Learning how to learn

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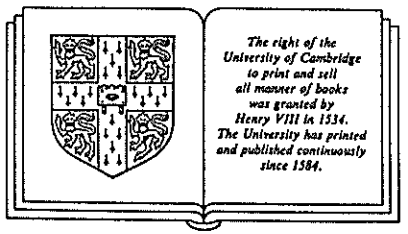

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1

LEARNING ABOUT LEARNING

WHAT IS THIS BOOK ALL ABOUT?

WE ARE CONCERNED with educating people and with helping people learn to educate themselves. We want to help people get better control over the meanings that shape their lives. Educating is powerfully liberating; failures in educating are powerfully oppressive. Wherever educating occurs, in schools and out, we think we can help people get better control over the events of educating, and thus over that part of their lives that is being transformed.

"Seek simplicity, but distrust it," claimed Alfred North Whitehead. We share this view, and desire in seeking simplicity to preserve complexity. Sometimes simple ideas are so obvious they are obscure. We will try to illustrate simple but potentially powerful strategies to help students learn and to help educators organize learning material. The two principal educational tools we will discuss are *concept mapping* (see Figure 1.1), which is a way to help students and educators see the *meanings* of learning materials, and *knowledge Vee diagramming* (see Figure 1.2), which is a way to help students and educators penetrate the *structure* and *meaning* of the knowledge they seek to understand. In addition, we will describe some strategies that help students and teachers move toward what we will call *shared* meanings and feelings. This task is ambitious, but our experiences have shown that it is not unattainable. We invite you to join us in an exploration that is still very much in progress, for we (the authors) and our students are continuing our search for ways to become better teachers and/or learners and to help students learn what it means to learn. This process is symbiotic: illuminated by the teacher and student sharing ideas and advanced by their mutual commitment to educating.

In Chapter 2, we will present a full discussion of concept mapping.

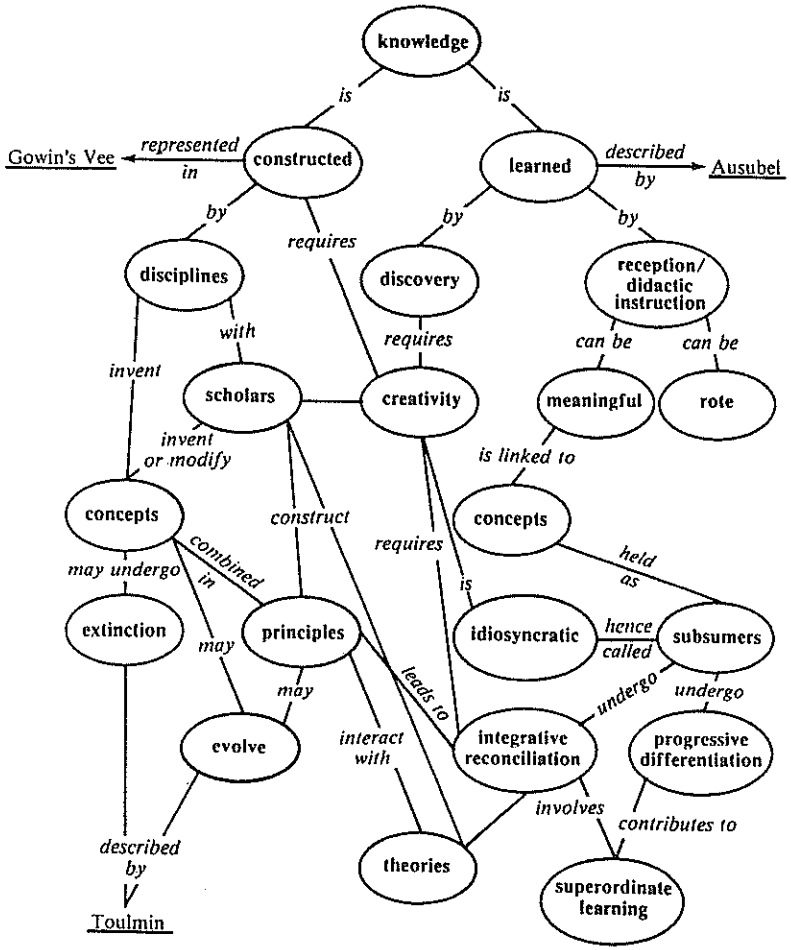


Figure 1.1 A concept map showing the major ideas presented in this book regarding acquisition and construction of knowledge. Key concepts are shown in ovals; appropriate linking words form key propositions.

We provide both practical advice and theoretical perspective, stressing that people think with concepts and that concept maps serve to externalize these concepts and improve their thinking. In Chapter 3, we show that Vee diagramming based on epistemological study of an event is a simple and flexible way to help students and teachers

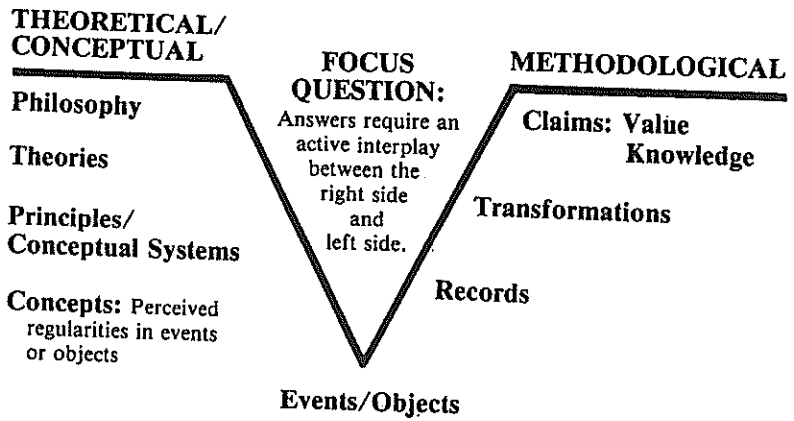


Figure 1.2 Gowin's Vee heuristic invented to illustrate the conceptual and methodological elements that interact in the process of knowledge construction or in the analysis of lectures or documents presenting knowledge.

grasp the structure of knowledge. It has been our experience that once people have tried applying concept mapping and Vee diagramming to familiar material, they see the value and power in these strategies.

For decades it has been debated whether education is an art or a science. We will not enter into this debate, which is somewhat analogous to the debate regarding heredity versus environment as the determinant of human performance. Whatever the detailed issues may have to say to us, our general premise is that education can be both an art (or craft) and a science and that human potential is influenced by both heredity and environment. Because almost no one today advocates eugenics, the only option available to educators is improvement of the learning environment. The strategies presented in this book are based on and derived from theoretical developments in learning psychology and philosophy in much the same way that many new medical, agricultural, or engineering practices are derived from theoretical advances in the sciences. Without belaboring the issues, we try to illustrate the symbiosis that exists between theory development and advances in educational strategies. We will show this relationship in the course of illustrating strategies for helping students understand how knowledge is constructed by human beings – by students, teachers, and scholars.

2

CONCEPT MAPPING FOR MEANINGFUL LEARNING

THE NATURE AND USES OF CONCEPT MAPS

CONCEPT MAPS are intended to represent meaningful relationships between concepts in the form of propositions. *Propositions* are two or more concept labels linked by words in a semantic unit. In its simplest form, a concept map would be just two concepts connected by a linking word to form a proposition. For example, "sky is blue" would represent a simple concept map forming a valid proposition about the concepts "sky" and "blue."

Except for a relatively small number of concepts acquired very early by children through a discovery learning process, most concept meanings are learned through the composite of propositions in which the concept to be acquired is embedded. Although concrete empirical props may facilitate concept learning, the *regularity* represented by the concept label is given additional meaning through propositional statements that include the concept. Thus, "grass is green," "grass is a plant," "grass grows," "grass is a monocot," and so on lead to increasing meaning and precision of meaning for the concept "grass." A concept map is a schematic device for representing a set of concept meanings embedded in a framework of propositions.

Concept maps work to make clear to both students and teachers the small number of key ideas they must focus on for any specific learning task. A map can also provide a kind of visual road map showing some of the pathways we may take to connect meanings of concepts in propositions. After a learning task has been completed, concept maps provide a schematic summary of what has been learned.

Because meaningful learning proceeds most easily when new concepts or concept meanings are subsumed under broader, more inclusive concepts, concept maps should be hierarchical; that is, the more general, more inclusive concepts should be at the top of the map, with progressively more specific, less inclusive concepts arranged below

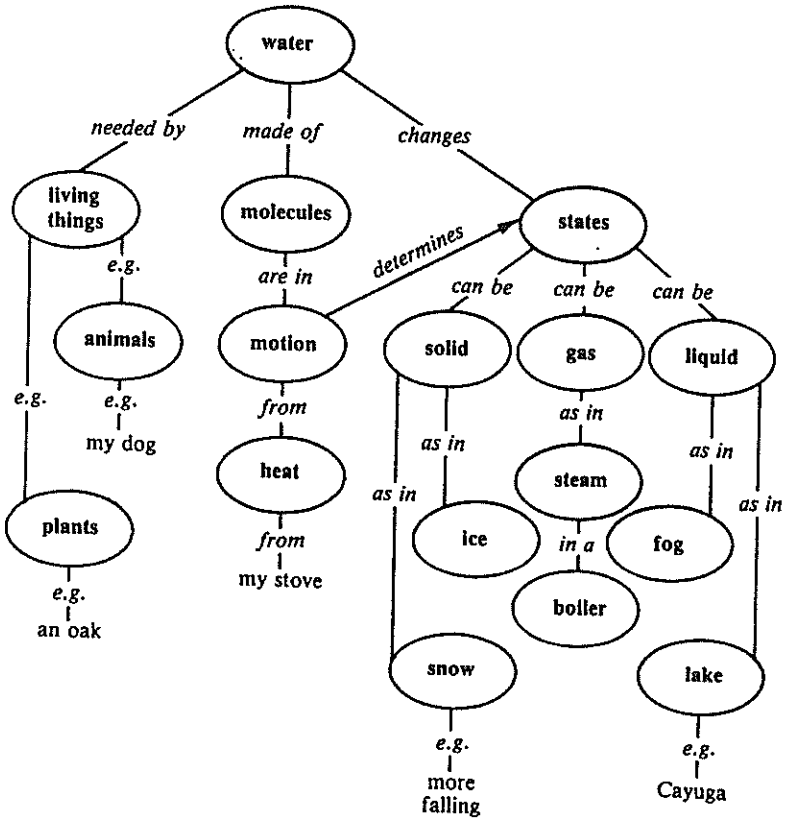


Figure 2.1 A concept map for water showing some related concepts and propositions. Some specific examples of events and objects have been included (in Roman type outside ovals).

them. Figure 2.1 shows such a concept map for water and closely related concepts and Appendix 1 shows a variety of concept maps from several disciplines. As Figure 2.1 shows, it is sometimes helpful to include at the base of the concept map specific objects or events to illustrate the origins of the concept meaning (the regularity being represented).

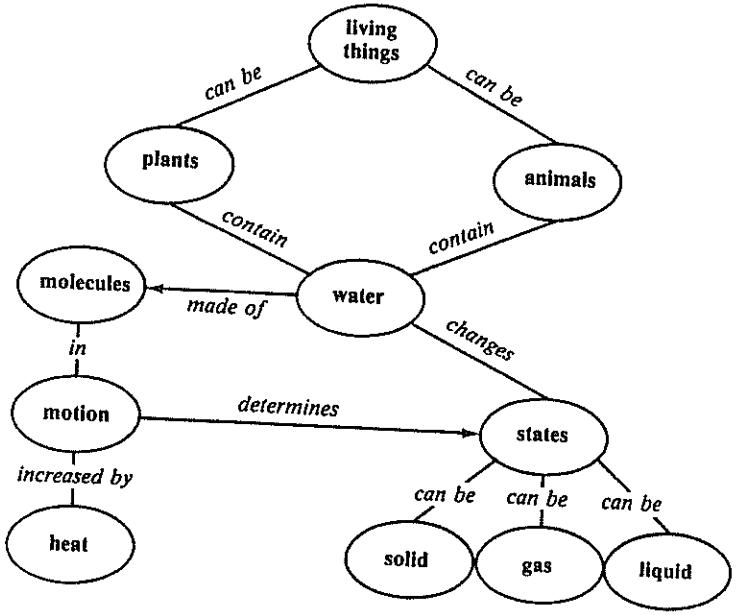
For different learning segments, the superordinate–subordinate relationships of concepts will change, and we therefore sometimes use the analogy of a rubber sheet for a concept map in which almost any concept on the map can be "lifted up" to the superordinate

position, but still retain a meaningful propositional relationship with other concepts on the map. Figure 2.2 shows examples of two "rubber map" configurations.

At first glance it may appear disturbing to see that the same set of concepts can be represented in two or more valid hierarchies. Although we do not understand the specific mechanisms operating in the brain that allow us to store information, it is clear that the neural networks that become established are complex, with many cross connections between functioning brain cells. These networks may account in part for the alternative patterns of meanings available to us when we employ stored concepts to perceive meanings. A somewhat similar phenomenon may be occurring as we shift our visual attention to perceive either a pair of faces or a goblet in the familiar illustration shown in Figure 2.3. Until further advances take place in our understanding of the neurobiology of memory processes, we are limited to models that merely describe the psychological processes that operate in learning and recall of meaningful materials.

Concept mapping is a technique for externalizing concepts and propositions. How accurately concept maps represent either the concepts we possess or the range of relationships between concepts we know (and can express as propositions) can only be conjecture at this time. Undoubtedly, we may develop new concept relationships in the process of drawing concept maps, especially if we seek actively to construct propositional relationships between concepts that were not previously recognized as related: Students and teachers constructing concept maps often remark that they recognize new relationships and hence new meanings (or at least meanings they did not consciously hold before making the map). In this sense, concept mapping can be a creative activity and may help to foster creativity.

The aspect of learning that is distinctly human is our remarkable capacity for using written or spoken symbols to represent perceived regularities in events or objects around us. Language is so much a part of our daily lives that we tend to take it for granted and not to stop and think about how useful language is for translating commonly recognized regularities into code words we can use to describe our thoughts, feelings, and actions. An awareness of the explicit role language plays in the exchange of information is central to understanding the value and purpose of concept mapping and, indeed, central to educating. Educative value is experienced when we recognize that we have grasped a new meaning and feel the emotion



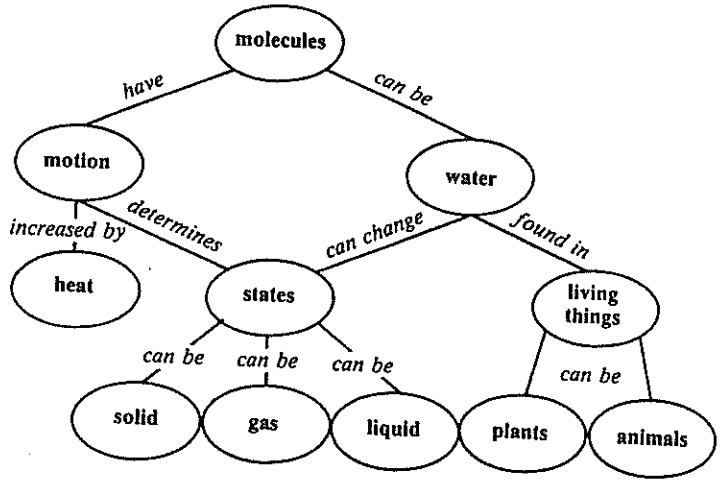


Figure 2.2 Two "rubber map" configurations showing eleven of the concepts in Figure 2.1 in new hierarchical arrangements.

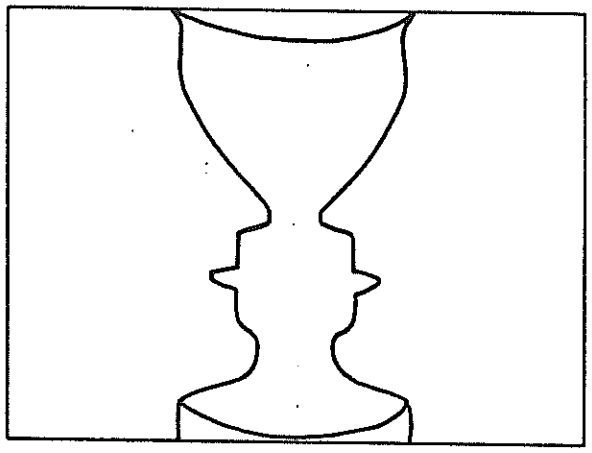


Figure 2.3 Perceptual shift illustrated by reversing figures.

that accompanies this realization. This educative regularity, called *felt significance,* is experienced by the learner to a greater or lesser extent depending on the profundity of the new concept or propositional relationships grasped and their impact on his or her perceptions of related concept meanings. Usually the feelings are positive, but occasionally they may be negative feelings or feelings of fear if we recognize how wrong some of our previous conceptions may have been or how truly ignorant we are about some topic or subject. This fear is a human capacity that we must recognize and encourage as an expression of felt significance.

Ideas that are novel, powerful, and profound are very difficult for us to think about; we need time and some mediating activity to help us. Reflective thinking is controlled doing, involving a pushing and pulling of concepts, putting them together and separating them again. Students need practice in reflective thinking just as teams need time to practice a sport. The making and remaking of concept maps and sharing them with others can be seen as a team effort in the sport of thinking. The computer programs we are now developing may facilitate such practice in thinking with concept maps.

Because concept maps are an explicit, overt representation of the concepts and propositions a person holds, they allow teachers and learners to exchange views on why a particular propositional linkage is good or valid, or to recognize missing linkages between concepts

that suggest a need for new learning. Because they contain externalized expressions of propositions, we have frequently found that concept maps are remarkably effective tools for showing misconceptions.[1] Misconceptions are usually signaled either by a linkage between two concepts that leads to a clearly false proposition or by a linkage that misses the key idea relating two or more concepts. Figure 2.4 shows examples of missing or faulty conceptions identified in an interview dealing with phases of the moon.

We have found it helpful to think about concept maps as tools for negotiating meanings. What do we mean by negotiating meanings? Let us pause to look at the definition of *negotiate:*

> to confer with another so as to arrive at the settlement of some matter . . . to deal with (some matter or affair that requires ability for its successful handling): MANAGE . . . to arrange for or bring about through conference, discussion, and compromise (a treaty).[2]

At first glance one may say that if the teacher (or textbook) is supposed to know what is right, how can we suggest that there should be negotiation with the learner? But our answer is that we are speaking about cognitive meanings, which cannot be transferred into students as blood is pumped into veins. Learning the meaning of a piece of knowledge requires dialog, exchange, sharing, and sometimes compromise.

Note that we do not speak about sharing learning. Learning is an activity that cannot be shared; it is rather a matter of individual responsibility. Meanings, on the other hand, can be shared, discussed, negotiated, and agreed upon. When concept mapping is done in groups of two or three students, it can serve a useful social function and also lead to lively classroom discussion. Figure 2.5 shows one of the first concept maps prepared in a junior high school science class. A group of three children shared their ideas on the meaning of a specific textbook passage and jointly constructed this map. Fre-

1 Misconception is the term commonly used to describe an unaccepted (and not necessarily "wrong") interpretation of a concept illustrated in the statement in which the concept is embedded. The expressed meaning is not, however, a misconception to the person who holds it, but a functional meaning. Partly for this reason, misconceptions are remarkably stable and may persist for years (see Novak in press). Research suggests that the best method for correcting a misconception is to identify one or more missing concepts that, when integrated into the individual's conceptual framework, will obliterate the misconception.

2 *Webster's Ninth New Collegiate Dictionary* (1983).

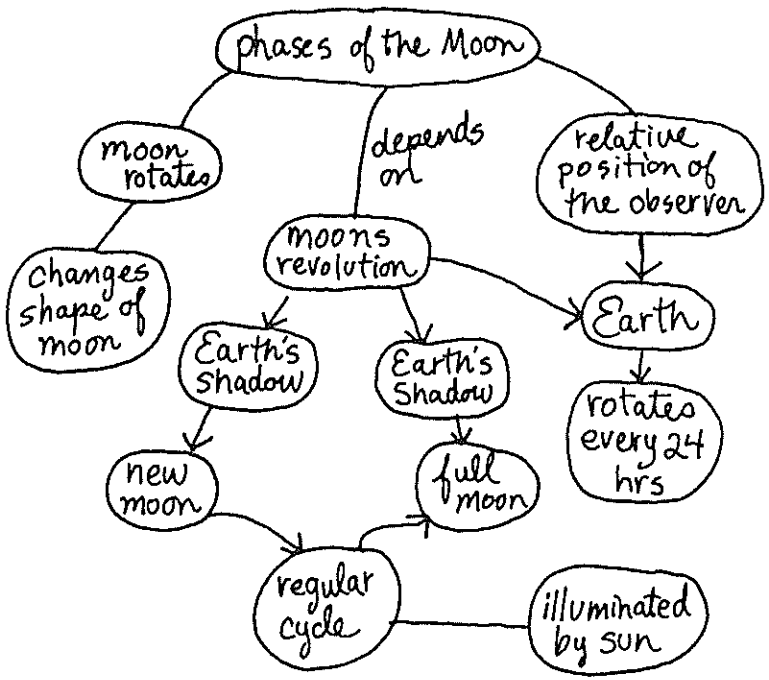


Figure 2.4 A concept map drawn from an interview, showing that this student held the faulty conceptions that the moon's rotation changes the shape (phases) of the moon and that the earth's shadows produce those phases – concepts dealing with the relative positions of the earth and the moon with respect to the sun were missing from the student's conceptual framework.

quently students will (properly) detect ambiguities or inconsistencies in text material and it is helpful for the teacher to step in and clarify concepts or propositions not well presented in the text. It is supportive for students to learn that they are not dull or stupid, but rather that the texts can fail to provide the knowledge needed for shared meaning.

The most important point to remember about sharing meanings in the context of educating is that students always bring something of their own to the negotiation; they are not a blank tablet to be written on or an empty container to be filled. In a manner analogous to the way a professional negotiator may help to bring labor and

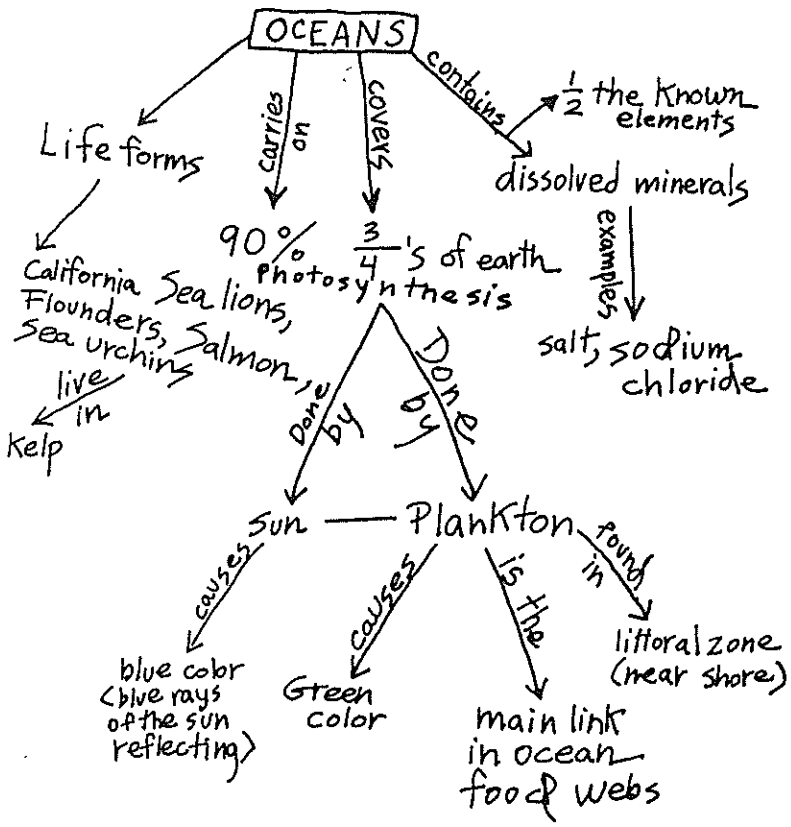


Figure 2.5 A concept map prepared from a science textbook by three seventh-grade students working together.

management together on a contract, concept maps are useful to help students negotiate meanings with their mentors. We will explore this idea further at other points in the book (as we seek to negotiate meanings with the reader). Whatever students have learned before needs to be used to fuel new learning. Both teachers and students need to recognize the value of prior knowledge to acquiring new knowledge.

Referring back to our discussion in Chapter 1 of Schwab's (1973) four commonplaces, we now see that concept maps can play a role

in teaching, learning, curriculum, and governance. For the learner, they help to make evident the key concepts or propositions to be learned, and also suggest linkages between the new knowledge and what he or she already knows. For the teacher, concept maps can be used to determine pathways for organizing meanings and for negotiating meanings with students, as well as to point out students' misconceptions. In curriculum planning and organization, concept maps are useful for separating significant from trivial information and for choosing examples. With respect to governance, concept maps help students understand their role as learners; they also clarify the teacher's role and create a learning atmosphere of mutual respect. Concept maps can foster cooperation between student and teacher (or child and school) in a battle in which the "monster" to be conquered is meaninglessness of information and victory is shared meaning.

Once students learn how to prepare concept maps, their maps can be used as powerful evaluation tools. In his *Taxonomy of Educational Objectives* (1956), Bloom outlined six "levels" of objectives in education.[3] It is easy to write objective questions that test whether or not what Bloom called Level I objectives – rote recall of specific information – have been met. But it is exceedingly difficult to design a test to determine whether new knowledge has been analyzed, synthesized, and evaluated by students (Bloom's Level IV–VI objectives). Concept mapping, because it requires students to perform on all six "levels" in one composite effort, makes such evaluation possible. As we will assert in Chapter 5, concept maps' most significant contribution to the improvement of educating may be the ultimate improvement of evaluation techniques, especially as they are applied in research.

Research in most fields is limited by the measurement tools available. We believe one reason educational research has made relatively little progress in the past eighty years has been the serious limitations of our measurement tools (which are mostly objective paper-and-pencil tests). Although Piaget's clinical interview has been proven useful in some settings, it has serious limitations as an evaluation device for large groups and the variety of learning objectives to be

3 The validity of the six levels of Bloom's taxonomy has been widely and justifiably criticized. We refer to this work only because it is widely cited in educational literature and because it is well recognized that evaluation of "higher" objectives is at best difficult.

assessed. Concept maps and Vee diagrams can be used to design better interviews, as we will show in Chapter 7, and to improve evaluation in research studies, as we will discuss in Chapter 8.

Our work has also shown concept maps to be useful in curriculum planning and in the design of instruction and educational research, and later chapters will be devoted to discussing their roles in these contexts.

HOW TO INTRODUCE STUDENTS TO CONCEPT MAPPING

As with any act of teaching, there is no one best way to introduce concept mapping. We will present several approaches, all of which have been tried, in one setting or another, and all of which show promise.

In every case, we began by introducing students to the idea of a concept. This introduction can be in the form of a set of activities dealing with learning and memory that we have developed and used with students from junior high school through college, or the idea can be introduced more simply by directly defining concepts, objects, events, and regularities. Table 2.1 shows some of the ways we have found successful for introducing concept mapping to children in grades one to three; Table 2.2 shows strategies that are successful from grades three to seven; and Table 2.3 shows those successful with students from grade seven through college. Although readers will want to examine the table(s) carefully for the age level with which they are most concerned, we will focus our attention on common threads that run through each of these sets of activities.

First, we are advancing the idea that the best way to help students learn meaningfully is to help them explicitly to see the nature and role of concepts and the relationship between concepts as they exist in their minds and as they exist "out there" in the world or in printed or spoken instruction. This is a simple but profound idea; it may take months or years for students to recognize that what they hear, see, touch, or smell is in part dependent on the concepts they have in their minds. This aim is basic to a program to help students learn how to learn.

Second, we are advocating procedures that will help students to extract specific concepts (words) from printed or oral material and

Table 2.1. *Strategies for introducing concept mapping in grades one to three*

A. *Activities to prepare for concept mapping*

1. Have children close their eyes and ask them if they see a picture in their mind when you recite familiar words, e.g., dog, chair, and grass. Use "object" words at first.
2. Print each word on the board after the children respond. Ask children for more examples.
3. Now continue with "event" words such as raining, skipping, and sewing, and ask children for more examples, writing words on the board.
4. Give the children a few words that are unfamiliar and ask them if they see a picture in their mind. (Scan through a dictionary and find short words that are likely to be unfamiliar to all children, such as "concept.")
5. Help the children recognize that words convey meaning to them when they represent pictures or meanings in their minds.
6. If you have bilingual students in your class, you might introduce a few familiar foreign words to illustrate that different peoples use different labels for the same meaning.
7. Introduce the word *concept* and explain that concept is the word we use to mean some kind of object or event "picture." Review some of the words on the board and ask if these are all concepts; ask if these all bring a picture to mind.
8. Write words on the board such as the, is, are, when, that, then. Ask if these words bring a picture to mind. Children should recognize that those are not *concept* words; they are *linking* words we use in language to link concept words together into sentences that have special meaning.
9. Label your examples "linking words" and ask students for additional examples.
10. Construct short sentences with two concepts and a linking word, e.g., sky is blue, chairs are hard, pencils have lead.
11. Explain to children that most of the words in the dictionary are concept words. (You might have them circle concept words duplicated from a child's dictionary.) Written and spoken language (except that of very young children) uses concept words and linking words.
12. Point out that some words are proper nouns. Names of specific people, places, or things are not concepts.
13. Have children construct some short sentences of their own using

Table 2.1. *(cont.)*

the concept and linking words on the board and some of their own words if they wish.

14. Have one child read a sentence and ask other children which are the concept words and the linking word(s).
15. Introduce the children to the idea that reading is learning how to recognize printed labels for concepts and linking words. Ask if it is easier to read words for which they have a concept in their mind. Point to examples presented earlier of the familiar and unfamiliar concepts and to words such as when, then, while, and there and ask which are usually easiest to read.

B. Concept mapping activities

1. Make a list of 10 to 12 related and familiar concept words, organizing these from more general, more inclusive concepts to less general, more specific concepts: For example, plant, stem, root, leaves, flowers, sunlight, green, petals, red, water, air would be a good set of related concepts.
2. Build a concept map on the board or overhead projector and introduce this as, perhaps, a "game we are going to learn to play with words, called concept mapping." See Appendix I for one example of a concept map made from the eleven concepts listed above.
3. Have the children recite some of the short sentences (propositions) shown on the map.
4. Ask if anyone knows a way to connect other concepts to the map, such as water, soil (or dirt), yellow, smell, carrot, cabbage.
5. See if anyone can suggest a cross link between the concepts added and other concepts on the map.
6. Have children copy the map from the board and add two to three of their own concepts (and cross links if they can).
7. Give children lists of related words and have them construct their own concept maps. Appendix I shows lists of words and sample concept maps constructed by first-grade children. Children were given the option of choosing which list of words they wanted to map.
8. If space permits, have children show their concept maps on the board and ask a few to explain the story their concept map tells. Avoid criticism of concept maps at this point and overemphasize positive attributes to help make concept mapping a positive affective experience. You will probably find that students who often do poorly in other classwork will make good concept maps

Table 2.1. *(cont.)*

with good cross links (albeit they may misspell words or write illegibly). This would be a good opportunity to encourage these children. If space is limited, concept map papers might be taped up on walls or cabinets for children (and perhaps parents) to observe and share.

9. Take some time to point out positive features of children's concept maps, e.g., especially good hierarchies or interesting cross links.
10. Select a short (10–30 sentence) familiar story or section from reading materials and duplicate copies for all children. Help them to identify some of the concept words in the story and some of the linking words. Select a passage that has some meaning, that is, some message about the world or about people.
11. Ask the children which concepts are most needed to tell what the story is all about, and have them circle the key concepts in their copy of the text.
12. Have children prepare a list of concepts from the story, listing first the concepts that are most important in the story and going down the list to concepts that are less important.
13. Discuss the children's list and then construct with them a concept map for the story. Appendix I shows an example of how this can be done.
14. Have the children construct their own concept map for the story, using activities similar to those for concept maps constructed from word lists.
15. Choose new stories (two or more) and duplicate copies for the children. Have children select stories and replicate activities done as a class: circle key concept words; prepare a list of concept words from most important to least important; and draw a concept map for their story.
16. Have some children read their stories to the class using only their concept map. See if the class can determine what the story is about.
17. Concept maps for each child could be posted about the room, together with the stories, for other people to see.
18. Have the children prepare a concept map for something they know most about (e.g., baseball, violin, swimming, autos) and present it to the class. An overhead projector would be helpful here, with children preparing transparencies before class, or you could have a few children each day draw their maps on the board. As with other maps, emphasize positive attributes and

Table 2.1. *(cont.)*

avoid negative criticism (other children usually offer plenty of this).
19. Have children write a short story based on their concept maps. Some of these might be read to the class.
20. From here on, almost any classroom activity should be relatable to concepts and concept maps. You might encourage children to paper the walls of their rooms at home with their own concept maps. Also, help them to see that one concept map can be linked to another and that all of the concepts we have are in at least some remote way linked to each other. This cross linking is what makes us "smart."

to identify relationships among those concepts. Here it is necessary to isolate *concepts* and *linking words* and to recognize that although both are important language units, they have different roles in conveying meaning.

A third key idea we want to express is that concept maps present a way to visualize concepts and the hierarchical relationships between them. Whereas most humans have a notoriously poor memory for recall of specific details, their capacity for recall of specific visual images is remarkable – we can easily recognize our close friends in a gathering of hundreds or in a photograph of a group. It would be extraordinarily difficult to program a sophisticated computer to make similarly reliable recognitions. Concept mapping has a potential for enlisting this human capacity for recognizing patterns in images to facilitate learning and recall. Much research is needed on this issue, and we hope this book will stimulate it. It would, of course, be disastrous if teachers expected students to memorize concept maps and be able to reproduce them in content, structure, and detail precisely as they were shown to the class. This would require the most demanding kind of rote recall, the polar opposite of the type of learning activity we are trying to encourage. We do not mean that any kind of concept map is as good as any other. In Table 2.4 we offer specific suggestions for evaluating concept maps, and we will discuss the use of concept maps for evaluation of learning further in Chapter 5.

We also want to emphasize that concept maps become increasingly more useful as students become more proficient at labeling the

Table 2.2. *Strategies for introducing concept mapping in grades three to seven*

A. Activities to prepare for concept mapping
1. Make two lists of words on the blackboard or overhead projector using a list of familiar words for objects and another list for events. For example, object words might be car, dog, chair, tree, cloud, book; and event words could be raining, playing, washing, thinking, thunder, birthday party. Ask children if they can describe how the two lists differ.
2. Ask the children to describe what they think of when they hear the word car, dog, etc. Help them recognize that even though we use the same words, each of us may think of something a little different. These mental images we have for words are our *concepts;* introduce the word concept.
3. Repeat the activities in step 2, using event words. Again, point out the differences in our mental images, or concepts, of events. You may want to suggest at this point that one reason we have trouble understanding each other sometimes is that our concepts are never quite identical even though we know the same words. Words are labels for concepts, but each of us must acquire our own meanings for words.
4. Now list words such as are, where, the, is, then, with. Ask children what comes to their minds when they hear each of these words. These are not concept words; we call them *linking* words and we use them in speaking and writing. Linking words are used together with concept words to construct sentences that have meaning.
5. Proper nouns are not concept words but rather names of specific people, events, places, or objects. Use some examples and help children to see the distinction between labels for *regularities* in events or objects and those for specific events or objects (or proper nouns).
6. Using two concept words and linking word(s), construct a few short sentences on the board to illustrate how concept words plus linking words are used by humans to convey meanings. Examples would be: The dog is running. or, There are clouds and thunder.
7. Have the students construct a few short sentences of their own, identify the concept words and tell whether each is an object or event, and also identify the linking words.
8. If you have bilingual children in the class, have them present some foreign words that label the same events or objects. Help

Table 2.2. *(cont.)*

the children recognize that language does not make the concept but only serves as the label we use for the concept. If we learn words but fail to learn what kind of regularity in objects or events the words represent, we have not learned new concepts.

9. Introduce some short but unfamiliar words to the class such as dire, terse, or *canis*. These are words that stand for concepts they already know, but have somewhat special meaning. Help children see that meanings of concepts are not rigid and fixed, but can grow and change as we learn more.
10. Choose a section of a textbook (one page is sufficient) and duplicate copies for the children. Choose a passage that conveys a definite message. As a class, ask them to read the passage and identify key concepts. (Usually 10 to 20 relevant concepts can be found in a single page of text material.) Also have the children note some linking words and concept words that are less important to the story line.

B. Concept mapping activities

1. Have the children rank order the concepts they have found in a text page from most general, most inclusive to least general, least inclusive. Their lists may vary, but they should recognize that some concepts are more salient to the story line than others. Now help them to construct a concept map using the concepts from their lists. This might be done on the blackboard.
2. For homework or seatwork, choose several other text passages and have students construct a map (using steps 9 and 10). There is value in having two or more children map the same text selection and later compare maps. We have also found it helpful to have students work in twos or threes to construct a map; much good discussion among students can occur. Individual or group maps can be put on the board or overhead projector and explained to the class.
3. A good way to help students recognize that good maps capture the essential meanings in a text is to have them read their map as a story one or two days after it was completed. Students who construct good maps will show remarkable fidelity in reproducing the meaning of text, even though they have not memorized the text.

Table 2.2. *(cont.)*

4. Make up two or more lists of concept words from some topic recently discussed in class. The words should be related, that is, they should have relevance to a common theme. Let students choose the topic of the word list and then have them repeat step 1 above.
5. After each student has constructed a few maps, it would be useful to introduce them to scoring procedures given in Table 2.4. Take one of the group-constructed maps and show them how it would be scored. Table 2.4 shows a sample of a map scored according to the criteria. Have students score one of their own concept maps and, showing the map on the board or overhead projector, ask a few students to explain their scoring values.
6. Have a "progress discussion" with the class:
   a. Review with them the definitions of concept, object, events, linking words, proper nouns.
   b. Remind them that some concepts, such as ice skate, volcanic explosion, or high achiever, are labeled by two or more words, even though they comprise simpler, more general concepts.
   c. Discuss the idea that we learn best when we tie new concepts to concepts we already have.
   d. Point out that hierarchically constructed maps help to subsume more specific concept meanings into larger, more general concepts.
   e. Help them to see that cross links on their maps mean they are tying together concepts that might not otherwise be seen as related. This cross tying or integrating of concept meanings favors retention and later use of concepts, especially in problem solving or creating new materials (new stories, poems, music, or experiments).
   f. Discuss alternative weightings for criteria in the scoring key and perhaps construct your own alternative key for scoring concept maps.
7. Discuss students' feelings about concept mapping, rote learning, and meaningful learning.

Table 2.3. *Strategies for introducing concept mapping in grades seven through college*

A. Activities to prepare for concept mapping

1. Make two lists of words on the blackboard or overhead projector using a list of familiar words for objects and another list for events. For example, object words might be car, dog, chair, tree, cloud, book; and event words could be raining, playing, washing, thinking, thunder, birthday party. Ask the students if they can describe how the two lists differ. Try to help them recognize that the first list is things or *objects* and the second list is happenings or *events,* and label the two lists.
2. Ask the students to describe what they think of when they hear the word car, dog, etc. Help them recognize that even though we use the same words, each of us may think of something a little different. These mental images we have for words are our *concepts;* introduce the word concept.
3. Repeat the activities in step 2, using event words. Again, point out the differences in our mental images, or concepts, of events. You may want to suggest at this point that one reason we have trouble understanding each other sometimes is that our concepts are never quite identical even though we know the same words. Words are labels for concepts, but each of us must acquire our own meanings for words.
4. Now list words such as are, where, the, is, then, with. Ask students what comes to their minds when they hear each of these words. These are not *concept* words; we call them *linking* words and we use them in speaking and writing. Linking words are used together with concept words to construct sentences that have meaning.
5. Proper nouns are not concept words but rather names of specific people, events, places, or objects. Use some examples and help students to see the distinction between labels for *regularities* in events or objects and those for specific events or objects (or proper nouns).
6. Using two concept words and linking word(s), construct a few short sentences on the board to illustrate how concept words plus linking words are used by humans to convey meanings. Examples would be: The dog is running. or, There are clouds and thunder.
7. Have students construct a few short sentences of their own, identify the concept words and tell whether each is an object or event, and also identify the linking words.

Table 2.3. *(cont.)*

8. If you have bilingual students in the class, have them present some foreign words that label the same events or objects. Help the students recognize that language does not make the concept, but only serves as the label we use for the concept.
9. Introduce some short but unfamiliar words to the class such as dire, terse, or *canis*. These are words that stand for concepts they already know, but have somewhat special meaning. Help students see that meanings of concepts are not rigid and fixed, but can grow and change as we learn more.
10. Choose a section of a textbook (one page is sufficient) and duplicate copies for the students. Choose a passage that conveys a definite message. As a class, ask them to read the passage and identify key concepts. (Usually 10 to 20 relevant concepts can be found in a single page of text material.) Also have the students note some linking words and concept words that are less important to the story line.

B. Concept mapping activities

1. Select a particularly meaningful paragraph or two from a text or other printed material. Have the students read the text and select the key concepts, that is, those concepts necessary for understanding the meaning of the text. List these concepts on the board (or overhead projector) as they are identified. Now discuss with the students which concept is the most important, most inclusive idea in the text.
2. Put the most inclusive concept at the head of a new list of rank-ordered concepts. List the next most general, most inclusive concepts, working through the first list until all concepts are rank ordered. There will not always be agreement among the students on the ordering, but usually only a few major differences in ranking of the concepts will arise. This is OK because it suggests that there may be more than one way to see the meaning of the text.
3. Now begin constructing a concept map, using the rank-ordered list as a guide in building the concept hierarchy. Have students help in choosing good linking words to form the propositions shown by the lines on the map. One good way to have them practice map making is to have students write concept words and linking words on paper rectangles and then rearrange these rectangles as they get new insights on the map organization. (See Figure 2.10.)

Table 2.3. *(cont.)*

4. Now look for cross links between concepts in one section of the map and concepts in another part of the concept "tree." Have students help to choose linking words for the cross links.
5. Most first effort maps have poor symmetry or some concept clusters poorly located relative to other more closely related concepts or clusters of concepts. Reconstruct the map if this would be helpful. Point out to students that at least one and sometimes two or three reconstructions of a map are needed to show a good representation of propositional meanings as they understand them.
6. Discuss the concept map scoring criteria in Table 2.4 and score the concept map constructed. Point out possible structural changes that might improve the meaning, and perhaps the score, of the map.
7. Have the students select a section of text or other material and repeat steps 1–6 on their own (or in groups of two or three).
8. Student-constructed maps can be presented to the class on the blackboard or overhead projector. "Reading" the map should make clear to other students in the class what the text was about, as interpreted by the map maker.
9. Have students construct a concept map for ideas important in a hobby, sport, or special interest they have. These might be posted around the room and informal discussion encouraged.
10. Incorporate one or two concept mapping questions in your next test to illustrate that concept mapping is a valid evaluation procedure that demands hard thinking and can illustrate understanding of the subject matter.

lines. When we first used concept maps, we seldom labeled lines on the assumption that whoever "read" a map could fill in satisfactory linking words. This proved to be true, however, only for persons thoroughly familiar with the learning activities the specific concept map was concerned with; it soon became apparent that most others, even those who knew much about the subject matter and about school settings similar to ours, could not make sense out of many of our maps. We now consider careful attention to the words selected to link concepts an essential aspect of instruction in concept mapping. This is not to suggest that one and only one correct linking word

exists. Often there are two or three equally valid ways to link two concepts, but each will have a slightly different connotation. For example, if we link the concepts *water* and *ice* with words such as *can be, becomes, sometimes is,* each proposition thus generated has a similar but not identical meaning. The changes in meaning become even more conspicuous when other, related concepts are linked to water and/or ice. If we add the concept *molecule* to our map, new relationships and new meanings involving ice, water, and molecules can be shown. Concept maps are thus powerful tools for observing the nuances of meaning a student holds for the concepts embedded in his or her map. When concept maps are conscientiously constructed, they are remarkably revealing of students' cognitive organization.

Sometimes it is useful to apply arrows to linking lines to show that the meaning relationship expressed by the linking word(s) and concepts is primarily in one direction. Ordinarily, hierarchical maps imply relationships between higher level concepts and subordinate ones. To reduce clutter on the map, we use the convention that no arrows are shown unless the relationship indicated is something other than a superordinate to subordinate linkage between two concepts. This convention also helps to accentuate the directionality of those relationships that are linked by arrows. Figure 2.6 shows a sample concept map drawn with arrows indicating some relationships.

Concept maps need to be redrawn. The first concept map a person makes is almost certain to have flaws: It may have been difficult to show important hierarchical relationships between concepts, or some concepts closely linked in meaning with others may be on the wrong side of the map so that the cross-link lines go all over the paper. We find that a second map usually shows key relationships more explicitly. Most students will not have the patience or interest to try a third or fourth version of their map for a topic, but they should be encouraged at least to make a second version.

A secondary important reason for redrawing maps is to clean them up – to make them neater, correct spelling errors, and reduce clutter or crowding. Most students need constant encouragement to improve their penmanship and to express themselves more clearly. Concept mapping can help to provide that encouragement, for redoing a map always involves more than simply making it look neater. The clarity of the relationships between the concepts illustrated on the map can always be improved on the revision, and thus there is an important added incentive for redoing maps – increasing the meaningfulness

Table 2.4. *Scoring criteria for concept maps*

1. *Propositions.* Is the meaning relationship between two concepts indicated by the connecting line and linking word(s)? Is the relationship valid? For each meaningful, valid proposition shown, score 1 point. (See scoring model below.)
2. *Hierarchy.* Does the map show hierarchy? Is each subordinate concept more specific and less general than the concept drawn above it (in the context of the material being mapped)? Score 5 points for each valid level of the hierarchy.
3. *Cross links.* Does the map show meaningful connections between one segment of the concept hierarchy and another segment? Is the relationship shown significant and valid? Score 10 points for each cross link that is both valid and significant and 2 points for each cross link that is valid but does not illustrate a synthesis between sets of related concepts or propositions. Cross links can indicate creative ability and special care should be given to identifying and rewarding its expression. Unique or creative cross links might receive special recognition, or extra points.
4. *Examples:* Specific events or objects that are valid instances of those designated by the concept label can be scored 1 point each. (These are not circled because they are not concepts.)
5. In addition, a criterion concept map may be constructed, and scored, for the material to be mapped, and the student scores divided by the criterion map score to give a percentage for comparison. (Some students may do better than the criterion and receive more than 100% on this basis).

of the composition – that is absent or less conspicuous in other forms of expository expression. We have found a greater willingness, especially in boys, to redo concept maps than to rewrite reports or themes. It is a good idea to get students used to redrawing their concept maps by asking to see both the first and second versions of the first map they draw, and continuing at least periodically to request multiple versions of their maps.

Concept maps as we have described them are not the only ways to represent meanings. Examples of other representational forms are shown in Figure 2.7. Flow charts are often used to represent sequences

Table 2.4: *(cont.)*

Scoring Model

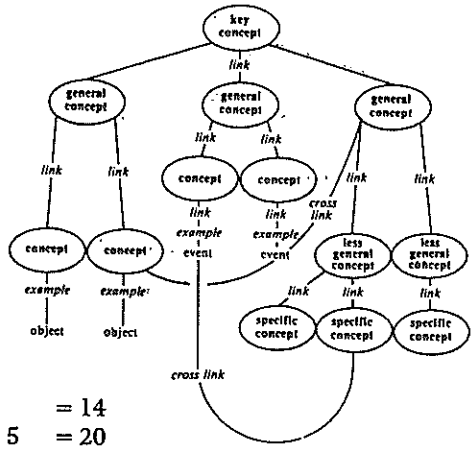
Hierarchy

Level 1

Level 2

Level 3

Level 4



Scoring for this model:

Relationships (if valid)	= 14
Hierarchy (if valid) 4 x 5	= 20
Cross links (if valid and significant) 10 x 2	= 20
Examples (if valid) 4 x 1	= 4
	58 points total

of activities. Organizational charts may show a hierarchy, but they represent administrative units and/or functions, not concept meanings. Cycles, such as the water cycle, are often used in science. Semantic networks and predicability trees are used in some psychological and linguistic writings. But none of these forms of maps are based on the theory of learning and theory of knowledge that underlie concept mapping strategies and their application to education. We believe that concept mapping, as described in this book, has more promise than other relationship schemes for both educating and research.

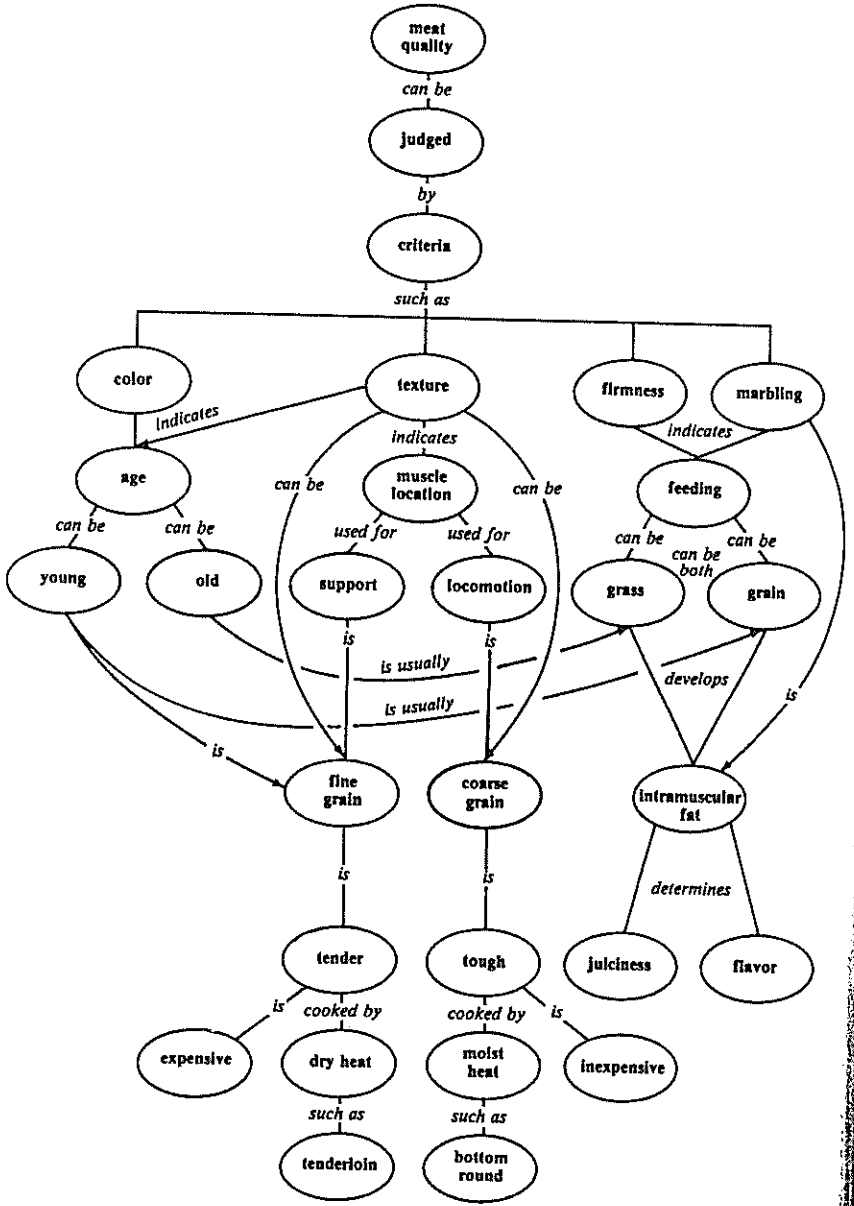
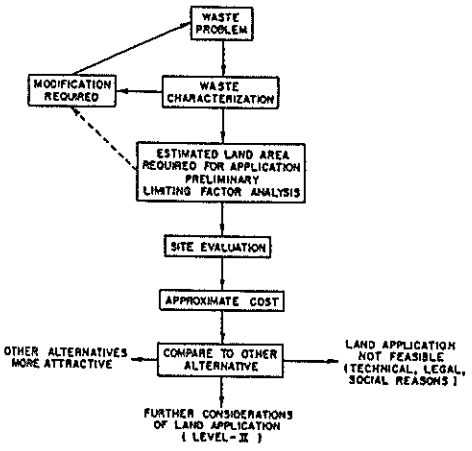
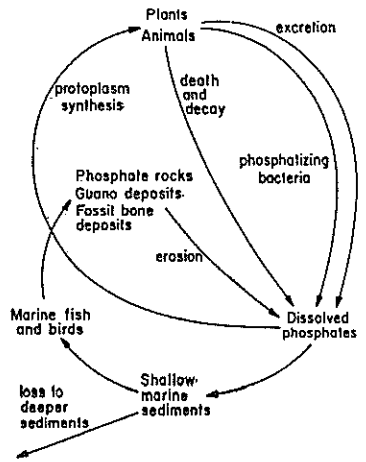


Figure 2.6 Concept map prepared for a course in meat science. Arrows show cross linkages.



(A)



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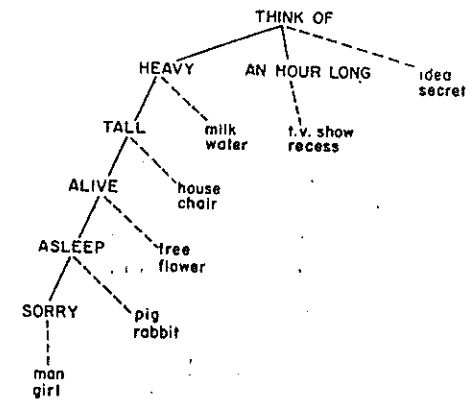


(C)

Figure 2.7 Flow charts (A), cycle diagrams (B), and predicability trees (C) are three other ways to represent concepts. None of these forms, however, is consistent with Ausubelian learning theory. (Figure 2.7A from Lochr et al. 1979, published by Van Nostrand Reinhold, and reprinted by permission from the Wadsworth Publishing Company, Belmont CA. Figure 2.7B from Goodnight et al. 1979, published by Van Nostrand Reinhold, and reprinted by permission from the Wadsworth Publishing Company. Figure 2.7C from Keil 1979, reprinted by permission from Harvard University Press, Cambridge, Mass.)

EDUCATIONAL APPLICATIONS OF CONCEPT MAPPING

Exploration of what the learners already know. In Chapter 1 we pointed out that meaningful learning requires a deliberate effort on the part of learners to relate new knowledge to relevant concepts they already possess. To facilitate this process, both teacher and student, if they are to proceed most efficiently in meaningful learning, need to know the "conceptual starting place." In the epigraph to *Educational Psychology: A Cognitive View*, David Ausubel says, "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Ausubel 1968 [2nd ed. 1978]).

Ausubel was not simply restating an old idea, for he devoted five chapters of his book to illustrating how the concepts and propositions the learner knows play a central role in meaningful (as distinct from rote) learning. Despite this lengthy and precise elucidation of the theoretical issues, however, he has not provided educators with simple, functional tools to help them ascertain "what the learner already knows." Concept mapping is such an educational tool; it has been developed specifically to tap into a learner's cognitive structure and to externalize, for both the learner and the teacher to see, what the learner already knows. We do not claim that a concept map is a complete representation of the relevant concepts and propositions the learner knows, but we do claim that it is a workable approximation, from which both students and teachers can consciously and deliberately expand and move forward.

Once students have acquired the basic skill of concept mapping, six or eight *key concepts* can be selected that are central to understanding the topic or area of instruction to be covered, and students are asked first to build a concept map relating those concepts and then to bring in additional relevant concepts and link them to form propositions that have meaning. It may be useful to rank order the concepts first presented if there are significant hierarchical relationships among them. Another approach would be to help students identify three or four major concepts in a section or chapter of their textbook and use these concepts to begin the construction of a concept map. The students can then more easily identify other relevant concepts

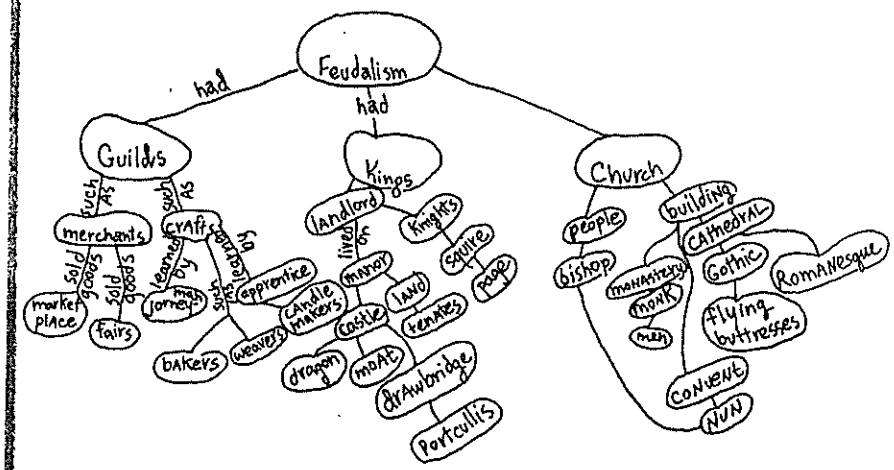


Figure 2.8 A concept map for history prepared by a previously low-achieving student in sixth grade.

and add these to form their own concept maps. Figure 2.8 shows a map prepared by a sixth-grade student from a history text. The map segment showing feudalism, guilds, kings, and church was drawn by the teacher, and the student added the other concepts. Note that not all lines were labeled, a common problem that only constant encouragement can correct. Nevertheless, the map does represent a good hierarchical organization of subordinate with higher order concepts. If the text had presented specific events or objects (e.g., names of kings or manors), students could also have added these in appropriate places. Incidentally, the student who drew the map in Figure 2.8 was usually a C or D student, partly because he consistently refused to do much of the less meaningful work required. His map (and others he drew) was subsequently used as a basis for class discussions, and his grades improved markedly over the remainder of the school year. We have found that many students classified as "learning disabled" are really bright children who lack the skill and/or motivation for rote mode learning, but who can move to the front of the class when they are given an opportunity for creative, meaningful representation of their knowledge (Melby-Robb 1982).

Meaningful use of concept maps as a preinstructional tool is best arrived at by (1) giving careful thought to the choice of key concept

labels selected as the base for the map, (2) helping students to keep searching their cognitive structures for relevant concepts, (3) helping students construct propositions between the concepts provided and the concepts they know by helping them to choose good linking words or perhaps to recognize what other, more general concepts fit into the hierarchy, and (4) helping them to discriminate between specific objects or events and the more inclusive concepts those events or objects represent.

The end product of this preinstruction mapping will be a good conceptual benchmark from which students can construct richer meanings. It will also serve the important purpose of illustrating conceptual growth: After three weeks of instruction, the students may be surprised to see how much they have elaborated, refined, and cross related concepts in their own cognitive structures. Nothing has more positive affective impact on encouraging meaningful learning than demonstrated success in substantive accomplishment of meaningful learning. Figure 2.9 shows two concept maps drawn by a basketball player, one early in the season, the other after several months of coaching (see also Figure 2.12). What we should pay attention to is a student's capacity to identify and enrich the meaning of his or her experience. (We are not advocating mere success by the students in achieving and producing maps; recognizing and valuing the change in meaning in human experience is the educational value.)

Roadmapping a learning route. We have already noted that concept maps are somewhat analogous to road maps in that they show relationships, not between places, but between ideas. Concept maps can help learners chart a course to get from where they are to the final objective. If you were planning an auto trip from, say, New York to Seattle via Houston you would probably begin with a national map showing interstate highways and the major cities en route. Next, you might look at individual state maps to locate interesting places to stop for meals, sightseeing, and sleeping. Finally, you might refer to local maps to plan specific routes through a city to a place of interest.

In much the same way, we can construct a global concept map showing the major ideas to be considered in a semester or a year, then move to specific concept maps showing a three- or four-week segment, and, finally, draw a detailed concept map for one or a few days of instruction. Just as with road maps, these three levels of magnification are useful to help learners to acquire and to recall a rich

store of detailed impressions, coordinated ideas and meanings, and vivid feelings and images. A glance at the "big map" should facilitate easy recall of various details observed en route.

One advantage we have in the classroom over a passenger in a car is that we can hang our maps – global, more specific, and detailed – on the walls so that both students and teacher can easily see where we are, where we have been, and where we are going. Walls are often enhanced by interesting wallpaper, so why not paper the walls with concept maps? To make the wall maps more interesting (and also of greater educational value) photos or pictures representing key concepts can be pasted on them in order to illustrate specific objects or events encountered, or to be encountered, during the conceptual journey and to "pump" meaning into the framework of more abstract regularities the concept labels represent.

Extracting meaning from textbooks. Learning to read effectively presents a dilemma. Words and phrases are hard to read when they have little or no meaning, yet reading is a powerful way to learn meanings. How do we break the cycle: How do we acquire meaning without first reading a text, and how do we read a text that has little meaning for us? Concept mapping can help to break through the meaning impasse.

A concept map with as few as six or eight concepts and propositions can give a general road map for reading a particular passage and help to break the meaningless – hard-to-read cycle. Figure 2.10 gives a brief example of a concept map for a small segment of text. This map was made by having the student write key concept words on paper rectangles and then move them, together with linking words, until a satisfying concept map was formed. It is obviously impracticable to devise concept maps for every paragraph or page of a textbook. But it is not an overwhelming task to work with students and sketch out together a map of the key ideas in a section or chapter. The 10 or 15 minutes this might take could not only save the students time in subsequent reading, but will also significantly enhance the meanings they will extract from the text. Moreover, because some misconceptions are almost sure to exist for any chapter-size segment of reading, *premapping* can clue students as to what misinterpretations they should watch out for as they read. Sometimes the greatest hindrance to extracting meaning from a text segment is what we think we already know, which may be either not true or significantly

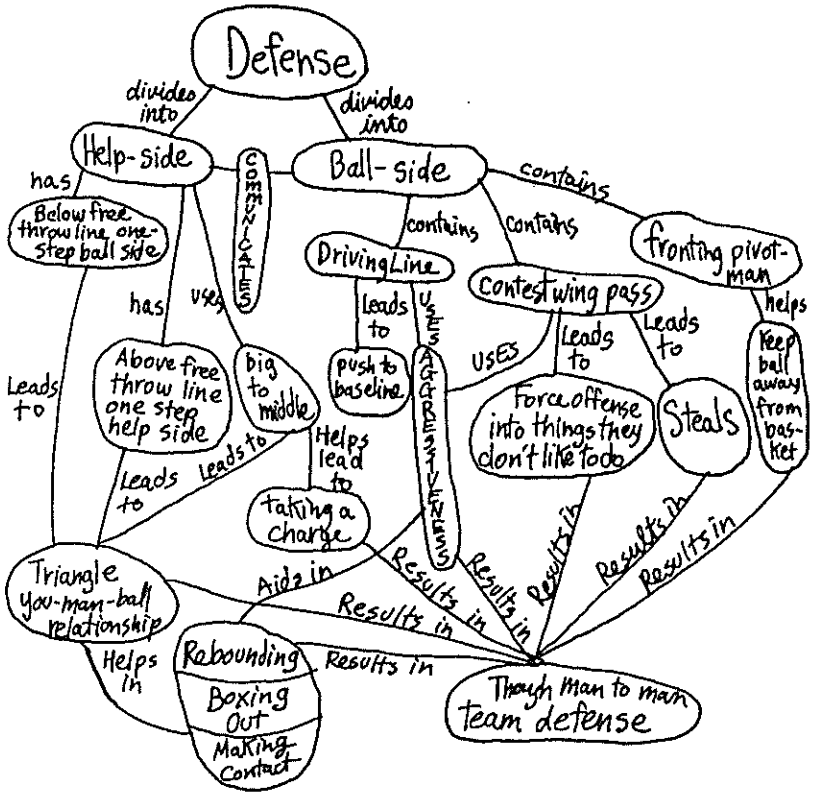
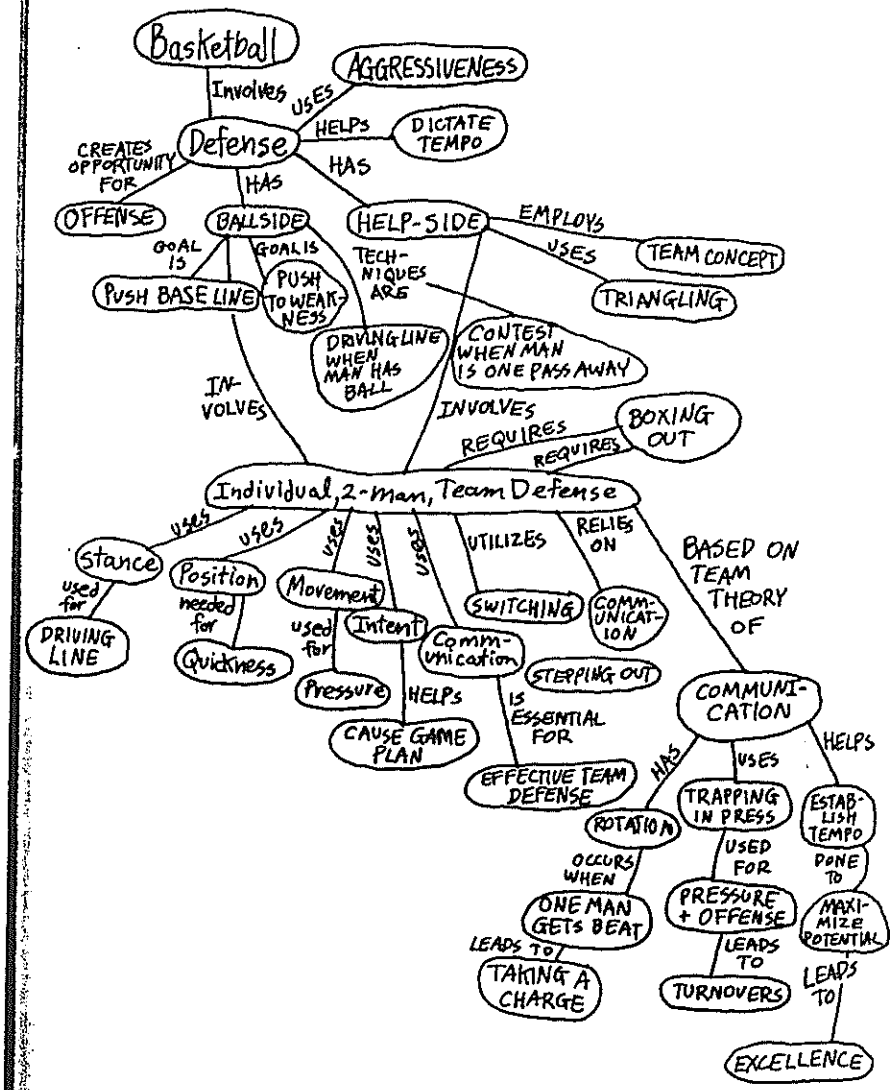


Figure 2.9 Two concept maps prepared by a basketball player, one (above) early in training and the other (facing page) late in the season. Note the increased complexity and integration of concepts, which was accompanied by much-improved player performance.

at variance with the view the text is presenting. We do not want students to believe that the printed text is always right, but we do need to help them to critically assess what the text is saying and what they come to believe after reading it.

Global and specific concept maps constructed for readings can help a student journey through the material for a whole course of instruction in a more meaningful way. The challenge is to help learners see the relevance of the global conceptual road map before they read the



text. Here, again, we are in a kind of "catch 22," where the global concept meanings to be developed in the text are part of what the learner needs in order to read the text meaningfully. We break out of this trap only if we are skillful in devising global concept maps

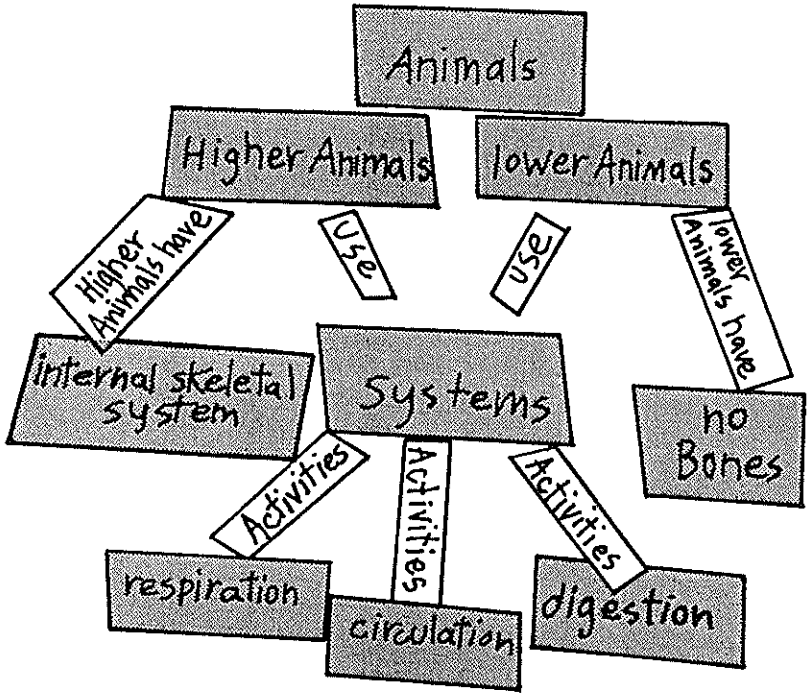


Figure 2.10 A concept map constructed from a section of a junior high school science textbook in which paper rectangles were used to permit easy modification of concept relationships.

that organize the ideas the students already have that can be brought to bear on the readings. This is where teaching becomes an art as well as a science.

Concept maps can be useful not only for understanding typical school textbooks but also for better understanding literary works such as novels. Figure 2.11 is a concept map prepared from *Eveline,* a story by James Joyce. Key ideas in the book are presented in a simple map, which can in turn be used as a basis for lively class discussions. Asking students to prepare concept maps to report on literary readings means that they must not only read a work, but also make some conceptual sense out of it. One of our former students developed a general concept map showing key concepts that can be found in any literary work, and this is included in Appendix I (Figure I.6).

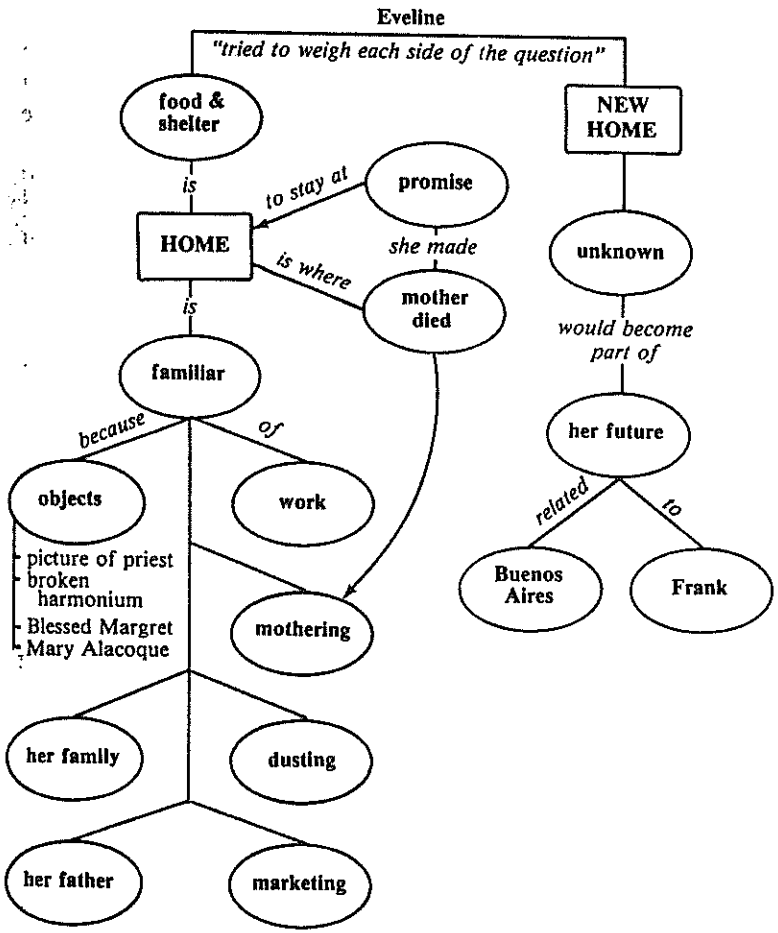


Figure 2.11 A concept map prepared to illustrate the key concepts in *Eveline, a novel* by James Joyce.

Extracting meanings from laboratory, studio, and/or field studies. Often students enter into a laboratory, studio, or field setting wondering what they are supposed to do or see; and their confusion is so great that they may not get as far as asking what regularities in events or objects they are to observe, or what relationships between concepts are significant. As a result, they proceed blindly to make records,

manipulate apparatus, or make constructions with little purpose and little consequent enrichment of their understanding of the relationships they are observing or manipulating. Concept maps can be used to help students identify key concepts and relationships, which in turn will help them to interpret the events and objects they are observing.

One could argue that there is value in any observation or manipulation of real-world materials, and to some extent this may be true. The touch, smell, taste, and texture of materials do provide some of the raw perceptions needed to construct perceived regularities (i.e., concepts). Furthermore, some would contend that cognitive or conceptual knowledge has little bearing on many manipulative learning activities. We would agree with Herrigel (1973), who has argued that expertise in something as motor-skill centered as archery requires first a recognition of the conceptual nature, purpose, and feel of the bow and arrow. Achievement in nearly every area of human endeavor would probably be enhanced if the relevant concepts and how they function were understood and used to interpret events or objects. Figure 2.12 is a concept map developed by one of our graduate students to help the basketball players he coached improve their performance. We have found that every skill is an action that can be seen more explicitly when the set of concepts that conveys the meaning of the action is identified and mapped.

Field trips have a recognized potential for being rich educational experiences, but too often they are little more than school social outings. A principal problem is that too often neither leaders nor participants know what they are to observe or what meaning these observations are supposed to convey. Students need to go into the field equipped with a framework of potential meaning, so that they will be able to interpret their observations, and a concept map can be a highly effective way to construct that framework. Figure 2.13 shows a concept map used to plan a field trip to a nature center where fifth- and sixth-grade students were to observe, among other things, the ecology of a rotting log. The map served as the basis both for planning classroom instruction on the topic before the trip and for discussing it with the students afterward. Kinigstein (1981) found that when concept maps were used in this way, students made positive gains in their understanding of ecological concepts as a result of their class and field experiences and were overwhelmingly positive in their attitudes toward the field work. Concept maps not only help students to gain meaningful knowledge from field experiences, they also enhance positive feeling and acting during and after the experience.

Reading articles in newspapers, magazines, and journals. We have found concept mapping to be a good "shorthand" for taking notes on papers or articles in newspapers, magazines, and technical journals. After a quick reading of an article, it is relatively easy to go back and circle key concepts or propositions and then to construct a concept map representing them in a hierarchical order. Constructing a concept map enables one to identify the most important concept(s) and/or propositions and to restate in a concise way the major points made in the article. The hierarchical organization of the concept map casts the meaning of ideas in the article into a framework that makes it easy to recall the substance of the article and to review the information presented in it. Figure 2.14 shows a concept map prepared from a journal article dealing with the value of coaching for improving SAT scores.

In order for a map to show a clearer and more complete set of relationships between the concepts or propositions in an article, key concepts or propositions must often be added to it. One of the reasons we often have trouble reading short journal articles or papers in a field unfamiliar to us is that some of the important concepts and propositions we need to capture the meanings of the main ideas are not repeated, not in the best position in the article, or missing entirely. A person familiar with the field will unconsciously fill in concepts or propositions and not even notice that the article is conceptually incomplete. There are very few writers who can prepare articles for lay readers on technical material; most "experts" tend to leave out explicit descriptions of key concepts or propositions that are very familiar to them, making their writing conceptually opaque to the lay reader. Concept mapping may be especially useful for preparing articles on technical subjects that lay persons can read and understand. We will have more to say on this subject in Chapter 4.

Planning a paper or exposition. Most students find writing a paper almost frightening; they simply cannot get their ideas together when they sit down to write. There is something terribly intimidating about the stare of a blank sheet of paper. Concept mapping is one way to ease over this hurdle. It is fairly easy to list a few concepts or propositions one wants or needs to include in a paper. Next, usually in a

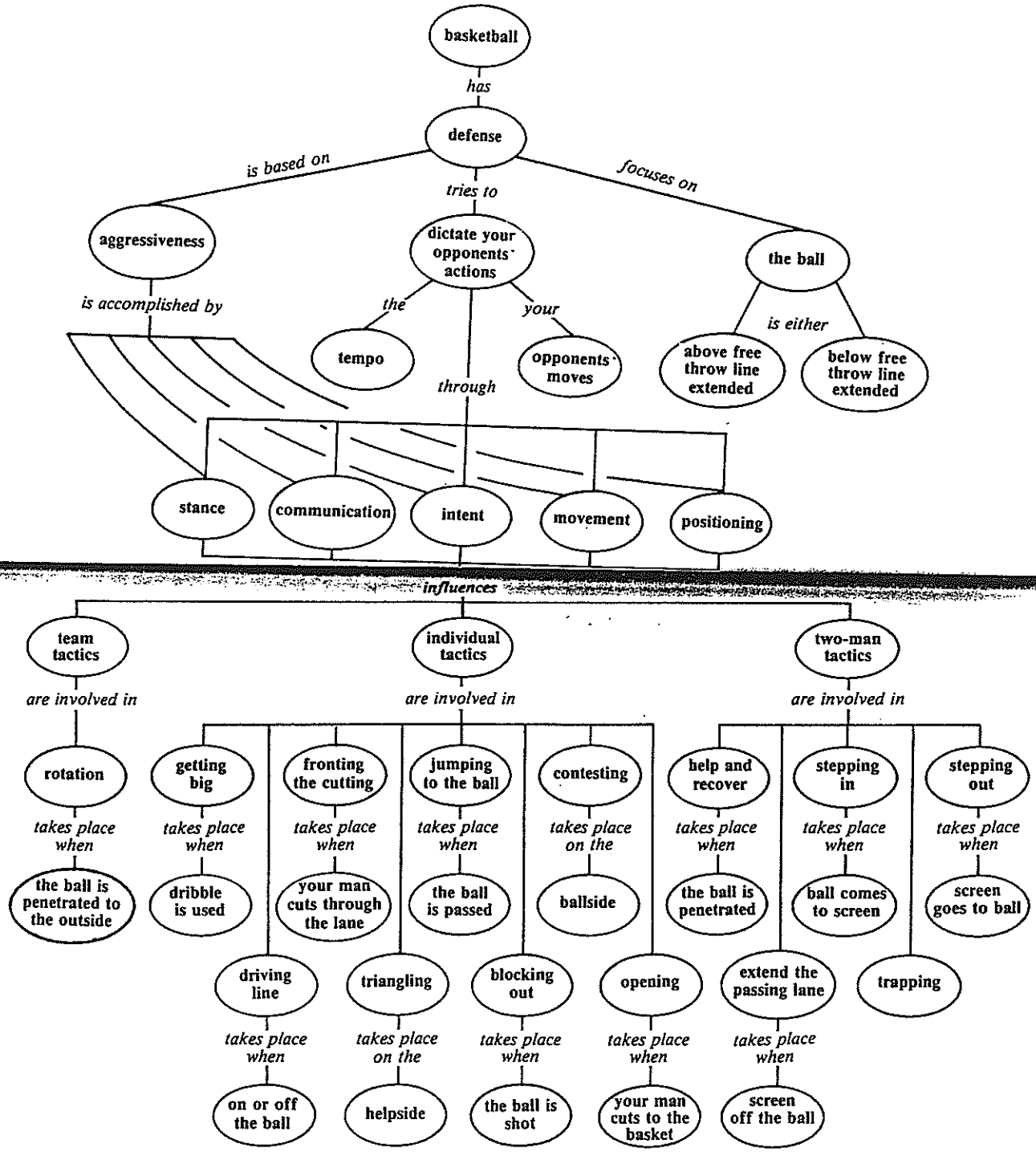


Figure 2.12 A concept map prepared by Brad Nadborne to guide his players in basketball training (see also Figure 2.9).

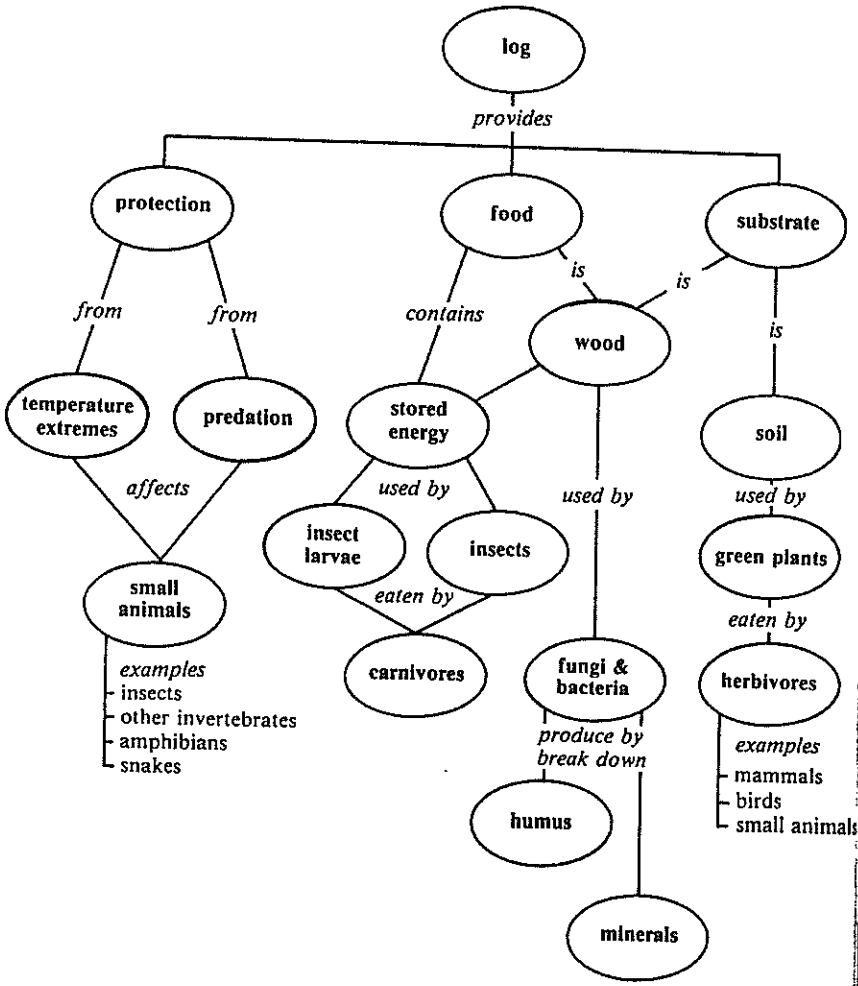


Figure 2.13 A concept map used to prepare an instructional unit, for fifth- and sixth-grade students, on a rotting log observed on a field trip.

few minutes, a brief concept map can be constructed – not a complete map with all the ideas, but one complete enough to guide the writing of that first paragraph. As a matter of course, a good first paragraph for most papers probably is a clear statement of the top four or five concepts and propositions in this concept map.

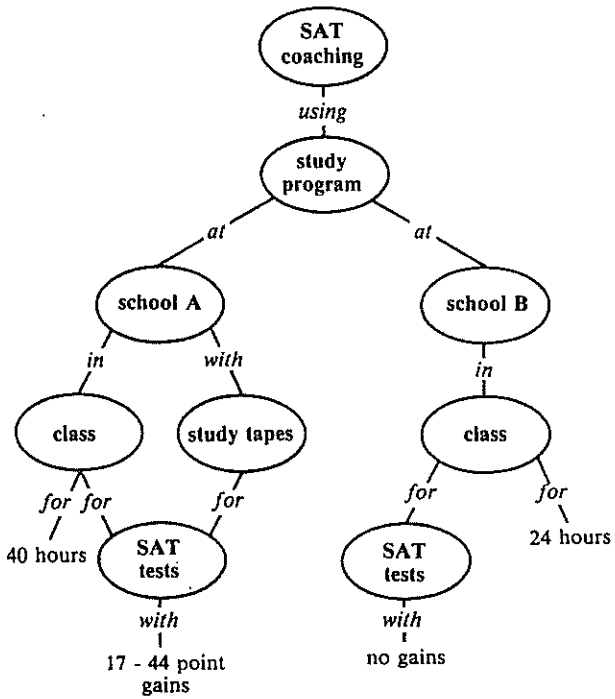


Figure 2.14 A concept map showing the key ideas in a journal article on the value of coaching for improving SAT scores (Sesnowitz et al. 1982).

We find that it is difficult to construct a complete concept map before beginning to write a paper (or chapter of a text). A first approximation can be prepared, however, which then can be quickly modified, added to, or reconstructed as the writing proceeds and the framework of ideas to be presented takes shape. Neither we nor our students have yet tried concept mapping for writing fiction, but we anticipate that the schematic nature of concept maps should provide the flexibility needed for fabricating interesting tales.

Written or spoken messages are necessarily *linear* sequences of concepts and propositions. In contrast, knowledge is stored in our minds in a kind of *hierarchical* or holographic structure. When we generate written or spoken sentences, we must transform information from a hierarchical to a linear structure. Conversely, when we read or hear messages, we must transform linear sequences into a

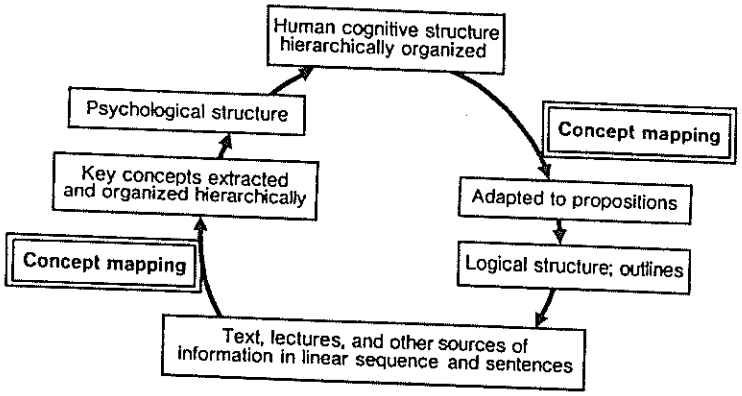


Figure 2.15 Schema illustrating how information is translated from or to the hierarchical structure of the brain to or from the linear structure of spoken or written language.

hierarchical structure in order to assimilate them into our minds. (See Figure 2.15) Concept mapping can aid this psychological–linguistic transformation, and more research is needed on how concept mapping can best be used to facilitate writing.

What has been said about writing papers applies also to the preparation of posters, handbill notices, exhibits, or mock-ups, and possibly to the construction of models as well (although we have not yet completed research on the latter). For a poster or exhibit, the concept mapping procedure might be carried over almost intact, with strings or ribbons tying together key ideas, pictures, or specimens to show hierarchical organization of meaning. We invite readers' comments on successes (or failures) that they experience using concept mapping to prepare papers or expositions.

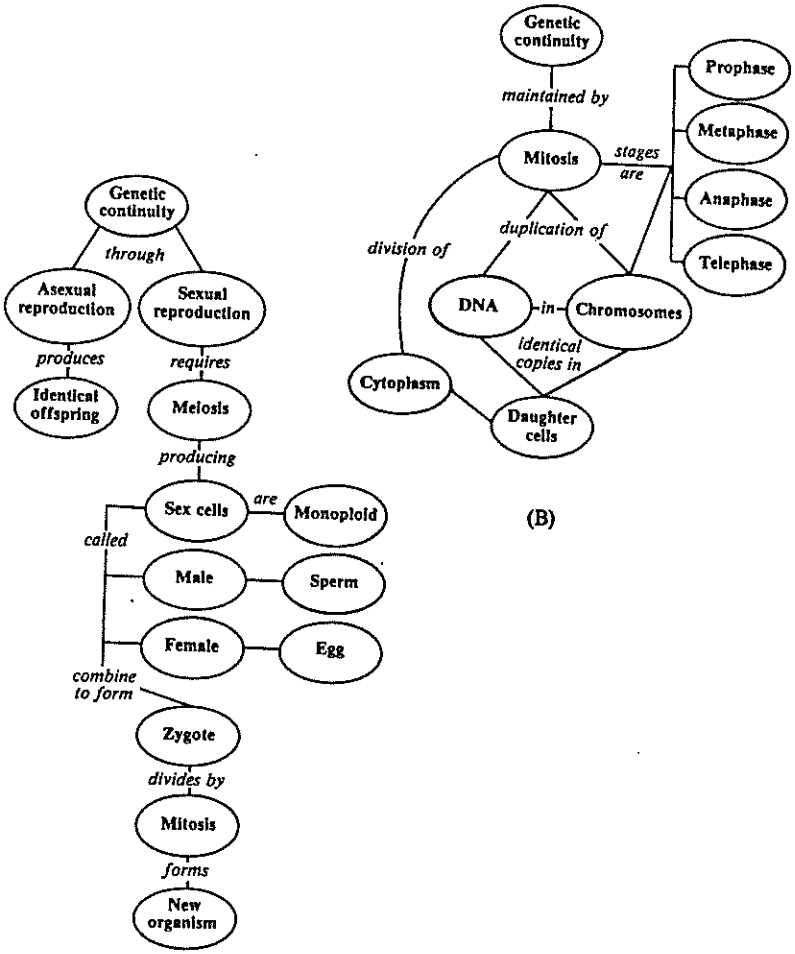
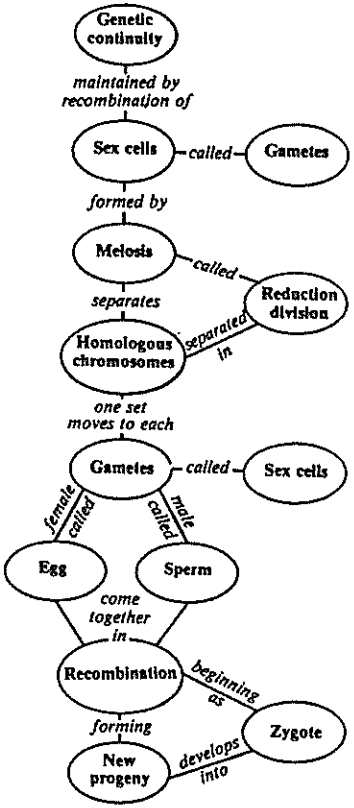
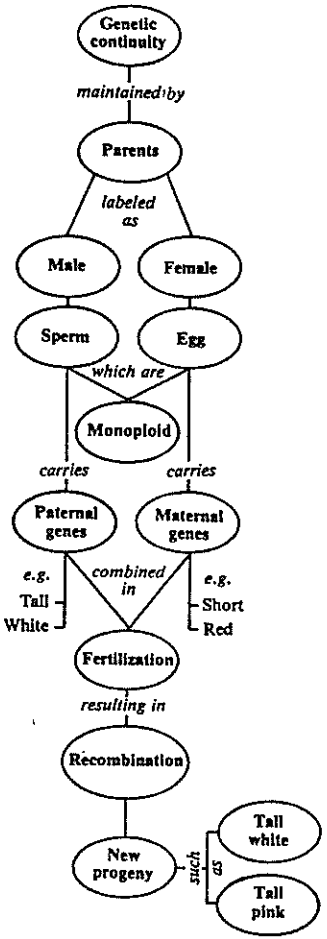


Figure 4.2 Four concept maps constructed to illustrate the major propositions in Chapter 6 of Oram, Hummer, and Smoot (1979). The maps show alternative hierarchies constructed from the key concepts in the chapter. We have added the superordinate concept, genetic continuity.





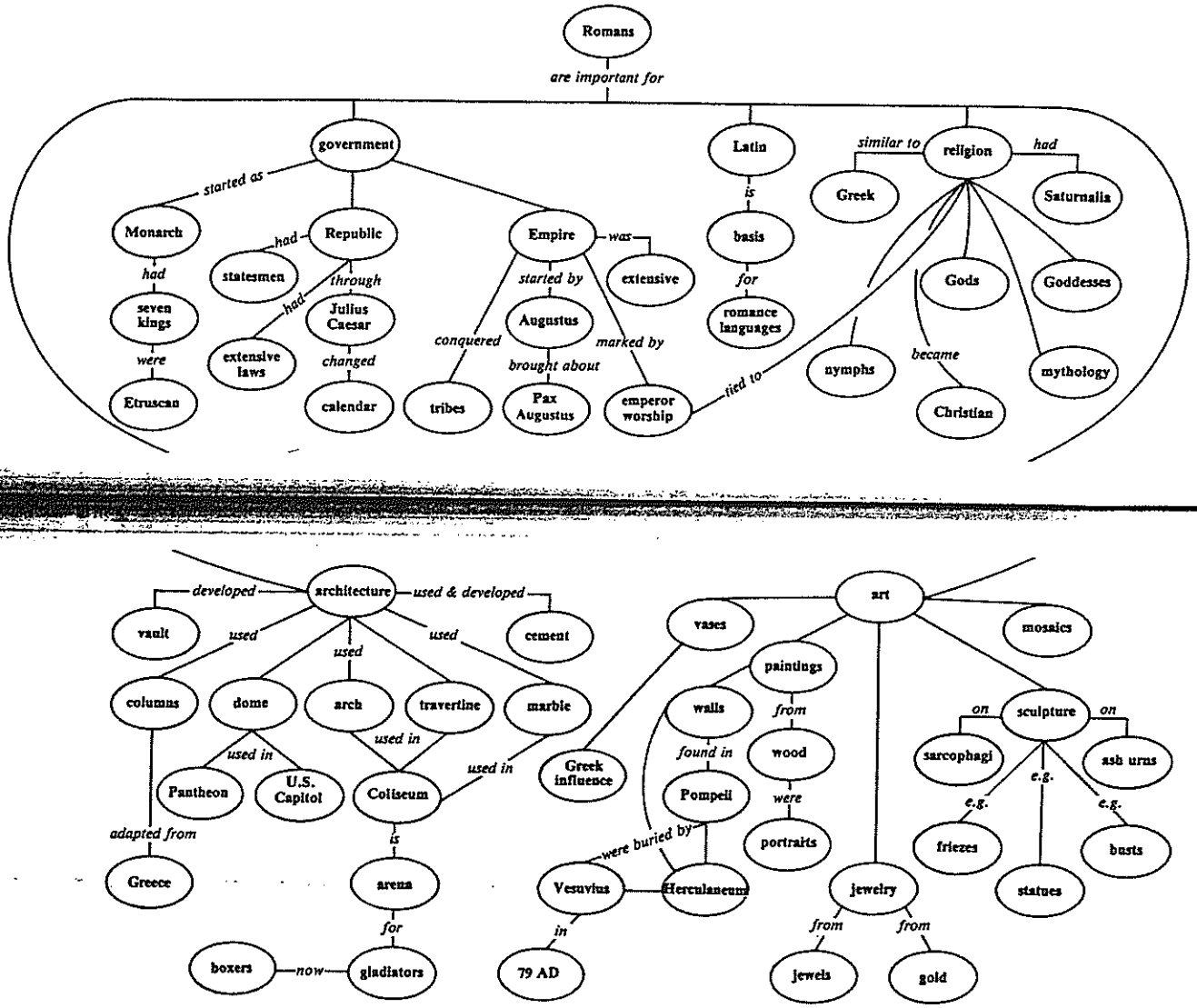
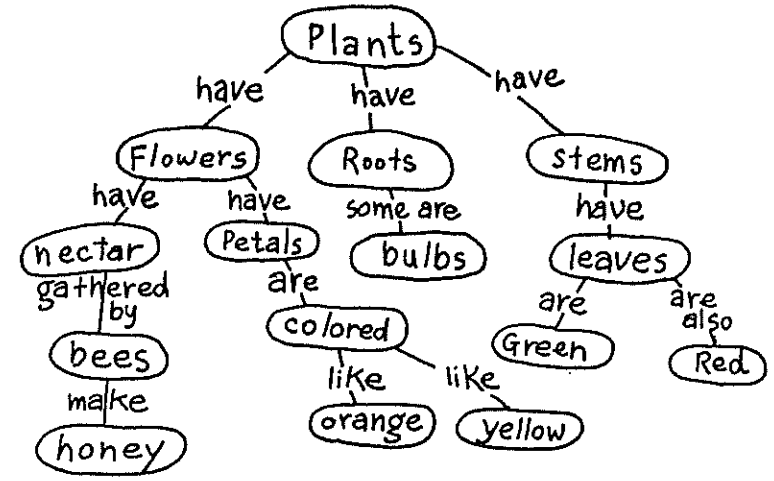
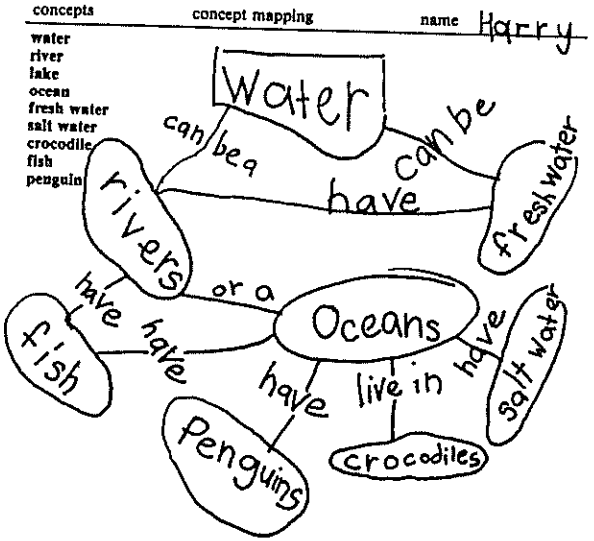


Figure 4.3 A concept map constructed to represent key ideas for a secondary school course in history. Additional topics could be added and corresponding concept map segments incorporated.

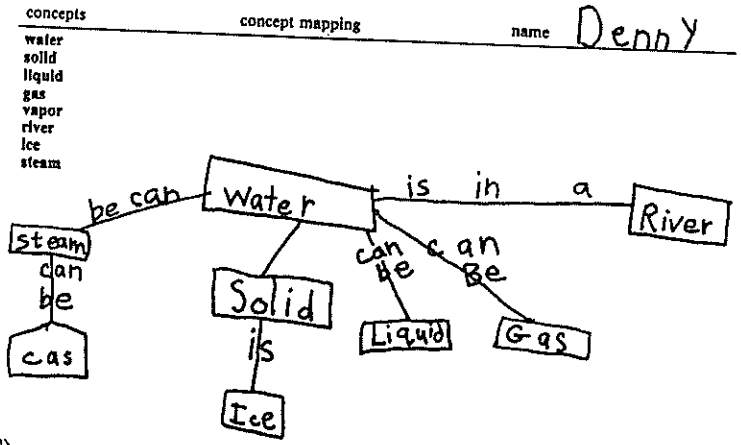


(A)

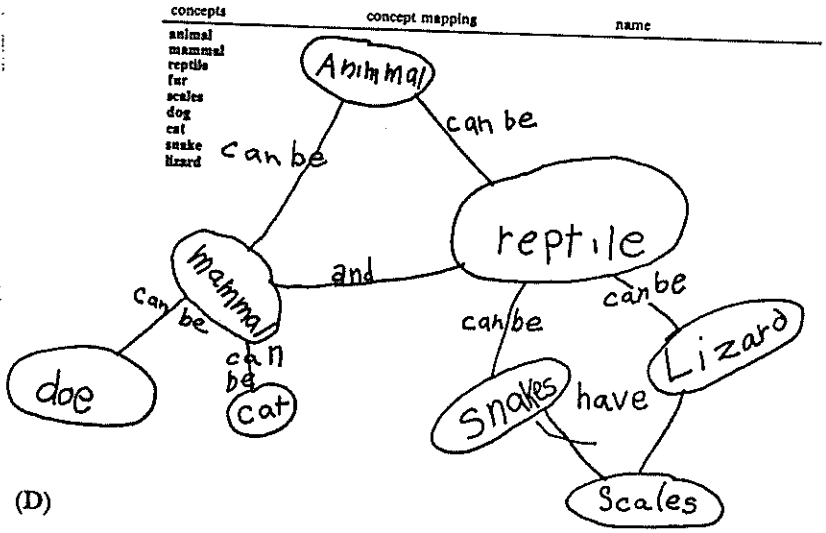


(B)

Figure I.1 A concept map (A) constructed with a first-grade class to illustrate how to make concept maps. A week later, children were given sheets with lists of words previously discussed in class and each constructed their own



(C)



(D)

concept map. Representative maps (B, C, and D) show keen awareness of concept meanings although Denny (Map C) either omitted or did not know the meaning relationship for *vapor*.

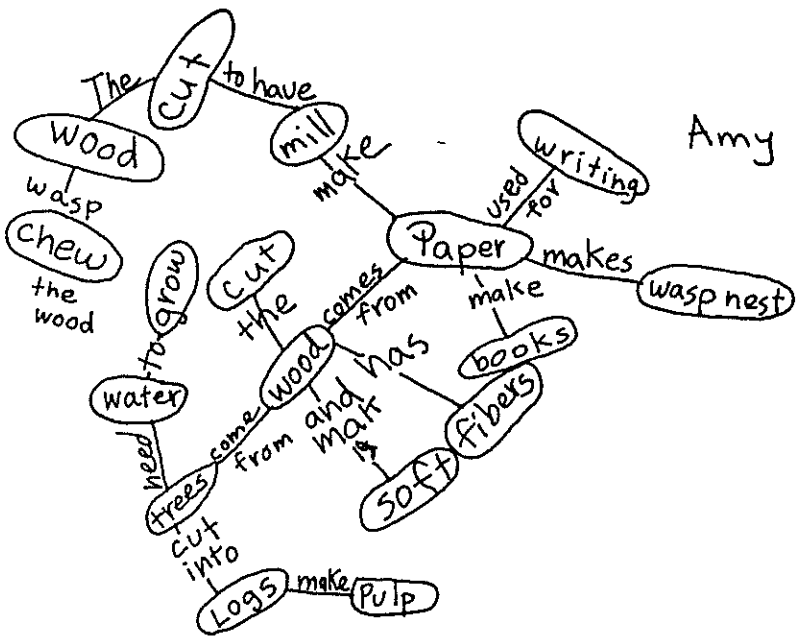


Figure I.2 A concept map constructed by a fourth-grade student, following a field trip to a paper mill, showing a good integration of concept meanings (see also Figure 5.5 showing poor integration of meanings).

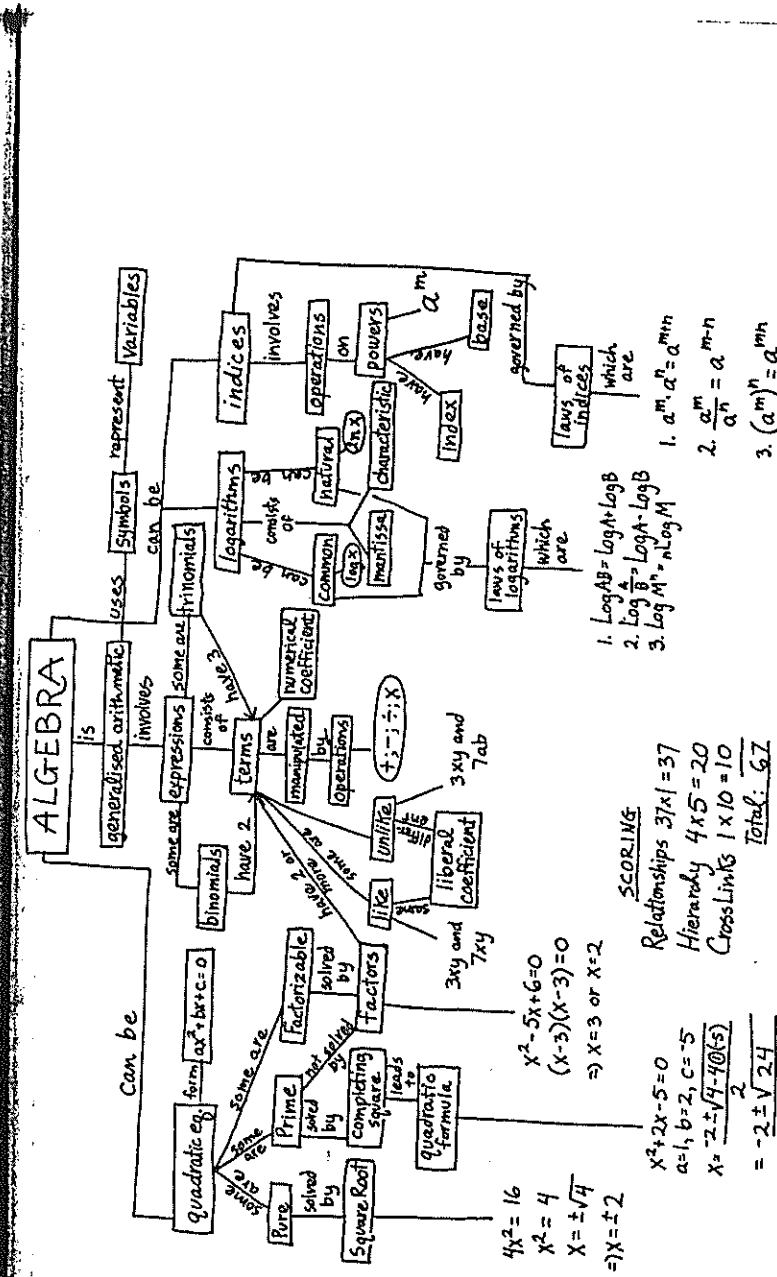


Figure I.3 A concept map for high school algebra constructed for a math review course for black African students (John Volmink, personal communication).

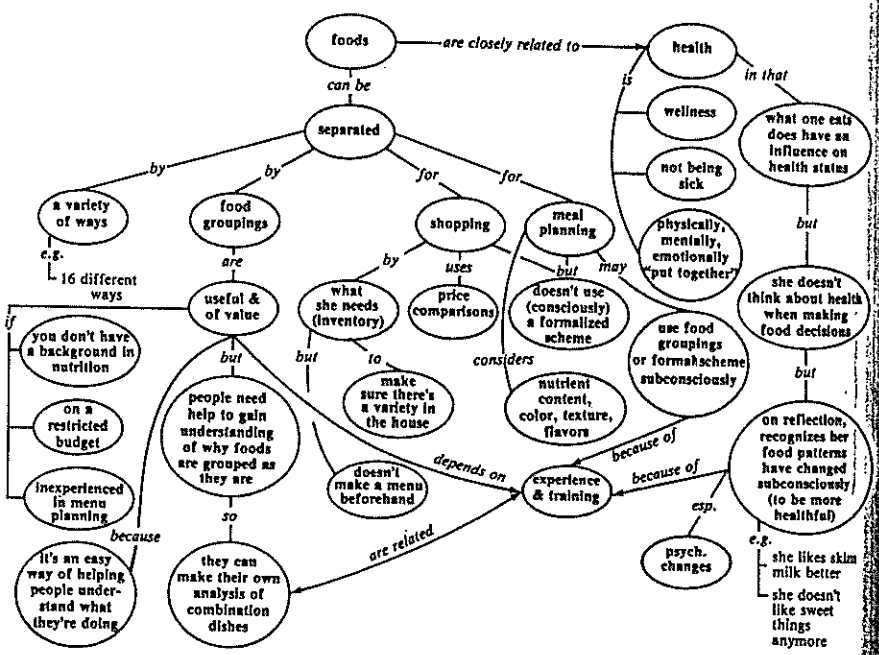


Figure I.4 A concept map constructed by a student from an interview transcript on nutrition. This map shows a common problem observed in that sets of concept are included in ovals. Students need to be encouraged to separate out such concept sets by forming additional concept networks.

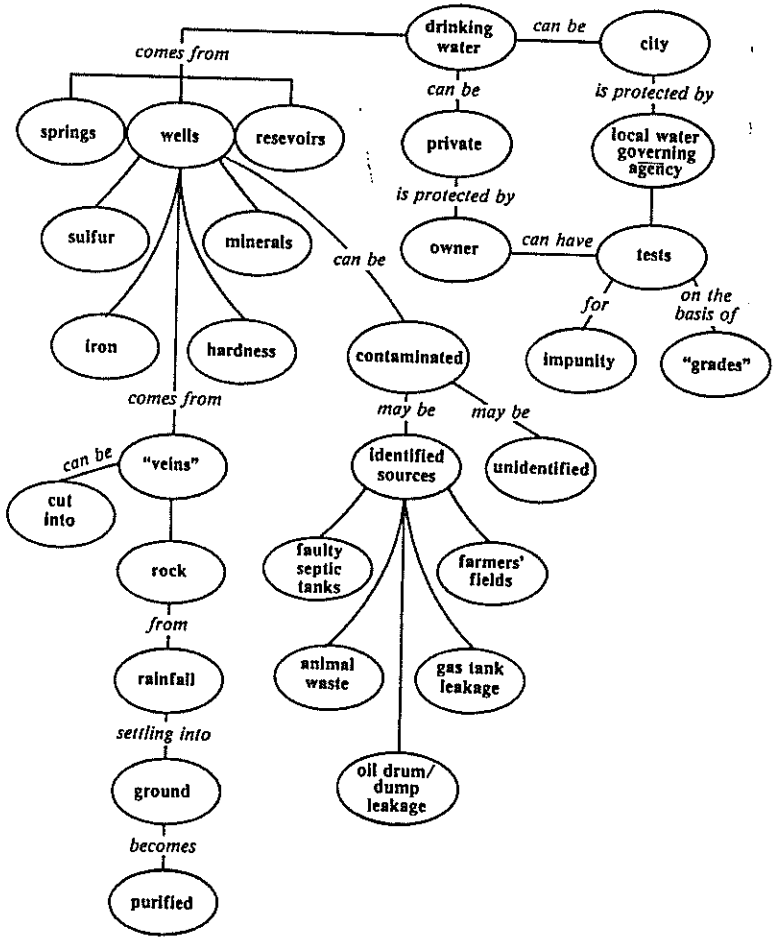


Figure I.5 A concept map prepared to guide interviews with the general public regarding their understanding of the origins of drinking water.

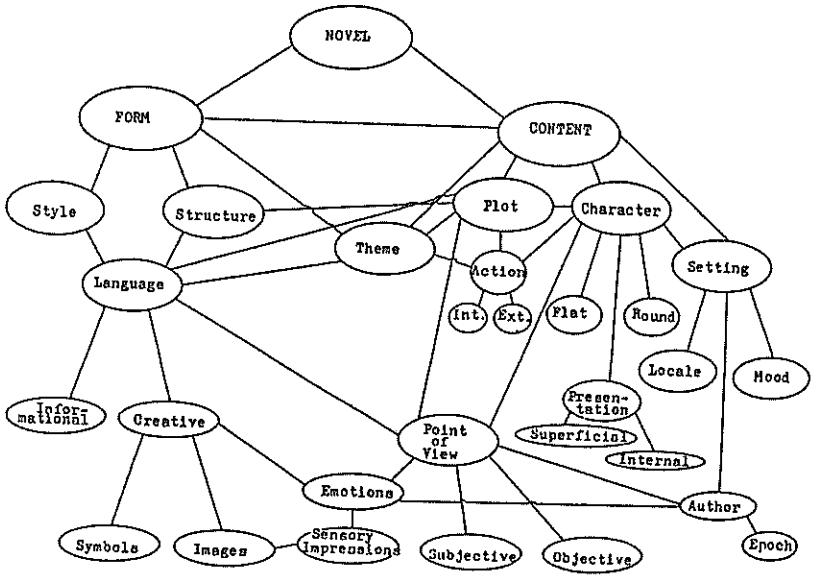


Figure I.6 An early concept map constructed by Marli Moreira (1977) as a basis for organizing instruction in literature. Lines connecting concepts were not labeled in our earlier work.

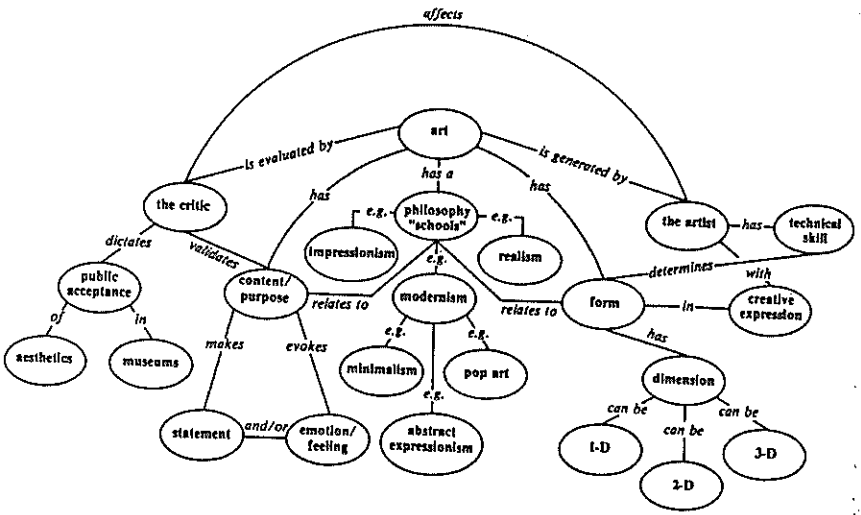


Figure I.7 A concept map prepared to guide interviews regarding individuals' understanding of art.