scientific facts and not related to experiments or activities were classified under the category of “fact,” and those that were connected with experiments or activities were classified as the category of “experiment”. Diagrams in the 15 units were documented separately from statements and questions.

For example, there were several kinds of statements in the unit “Seed Germination.” The statement “There are many kinds of seeds, and let’s sort them” was classified as “experiment”. Another statement, “After seeds sprout, seedlings grow gradually,” was a scientific fact and classified under the category of “fact”. The question “After seeds are soaked in the water, do they get bigger and bigger?” was classified under the category of questions associated with experiments. Two charts presented in this unit measured and compared the growth of seeds after soaking in water. These were classified as “diagrams.”

2. Analysis of the Textbook Data

A list of the attributes of concepts connected with living things, animals, and plants in the first through fourth grade textbooks was analyzed in search of patterns of discussion common to the three concepts.

The content organization of the texts was analyzed using a diagram showing the sequential relationships of all the topics in the units connected with the three concepts for grades one through four. The development in the textbooks for grades one through four of the three biological concepts was analyzed using concept maps. The following aspects of concept development were analyzed:

a. Connections between concepts: Concept maps were used to evaluate connections between interrelated concepts.
b. Levels of complexity: Concept maps were used to examine the number of hierarchical levels used in developing each concept.
c. Repetition: Repetition of concepts was documented.

The relative frequency of questions, facts, experimental directions, and diagrams in the 15 units connected with the three concepts was calculated as a means of analyzing the pedagogical emphasis of the texts. The content of the units was also subjected to qualitative analysis from various perspectives, including students’ prior knowledge, scientific inquiry, links among concepts, development of classification schemes, and application of concepts.

The three biological concepts in the minds of students were compared to those in the textbooks. This comparison focused on the attributes that students considered the three concepts to possess and the attributes of the concepts presented in the textbooks.

V. Results and Discussion

Analysis of the elementary science textbooks used in grades one through four in Taiwan generated descriptions of three main aspects: the attributes of the concepts of living things, animals, and plants; the development of the three concepts in the texts; and the pedagogical emphasis of the texts. In addition, comparison of the children’s concepts with those in the text was also discussed.

Table 2. Attributes Related to the Concepts of Living Things, Animals, and Plants in the Science Textbooks in Taiwan From Grades One Through Four

Grade	Unit name	Major concepts	Attributes related to major concepts
1	aquarium	"living things, nonliving things, animals, plants"	
1	lovely animals	animals	"habitat, food, structure (body)"
1	seeds gemination	seeds	"growth, structure (color, size, shape)"
1	common living things	"living things, animals, plants, flowers, leaves"	"structure (color, size, shape)"
2	small animals	animals	"habitat, movement, structure (shape, legs), behaviors "
2	plant body	"plants, roots, stems, leaves"	"growth, structure (shape)"
2	common animals	"animals, birds, fish"	"habitat, movement, food, structure (fur, fin)"
2	pretty flowers	"flowers, petals, stamen, pistil"	"habitat, structure (shape, color)"
2	let's plant beans	"seeds, flowers, fruit"	"growth, structure (shape)"
3	aquatic plants	"aquatic plants, roots, stems, leaves"	"habitat, structure (shape)"
3	earthworms	earthworms	"habitat, movement, structure (shape)"
3	silkworms	silkworms	"habitat, growth (life cycle), growth (dormancy), " structure (shape)
3	fish	fish	"habitat, movement, breath, structure (shape)"
4	plant transpiration	"roots, stems, leaves, plant transportation"	growth
4	food chains	"food chains, food webs, animals, plants"	food

1. Attributes Related to the Three Concepts

Table 2 summarizes the topics of all 15 units associated with the three concepts in the elementary science textbooks for grades one through four and the attributes related to the three concepts. In the textbooks, the most commonly used attributes of the concepts of living things, animals, and plants were: "habitat," "movement," "growth," "energy source," and "structure." Among these attributes, "structure," especially morphological structure (shape, color, size, or appendages), was the most frequently addressed attribute. The commonly used attributes of the three concepts differed slightly. The texts discuss "structure" and "has life" more often for living things; "habitat", "structure" and "food" more often for animals; and "growth" and "habitat" more often for plants.

All the classification diagrams in the units were based on these attributes, such as six legs ("structure"), eating plants and animals ("energy source"), and member of a group ("are animals or plants"). Four of the 15 units included classification tasks and three contained classification diagrams. In the grade one unit, "Aquarium," there were two similar hierarchical diagrams, one of which divided things in an aquarium into two subgroups, living things and nonliving things, and another divided living things into animal and plant subgroups. The grade two unit "Small Animals" used the same kind of diagram to divide small animals into two subclasses, one with six legs and another without six legs.

Similarly, a diagram with more hierarchical levels was provided in the unit "Food Chain." The first level of classification involved dividing animals (spiders, caterpillars, cat, snakes, roosters, and rabbits) into subgroups of carnivorous or non-carnivorous. The carnivorous subgroup was further divided into two groups by distinguishing animals that eat plants as well as other animals.

The children's attributes for the three concepts (Shiao, 1995) were not very similar to those presented in the textbooks. For many students, "movement" ("can move") was a more important trait of living things than "growth", or "has life," which were emphasized in the textbooks. "Movement" was used much more often as a critical feature of animals than were other attributes. "Movement" ("cannot move"), "growth", "habitat" ("grows in soil") and "has life" were commonly used as defining attributes of plants, but "structure" was not.

2. Concept Development

Concept development in the text was analyzed with a primary focus on content organization and connections, repetition, and the complexity of the three concepts. Concept development was analyzed from the perspective of students' conceptual development.

3. Organization of the Three Concepts

The sequential relationships of the topics of the 15 units connected with the three concepts are shown in Fig. 1, and the major concepts in each topic are presented in Table 3. The data demonstrate that, as the students move from first through fourth grade, biological concepts progress from higher to lower hierarchical levels.

The concepts of living and nonliving things are discussed at the beginning of first grade, and the concept of living things is one of the earliest biological

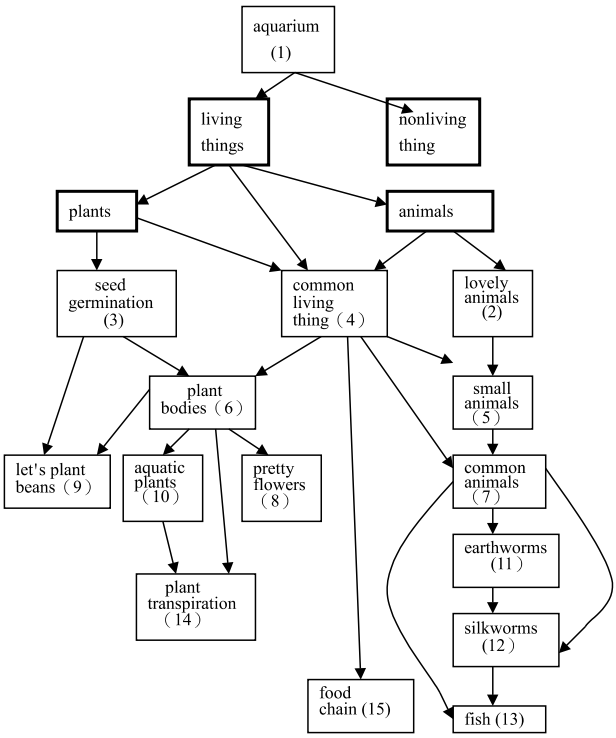

Fig. 1. Development of the concepts of living things, animals, and plants in the elementary science textbooks used in Taiwan from grades one to four.

Note: There is a unit name in a square. Numbers mean the sequence of units related to the three concepts. There is a concept in a bold square.

concepts introduced during elementary school years. More topics concerning animals and plants are studied later in the first and second grades. In the third grade, specific animals, such as earthworms, silkworms, and fish, and specific plants, such as aquatic plants, are studied.

According to the theory of children's concept development (Anglin, 1977; Callanan, 1985) and findings concerning the three concepts among fourth graders (Shiao, 1995), it might be proper for a science text to begin at a basic level with familiar concepts like fish or birds, then introduce higher-level concepts such as animals and plants, and lastly discuss the superordinate-level concept of living things. It appears that students are taught these concepts backward in school.

Connections among the 15 topics concerning the three concepts (Figs. 2-4) were rarely addressed in the texts, although they were mentioned in the teacher's guides. Several topics were connected with the animal concept, including "Lovely Animals" in grade one, "Small Animals" and "Common Animals" in grade two, and "Earthworms," "Silkworms," and "Fish" in grade three. In the "Lovely Animals" unit, examples of various kinds of animals were introduced, including insects, mammals, birds, and reptiles. In "Small Animals," different types of animals, such as insects and earthworms, were introduced; and in "Common Animals" such vertebrates as mammals, birds, and fish were introduced. Earthworms, silkworms, and fish were not linked to any of the previous units. Connections among the units concerning the animal concept were not addressed at all in the texts.

Similarly, three units ("Common Living Things", "Pretty Flowers" and "Let's Plant Beans") concerning plants explicitly discussed the characteristics of flowers. The connections involving the flower concept among the units were not addressed, however. Moreover, no connections were made between the concepts in the two units regarding seed germination, "Seed Germination" and "Let's Plant Beans." Students are apparently expected to perceive and make these connections by themselves.

4. Connections between Concepts

The concept maps (Figs. 2-4) for the 15 units show gaps in the texts between some interrelated concepts. In the unit "Aquarium," links between the shared attributes dividing living things from nonliving things and dividing plants from animals were not explicitly presented (Fig. 2). No questions or proposi-

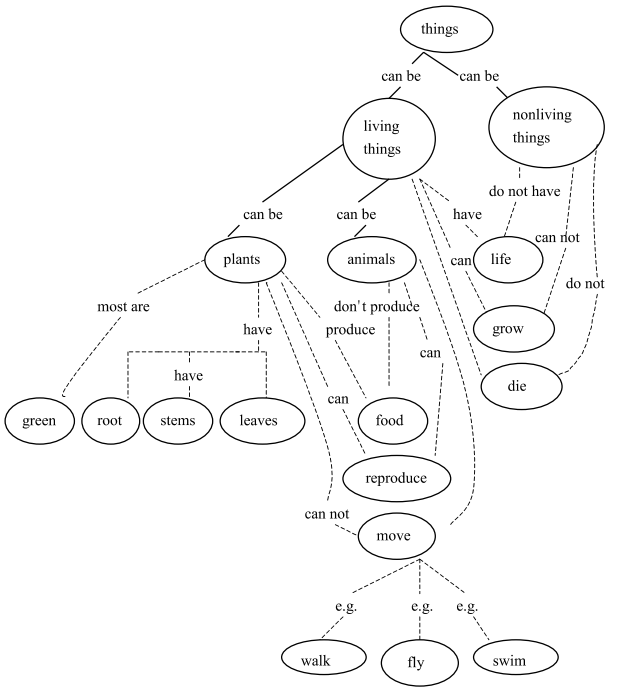

Fig. 2. First Spring, Unit 3, Aquarium.

Note: Straight lines mean that concepts are addressed in the text. Dashed lines mean that concepts are not Explicitly addressed in the text but are in the teacher's guide

tions concerning similarities between animals and plants were presented in the unit. The texts with "Common Living Things" separately discussed the characteristics of animals and plants but did not discuss the common attributes shared by plants and animals and did not review the relationship whereby the category of living things subsumes animals and plants. Thus animals and plant were not connected to living things, and no links were made between plants and animals.

Furthermore, in the grade two unit "Common Animals" the text introduced three kinds of commonly seen animals: mammals, birds, and fish. No connections, such as having a backbone, were made among the three kinds of animals. The term "mammals" was not mentioned, although the characteristics of mammals were addressed. It would be proper to mention "mammal" here, which would make the concept and links to it more clear.

In addition, the relationship between the concepts of flowers and plants was not pointed out in the grade two units "Pretty Flowers" though it was mentioned in the grade one unit "Common Living Things". This conceptual fragmentation may be one of the reasons why the students did not have coherent views of the three concepts (Shiao, 1995). However, material in some of the 15 units was well presented, and connections were made between various levels in hierarchy. "Silkworms" was one of these units. At the beginning of the unit, the text reminded students of the life cycle of bean plants presented in a previous unit, and thus attempted to tie the life cycle of silkworms to students' prior knowledge.

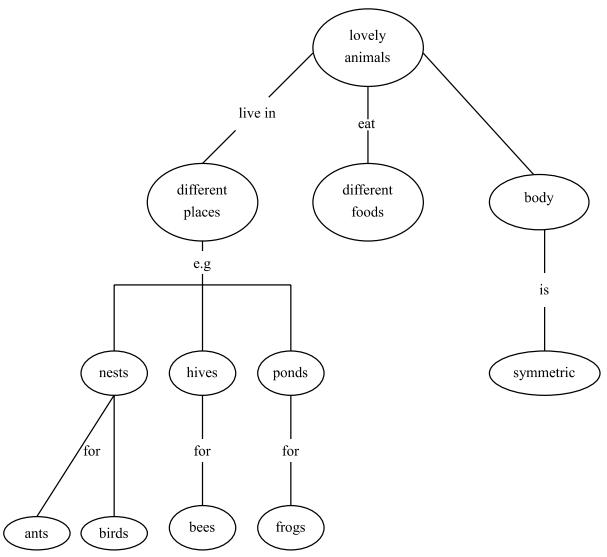

Fig. 3. First Fall, Unit 6, Lovely Animals.

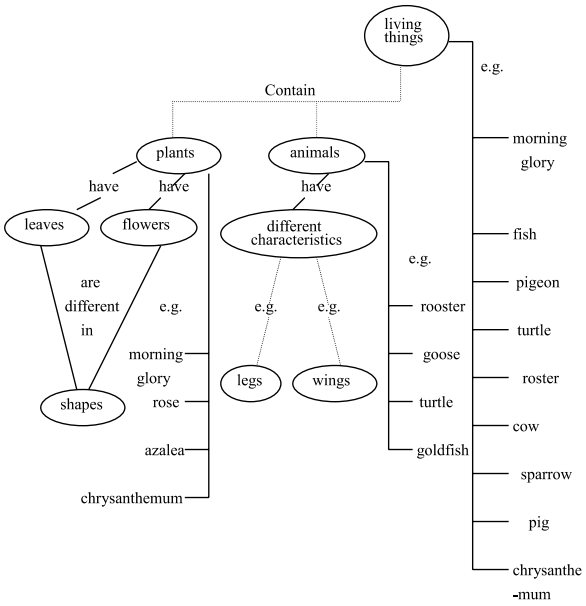

Fig. 4. 1st Spring, Unit7, Common Living Things.
Note: Straight lines mean that the links are described in the text. Dashed lines mean that the links are not described in the text.

5. Repetition of the Three Concepts

The content organization also indicated that the texts are designed to provide students with repeated and regular exposure to the three concepts. For instance, students repeatedly investigated the concepts of plants, leaves, stems and roots in "Plant Body" in grade two, in "Aquatic Plants" in grade 3, and in "Plant Transportation" in grade four (Fig. 1).

A number of examples and attributes of the three concepts were repeated within or across grades. The texts repeated some examples of animals in related units. For instance, fish were mentioned in four units in grades one and two as an example of a living thing and an animal. Similarly, the morphological structures of animals were repeatedly addressed in a general or specific way with different animals.

However, some of the concepts lacked repetition in different contexts. The concept of living things was first introduced in the first grade "Aquarium" unit, and was the only topic to deal with the distinction between living and nonliving things. In this unit, all living things were aquatic. No other unit discussed the difference between living and nonliving things again. This may have misled students into thinking that living things are things that live in water (Shiao, 1995).

Though the concept of living things was repeated

once in the grade one unit “Common Living Things”, connections between living things and plants and animals were not made. The shared attributes of animals and plants were not discussed in that unit, either.

6. Levels of Complexity

The concept maps (Figs. 2-4) revealed the complexity of the material presented in each of the 15 units concerned with the three concepts. In the case of grades one and two, the maps all consist of between three and four hierarchical levels, except for the unit “Let’s Plant Beans” with nine levels. In grades three and four, three to five levels are common, and several concepts have eight to ten levels. For higher grades, the maps become more complex. Most units have less than five hierarchical levels. The textbook authors seem to have kept the relationships among the concepts simple so that students can deal with them.

The unit “Aquarium” probably is very difficult for first graders to comprehend, however. The major concepts include four hierarchical levels. The highest level concept is “things” including living and nonliving things, which are on the second level. For their part, living things consist of animals and plants, which are on the third level. Examples of aquatic animals and plants are at the lowest level. According to Inhelder and Piaget (1964), children have difficulty in developing the relationships between a class and its sub-classes or super-ordinate classes. A relationship with four levels is thus beyond first graders’ comprehension.

7. Pedagogical Emphasis

The texts were very question-oriented. Sixty-one percent of the sentences in the 15 units were questions, 15% were descriptive statements concerning factual scientific knowledge, 20% were experimental directions, and 3% were diagrams (Table 3).

Question-oriented textbooks emphasize science as a way of thinking rather than a body of knowledge. It seems that the authors paid attention to students’ prior knowledge of science concepts by asking many questions. But the texts did not bridge the gaps between children’s concepts and those of scientists, however.

The texts developed biological concepts mainly by asking questions. Questions can motivate students to focus their attention and thinking, and thus can promote learning. However, the answers to the questions, which was the primary content of the texts, were usually not presented in the texts and sometimes explicitly appeared in pictures. Lacking answers to the questions and adequate links between concepts, it would not possible for students to develop a meaningful understanding of the three concepts in the absence of effective

Table 3. The Distributions of Statements in the Units Related to the Three Concepts in Elementary Science Textbooks Used in Taiwan

No.	Grade	Unit no.	Unit name	Questions			Descriptive statement		Dia.	Total
				fact	exp.	total	fact	exp.		
1	1st fall	3	Aquarium	0	6	6	0	0	2	8
2		6	Lovely Animals	4	1	5	0	1	0	6
3	1st spring	5	Seed Germination	0	2	2	1	4	2	9
4		7	Common Living Things	2	0	2	0	3	0	5
5	2nd fall	2	Small Animals	2	5	7	2	1	1	11
6		3	Plant Bodies	1	7	8	2	0	0	10
7		7	Common Animals	12	0	12	0	0	0	12
8	2nd spring	3	Pretty Flowers	0	6	6	0	1	0	7
9		4	Let’s Plant Beans	0	7	7	1	1	0	9
10	3rd fall	2	Aquatic Plants	4	8	12	0	1	0	13
11		4	Earthworms	2	9	11	0	6	0	17
12	3rd spring	2	Silkworms	2	14	16	6	0	0	22
13		4	Fish	2	10	12	3	1	0	16
14	4th fall	3	Plant Transpiration	0	7	7	3	20	0	30
15		7	Food Chains	11	0	11	13	1	2	27
			Total	42	82	124	31	40	7	202
			˜%	21%	41%	61%	15%	20%	3%	100%

“ Exp. - experiment, Dia. - diagram”

instruction.

Overall, 60% of the statements were associated with experiments or activities (Table 3). Experiments were mixed in with the content of the texts, and sought to simultaneously develop students' process skills and concept understanding. It seems that the texts put as much emphasis on process skills as on concepts. However, the experimental procedures usually were presented in the texts, and the students had to follow them while doing experiments. The experiments in the text were used to confirm scientific facts or to provide observations of the facts. Most of the scientific knowledge was not explicitly provided in the texts. The texts lacked inquiry-based experiments.

In most of the classification tasks, the students were just asked to list members in each subgroup. They were not encouraged to develop their own schemes for classifying things, living things, and animals. However, in the unit of "Seed Germination," students could sort seeds in their own ways.

Many familiar examples and pictures of animals and plants were presented in the texts. However, the texts put more emphasis on differences between examples or concepts than on similarities. For example, "How are the features of aquatic plants different from each other?" was asked in the unit "Aquatic Plants." This may have made it difficult for students to make links across examples in a group or related concepts and integrate the defining attributes of concepts.

Instilling a thorough understanding of science concepts means enabling students to apply concepts in different contexts, and does not mean forcing students to memorize isolated concepts or facts (Eichinger and Roth, 1991). Applications of concepts connected with living things, plants, and animals were given little coverage in the texts. Human dependence on plants and animals was not explicitly discussed in the units, except in "Food Chains", which gave some examples showing how people are connected with animals and plants.

VI. Conclusions and Recommendations

An analysis of the science textbooks used in Taiwan in grades one through four has revealed problems in content organization, concept development, and pedagogical emphasis.

The organization of the three concepts went against the trend of children's concept development. It is suggested that the three concepts be organized to progress from more specific concepts (e.g., fish and silkworms), to lower level and less general concepts (animal and plants), and then to the very high and more general level concept of living things.

Based on the development of logical thinking in class inclusion, the three or four levels of hierarchical relationships concerning the three concepts in the first grade unit "Aquarium" were beyond first graders' comprehension. It would therefore be proper to address the concept of living things and its hierarchical relationships with the concepts of animals and plants at a later point in the elementary school years.

Links among the three concepts within a unit or across units were not adequately made in the texts. The texts should provide enough information to allow connections between the three concepts to be made.

The texts presented science as a way of thinking and as a process, but needed to put more emphasis on the application of concepts in different contexts and on inquiry-based experiments. Furthermore, instead of following the given schemes, the texts should have helped students develop their own schemes in classification tasks.

Science textbooks are the major, and often the only, source used by elementary school teachers in Taiwan. The suggestions based on the findings in this study thus may provide essential information on how biological concepts should be presented in elementary school science textbooks.

References

Abdullah, K.B., & Lowell, W. E. (1981). The ability of children to generalize selected science concepts. *Journal of Research in Science Teaching*, **18**(6), 547-555.

Anglin, J. M. (1977). *Word, object, and conceptual development*. New York: W. W. Norton & Company.

Callanan, M. A. (1985). *Object labels and young children's acquisition of categories*. Paper Presented at the Society for Research in Child Development Conference. Toronto, Ontario.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: The MIT Press.

Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education*, **5**, 61-84.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education*, **13**, 105-22.

Eichinger, D., & Roth, K. J. (1991). *Critical analysis of an elementary science curriculum: Bouncing around or connetedness*? East Lansing, MI: Center for the Learning and Teaching of Elementary Subjects.

Inhelnder, B., & Piaget, J. (1969). *The early growth of logic in the child*. New York: W. W. Norton & Company.

Kossan, N. (1981). Developmental differences in concept acquisition strategies. *Child Development*, **52**, 290-298.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge, MA: Cambridge University Press.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, **8**(3) 382-439.

Shiao, Y. S. (1995). *Elementary children's concepts of living things. ani-*

mals and plants in Taiwan. Unpublished doctoral dissertation, University of Iowa.
Siegler, R. S. (1991). *Children's thinking*. Englewood Cliffs, NJ: Prentice Hall.
Staver, J. R., & Bay, M. (1987). Analysis of the project synthesis goal cluster orientation and inquiry emphasis of elementary science textbooks. *Journal of Research in Science Teaching*, **24**(7), 629-643.
Staver, J. R., & Bay, M. (1989). Analysis of the conceptual structure and reasoning demands of elementary science texts at the primary (K-3) level. *Journal of Research in Science Teaching*, **26**(4), 329-349.
Tull, D. I. (1991). *Elementary textbooks versus the child: Conflicting perceptions of biology*. A paper presented at the annual meeting of the National Association for Research in Science Teaching, Lake Geneva, Wisconsin.

國小自然教科書中生物方面的概念發展

蕭月穗

台東師範學院初等教育系

摘 要

此研究探討國小自然教科書中，有關生物方面的概念發展。生物方面的概念，主要包括生物、動物、植物。教科書是民國八十四年，國小所使用的國編本自然。分析一到四年級自然課本中，與生物相關的15個單元。這些單元的概念發展，從三方面來分析：(1) 概念屬性，(2) 單元內容的組織，以及概念的連結性、複雜性、重複性，(3) 教學設計。結果顯示，此三概念常用的屬性爲”運動“、”生長”、”食物”、”構造上特徵”。概念安排，由較高層次概念（生物)，到較低層次的概念（動物、植物)，到更小範圍的概念，譬如魚、蠶。單元內概念間的關連，大都有描述，但是某些概念間的關連沒有提到。有的概念重複出現，但單元間概念的聯繫不夠。內容多以問題方式呈現，但缺少概念的應用。