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ABSTRACT

One way that teachers can assist students to learn from their textbooks is through the use of verbal-spatial representations of text structure. This report offers teachers and teacher educators information about learning to make idea maps for instructional use with elementary science texts. Idea maps, which are verbal-spatial representations of ideas and the relationships connecting them, can resemble flow charts, diagrams, or tables. The information in this report is based upon selected results from a study of eight preservice elementary teachers who received several hours of individual instruction in idea mapping and then independently read and mapped two passages of elementary science text. The report presents the instructional materials, describes the instructional sessions, and considers selected data from the independent work sessions as indications of the preservice teachers' learning from the instructional sessions. The results show that all but one student followed the instructional guideline to make "global maps," which were limited to key text ideas. On the other hand, four of the eight students required major levels of assistance to complete at least one of their idea maps. The results of think-aloud protocols also showed that the preservice teachers used a wide variety of strategies to begin their idea maps. Implications are discussed for the use of the instructional materials by teachers and educators. (Six tables of data are included; an appendix--which comprises about half the document--presents the instructional materials used to introduce the student to idea maps. (Contains 38 references.) (Author)

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LEARNING TO MAKE IDEA MAPS WITH ELEMENTARY SCIENCE TEXT

James O. Armstrong
Boise State University

April 1993

Center for the Study of Reading

TECHNICAL REPORTS

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Abstract

One way that teachers can assist students to learn from their textbooks is through the use of verbal-spatial representations of text structure. This report offers teachers and teacher educators information about learning to make idea maps for instructional use with elementary science texts. Idea maps, which are verbal-spatial representations of ideas and the relationships connecting them, can resemble flow charts, diagrams, or tables. The information in this report is based upon selected results from a study of eight preservice elementary teachers who received several hours of individual instruction in idea mapping and then independently read and mapped two passages of elementary science text. The report presents the instructional materials, describes the instructional sessions, and considers selected data from the independent work sessions as indications of the preservice teachers' learning from the instructional sessions. The results show that all but one student followed the instructional guideline to make "global maps," which were limited to key text ideas. On the other hand, four of the eight students required major levels of assistance to complete at least one of their idea maps. The results of think-aloud protocols also showed that the preservice teachers used a wide variety of strategies to begin their idea maps. Implications are discussed for the use of the instructional materials by teachers and teacher educators.

LEARNING TO MAKE IDEA MAPS WITH ELEMENTARY SCIENCE TEXT

Many American students in the middle grades have difficulty learning from their textbooks (Applebee, Langer, & Mullis, 1989). Students are often unable to carry out such tasks as summarizing or identifying key ideas of text because they are not sensitive to the overall structure of informational text (McGee, 1982; Taylor, 1980; Taylor, 1986; Winograd, 1984). One way that teachers can assist students in identifying the overall structure of text is through the use of verbal and spatial representations of text structure. A recent review of comprehension instruction (Pearson & Fielding, 1991) found that the use of verbal-spatial representations of text led to improved learning. Classroom training studies involving middle-grade students and their use of verbal-spatial representation of text reveal that the effectiveness of such representations on learning depends upon the learner's active role in creating or completing the text representation (see Armbruster, Anderson, & Meyer, 1991; Armbruster, Anderson, & Ostertag, 1987; Berkowitz, 1986; Gallagher & Pearson, 1989).

Idea maps (Barman et al., 1989), which are verbal-spatial representations of ideas and the relationships connecting them, can aid students in identifying and using the features of text to understand what they read. Idea maps can resemble flow charts, diagrams, or tables and may be classified generally into node-link maps and frames (West, Farmer, & Wolff, 1991). Please see the Appendix for examples of node-link maps (Figures 1, 4-8) and frames (Figures 2, 3).

A node-link map is a network of circles and arrows. Nodes appear as circled words, which are labels for concepts. In other words, nodes are the names of objects or events. Nodes are connected by links, which are lines or arrows. Links are usually labeled, making explicit the relationships between the nodal concepts. Most node-link maps present information in a hierarchical display, with the most important information appearing at the top of the map paper. Based upon the kinds of links they use, node-link maps may be classified as concept maps, knowledge maps, or flowcharts. Each of these kinds of maps will be described, in order of the decreasing explicitness of information that their links provide.

Concept maps, which were developed by Novak and associates (Novak & Gowin, 1984; Novak, Gowin, & Johansen, 1983; Novak & Musonda, 1991), link nodes together so that they may be read as propositions. In addition, the information in a concept map is arranged hierarchically, with the most important (or most inclusive) concept appearing at the top of the map as its superordinate term. In these respects, the node-link maps in this study (see Figures 1, 4-8) resemble concept maps. Links are represented as arrows with verbs as their labels, and the superordinate term appears at the top of each map. Mappers use their existing knowledge and text information as sources for generating map links. For example, the nodes "people" and "food" might be joined by different links (such as "need," "pay a lot for," or "enjoy"), depending on whether the text is about survival, economics, or dining.

Knowledge maps, as developed by Dansereau and associates (Dansereau & Cross, 1990; Evans & Dansereau, in press; Lambiotte, Dansereau, Cross, & Reynolds, 1989), use a linking system of three kinds of arrows, which represent dynamic, descriptive, or elaborative relationships. Each kind of arrow has a set of standard labels that further specify the relationship connecting map nodes. For example, a descriptive arrow may be labeled "T" (standing for "Type"), "P" (for "Part"), or "C" (for "Characteristic"). These "canonical links" thus specify visually and verbally the kind of relationship between map nodes. The node-link maps in the present study include two adaptations of the features of knowledge maps: a set of Standard Links and two kinds of arrows to represent descriptive and dynamic relationships. A list of Standard Links and arrows (and non-standard links) is included in the "Presentation Materials" of the Appendix.

Flowcharting, as developed by Geva (1983), can be used to construct a hierarchical analysis of text. This feature of flowcharts resembles that of concept maps. The nodes in a flowchart represent text concepts, and the links are unlabeled lines and arrows of various forms. Each link form represents a unique rhetorical relationship: for instance, " - - - - -" stands for "process," and "______" stands for "example." The differentiated lines and arrows of flowcharts resemble those features of knowledge maps, but the links in a flowchart are not labeled as they are in a knowledge map. In general, the flowchart format leads to relationships between concepts that are made less explicit than are the relationships in concept maps and knowledge maps.

Thus, of the three types of maps, concept maps use a format that allows the greatest opportunity for making precise and explicit the relationships among key parts of text. The node-link maps in the present study can be viewed as a hybrid of the concept maps and knowledge maps just discussed. That is, the node-link maps in the Appendix can be read as a hierarchy of propositions that are interconnected with Standard Links, non-standard links, and arrows.

Unlike node-link maps, frames have fixed formats, which determine the relationships among the pieces of knowledge that are represented. The table (see Appendix, Figure 2) and the matrix (see Appendix, Figure 3) are two common frame formats. Tables and matrices include labels of main ideas for either columns or rows (tables) or both columns and rows (matrices). This structure allows subordinate information about the main ideas to be entered into the frame slots, which appear as the boxes formed by the rows and columns.

Tables and matrices are frames that may be used in nearly all content domains, such as in the sciences, social sciences, and the humanities. Frames have also been developed as generic content-dependent structures that reflect the conceptual structure of the domain and the domain topic as it is instantiated in the text (Armbruster & Anderson, 1984, 1985). In every Problem-Solution frame, for example, there are three slots: *Problem*, *Action*, and *Results* (Armbruster et al., 1987). This structure corresponds to a way that historical information is often organized. The slots of the frame are filled with key information about the concept domain and define the main ideas of the text content.

The purpose of this report is to provide teachers and teacher educators with information about learning to make idea maps for instructional use. This information is based on the work that eight preservice teachers carried out with instructional materials that I developed in connection with my dissertation study (Armstrong, 1992). The focus of the dissertation study was on the roles of prior topic knowledge and text features in how the preservice teachers made idea maps to represent elementary science text. The study's focus was not to evaluate the instructional materials or procedures. Even so, some of the data from the preservice teachers' independent mapping sessions seemed to be directly related to their earlier work with the instructional materials. Reflecting upon these connections has led me to prepare this report. The focus of this report is to present the materials and procedures that were used in my study and to determine the extent to which independent work of the preservice teachers followed the instructional guidelines for making idea maps. Finally, this report provides some evidence that supports the modified use of the instructional materials by teachers and teacher educators.

METHOD

Subjects

The subjects were eight students enrolled in a university elementary teacher certification program. The subjects, seven females and one male, were randomly selected from a pool of volunteers who were enrolled in a reading education course. Three of the subjects were graduate students working toward a master's degree with elementary school certification, and five were undergraduate students. In this report, all student names are fictitious.

Materials

Use of Study Strategies

Because selection and organization of important information have been discussed as conditions of meaningful learning (Armbruster et al., 1991; Mayer, 1989), students were given a sheet of blank, lined paper and asked to write a list of the study strategies that they typically used while reading texts for academic courses. In particular, they were asked to list what they did to select and organize information that they wanted to remember from text.

Instructional Materials

Materials were developed for an instructional session that introduced students to idea maps and map production. These materials (except for published passages from science textbooks) appear in the Appendix.[1] However, each type of exercise that was used in the dissertation study is represented in the Appendix.

The instructional materials in the Appendix present the idea map as a means of representing the interrelationships of main ideas in informational text. Node-link maps and frames are presented as types of idea maps that represent the general structural patterns that authors use in informational text: description, comparison/contrast, and explanation. Sample texts with corresponding idea maps are included and discussed.

These materials focus on making node-link maps to represent elementary science text. My reasons for choosing this emphasis were largely subjective, based upon the characteristics of the maps and the time constraints of the study. In particular, the node-link map is applicable to different text structures, whereas the matrix frame is appropriate primarily for texts with a comparison/contrast structure. I also speculated that the node-link map would allow for greater individual variations in mapping than the fixed format of frames would allow. This condition was important because I wanted to study the variations in implementation of instructional mapping procedures. Finally, the instructional time and scope of the study dictated that a limited study of idea maps be undertaken.

In general, the format of the idea maps in this study represents a hybrid of knowledge maps (Dansereau & Cross, 1990; Evans & Dansereau, in press; Lambiotte et al., 1989) and concept maps (Novak & Gowin, 1984; Novak et al., 1983; Novak & Musonda, 1991). Like knowledge maps, idea maps use a set of standard links (see "Standard Links for Mapping Informational Text" and "Supplement to Standard Links . . ." in the Appendix). Like the links in concept maps, the links in idea maps are usually verbs, and the map unit is a proposition. Furthermore, the last "Standard" Link listed is an unnamed "supplemental" link. In other words, this link gives the mapper complete freedom to generate an appropriate link connecting two concepts. Thus, the specific "Standard Links" do not prescribe the full extent of link choices; rather, the "Standard Links" serve as guides for thinking about expressing conceptual relationships.

The unit for building idea maps is the Linked Concept Pair (LCP), which consists of two nodes and a connecting link. Each node is a concept (typically a noun) that appears in an oval; each link consists of a label (typically a verb) and an arrow indicating the type and nature of the relationship connecting two nodes. Two types of links are described, *descriptive* and *dynamic*. Descriptive links are used to establish the identity of concepts; dynamic links show the conceptual relationships of sequences,

[1] The first page of the Appendix serves as a list of its contents. Please note that asterisks indicate that some of the exercise materials from the dissertation study are not included in this report.

processes, and causation. The set of Standard Links is suggested as a way to begin to think about the relationships presented in text.

The instructional materials in the Appendix also include a discussion of strategies and techniques for making maps. Practice exercises appear on a range of tasks--from choosing the appropriate link to join a pair of concepts to mapping short passages of informational text. Suggested responses accompany the exercises to provide a minimal level of feedback to mappers.

Think-Aloud Practice

In preparation for the independent work sessions of the study, students were given materials for practicing the think-aloud procedure (Ericsson & Simon, 1984), for which people orally report their thoughts while carrying out a task. These materials included a complete text segment of about 200 words from a science textbook written for the fifth-grade level (Mallinson et al., 1991). Students in the study were directed to simply "tell what you're doing step by step. Express your thoughts while you work." Thus, the study explicitly included directions that conformed to the guidelines suggested by Ericsson and Simon for concurrent verbal reporting.

These guidelines were developed in response to objections that verbal reporting modified the thought processes connected to a task, were unrelated to the thinking required to carry out the task, or were incomplete accounts of the thinking required to perform the task. Whereas Ericsson and Simon (1984) acknowledge that intermediate steps in mental processes may not pass through working memory and consequently may not be reportable, they also provide empirical evidence suggesting that concurrent verbal reporting of the *contents* of working memory does not modify mental processes, that verbal reports are pertinent to problem-solving tasks, and that the *contents* of working memory can be completely reported. In other words, concurrent verbal reporting emphasizes the *contents* of working memory, *not explanations* of thought processes. (For an extended discussion of these guidelines, see Ericsson & Simon, 1984).

Although the think-aloud materials are not included in this report, they are mentioned here because the think-aloud practice constituted instruction in idea mapping, that is, a review of mapping prior to the independent work sessions. In addition, during the independent work sessions, students thought aloud as they mapped informational text. Their think-aloud protocols served as a source of data that are discussed in this technical report.

Independent Work

Texts. Two passages were photocopied from commercially published textbooks (student editions). Each passage is a complete lesson (text, diagrams, pictures, and adjunct questions) that is part of a chapter. Each textbook was written at the fifth-grade level. "Plants Make Food" (Barman et al., 1991) is 847 words long and in this report is often called the "photosynthesis text." The other text, "Weather and the Atmosphere" (Mallinson et al., 1991), is 680 words long and in this report is sometimes called "the weather text."

Mapping supplies. For idea map production, students were provided with pens and unlined paper (8 1/2 by 11 inches).

Researcher's equipment. A camcorder and blank videotapes were used to videotape the students' independent mapping sessions. A remote lapel microphone was used in conjunction with the camcorder microphone.

Although the independent work sessions were not the focus of this report, some of the data from the independent sessions were used as an indication of the students' transfer of mapping instruction to independent work.

Procedure

Pilot Development

During the summer of 1991, I developed new materials and piloted them in conjunction with selected procedures for the study. Three female students, who were currently enrolled in a university's elementary teacher certification program, were paid volunteers in this work. These students worked individually with me. Between sessions with different students, I refined explanations and instructional models, edited practice items, and added explanatory materials. For example, during my work with these students, I guided them with insights that I incorporated into the "Suggestions for Mapping Informational Text" (see Appendix). However, I also realized that I could not anticipate how every student might get stuck while learning to map. Thus, I decided to provide limited assistance to students during their independent mapping sessions in the dissertation study. This decision was consistent with my intent to approximate the natural conditions in which I would be available to follow up an inservice or preservice instructional session.

Dissertation Study

The procedures for the study were carried out between September 9 and November 9, 1991. A pool of 15 preservice teachers, who were enrolled in a reading education course, volunteered to participate in the present study. Prior to volunteering, students were told that they would be developing idea maps for instructional use, that this work would involve about eight hours over a three-week period, and that they would be paid at the rate of six dollars per hour. Eight of the 15 students were randomly selected for participation in the study. After just two hours' work, one student withdrew from the study for personal reasons and was replaced by another student, who had been randomly selected from the remaining volunteers.

Each student participated in three individual sessions with me. The sessions took place in several conference rooms in the Education Building on campus. The sessions with one student took place in the building that houses a reading center. Work was done at a large table.

Session 1: Instructional. The instructional emphasis was on a self-paced preparation for learning to map text. The instructional materials and procedures were presented in the order that they appear in the Appendix. The written commentary that accompanies the map links, sample texts and maps, and practice exercises were delivered to the students. Sometimes the students read the commentary; at other times, I summarized it. In either case, the written commentary served as a guideline for each session.

In each session, there was a consistent emphasis on the following points which I explicitly discussed with each student:

1. Learning to map is a challenge for everyone. What a person does to select and organize other academic reading material may help a person in learning to map text.

2. The purpose of the mapping is to produce a "global map" (Novak & Gowin, 1984) for instructional use. A typical map consists of 10 to 15 concepts and the relationships connecting them. A global map represents the main text ideas and the relationships among them. The most important term, the superordinate concept, usually is placed at the top of the map.

I had two reasons for suggesting the range of 10 to 15 LCP units. First, a previous study (Armstrong, Armbruster, & Anderson, 1991) showed that 10 to 15 LCPs could capture the main ideas and relationships of a text lesson. Maps with 20 or more LCPs usually cluttered the paper and included so many details that they seemed to compete with the main ideas for the reader's attention. Second, idea maps are like summaries that use a spatial and verbal format. One-paragraph summaries typically include 8 to 12 sentences (Sullivan, 1984), and 10 to 15 LCPs roughly correspond to that number of clauses, which is a reasonable range for a single paragraph.

3. An idea map is built from LCPs, as described in the instructional materials. Almost all LCPs can be read as a short sentence or a complete idea.

4. Practice with Standard Links and short passages would be minimal so that the students could focus on the purpose and process of mapping larger segments of text.

5. Using a prescribed set of Standard Links might not be the most successful way of introducing elementary students to mapping their informational text. (See Novak & Gowin, 1984, for curricular materials and suggestions for introducing elementary students to concept mapping.)

During instructional sessions, I presented examples of Descriptive Maps (Figures 1, 5, and 6 in the Appendix) and an Explanation Map (Figure 4) along with the texts that they represented. I discussed how these texts and figures corresponded to the general characteristics of texts having overall structures that can be identified as Description or Explanation. I also presented the characteristics of the Comparison/Contrast structure, but said that the focus of our work was on the other text structures. Finally, during their practice sessions with Exercises 1 through 4 (see the Appendix), I modeled the thought processes of mapping very short segments (up to several sentences) of text. Although I did not model the mental processes of reading and mapping an entire text (of a paragraph or more), I suggested that students begin to map by reading the text with mapping in mind and then by using their usual strategies for selecting and remembering information from text. Next, I suggested that they try to work out the "big picture." This meant for the students to sketch on paper the relationships between the few *essential text concepts* that they were certain that they wanted to include in their map. Once this "big picture" took shape, then students could work with the text to decide upon an appropriate level of detail for a global map.

Although I did not keep detailed records of the extent to which students elected to carry out the practice exercises, I noted that all eight students completed Exercise 1. On Exercise 2, four students completed it, three did every other item, and one skipped it entirely. All students did three or four items in Exercise 3 and both passages in Exercise 4. At the discretion of the students, we discussed particular items in Exercises 1 through 3. We discussed their maps of both passages in Exercise 4.

Near the end of the instructional phase, students carried out a "talk through" of one of the maps that they had completed with my guidance in Exercise 4. A "talk through" involves reading aloud and explaining the map to another person. This technique is one way that a person can check a map for accuracy with the text and for clarity. In this study, the "talk through" also anticipated the verbal reporting required during independent work.

Although the instructional sessions were not timed, they averaged about three hours in length.

Session 2: Independent work. Session 2 consisted of think-aloud practice, knowledge assessment on the topic of photosynthesis or air and weather, and idea mapping of the corresponding text. Texts were randomly assigned to each student's first session until four students had been assigned the same first text. Then the order of texts was counterbalanced between Session 2 and Session 3.

After I introduced and modeled the *think-aloud procedure*, several students began to practice by explaining everything they reported. In these cases, students were told the following: "Just state your conscious thoughts as you work. Give reasons when they come to mind while you work."

Practice was carried out, progressing from relatively simple tasks to a complex one, which involved producing an idea map for a short passage on the Dust Bowl or the uses of microwave energy. (Mallinson et al., 1991). At the same time that students were learning to think aloud, they were continuing the kind of mapping practice that they had done at the end of the instructional session.

Students read the passage silently the first time through, but were asked to report aloud any conscious thoughts that occurred to them about mapping. (This direction reminded them of what they were advised to do during the instructional phase--to anticipate mapping while reading text.) After their first complete silent reading of a passage, students were permitted to reread the text. They were asked to read aloud any portion of the text that they chose to reread.

Practice proceeded with students until they felt able to express their thoughts fluently as they worked on a task. During think-aloud work, the main prompt that I used was, "Keep talking."

The *topic knowledge assessment* is beyond the scope of this report, but is discussed in the dissertation study (Armstrong, 1992).

After completing the knowledge assessment on a topic, students read the text on the same topic, on either air and weather or photosynthesis. Thus began the *map development* phase of the independent work session. The reading and mapping phases of map development were videotaped. The stopwatch function was used to record the length of the mapping session. The mapping session officially began when the student received a passage to read and ended when the student indicated that she or he was done. I operated the camcorder.

Students were directed to read the text as they usually would, having the purpose of mapping in mind. If they typically made written notes while reading, they were permitted to do so for mapping. To this point, the students were asked to report orally (or as written notes) only what they normally would be attending to while reading informational text with the purpose of comprehending it and mapping it.

After reading the text, students were asked to map the text, according to what they had learned about idea mapping during the instructional phase. While mapping, they were permitted to use their instructional materials. Students were directed to represent in a map the information from the text lesson that they felt was essential for a class of "average fifth graders" to know. The students were asked to think aloud as they built their maps. (Students were not expected to talk constantly while actually writing or trying to find a passage during a lookback to the text.) During all sessions, I reminded the students to "keep talking." From time to time, I also asked students to talk louder.

Consistent with the conclusions I drew from piloting the mapping procedures, I decided to provide "scaffolding" for students. Scaffolding (Wood, Bruner, & Ross, 1976) involves a tutor or other expert who provides assistance to a learner who is unable to complete the task independently at a required time. Prior to the present study, I decided that I would not provide scaffolding until the students had worked completely on their own for at least 40 minutes. After 40 to 45 minutes of reading and mapping, I asked the students, "Do you have the big picture?" I chose 40 minutes as the point of intervention because, in a prior study (Armstrong et al., 1991), that was the time in which the 27 practicing teachers had completed their maps . If the students said that the main parts of their maps were in place, then I provided no scaffolding at that time. If they still hadn't worked out the big picture, then I offered assistance *if they wanted some suggestions*. The students were familiar with the term "big picture" because I had emphasized it as an important step in the development of a global map. The "big picture" referred a sketch on paper of the relationships between the few *essential text concepts* that students were certain that they wanted to include in their maps. Once this "big picture" took shape, then students could work with the text to decide upon an appropriate level of detail for a global map.

Later on in the sessions, I offered assistance if students requested it or if time was running short because of schedule conflicts. Whenever I provided scaffolding, my comments were almost always presented in the form of asking questions or suggesting at least two ways of representing the same information. From time to time, students would ask me if they could map concepts in a certain way. For example, Flora wanted to know if she could use *from* as a link, and Becky asked if a node could contain more than one concept. In all instances I tried to leave the student with the decision of what and how to map. Even so, this form of assistance could be considered instructional although it occurred in work sessions that were primarily for independent work.

Students conducted a "talk through" upon completing their maps. I reminded them that a talk through served two purposes: to make sure that their maps read fluently and to verify their maps with the information in the text. From the standpoint of research methodology, of course, this procedure afforded another opportunity for concurrent verbal reporting of the processes involved in building the relationships among the concepts represented on the map.

Session 3: Independent Work. With two exceptions, the procedures for Session 3 were the same as those described for Session 2. Session 3 did not include think-aloud practice, but did include a debriefing session after the mapping was completed.

During debriefing, I mentioned that idea maps might be useful in helping students to learn from informational text, but I cautioned students that many textbooks (even when supplemented with an idea map) are likely to be inadequate for students to learn scientific explanations in a meaningful way. Many science texts treat complex concepts in superficial ways (Pauling, 1983). I also provided students with a short bibliography of sources on idea mapping.

Most of the students spontaneously commented that the sessions were interesting and that mapping turned out to be much more difficult than they had first thought it would be. Four of them wanted to know if they could have copies of the materials. After all the students had completed their sessions, their instructional materials were made available to all students.

Analysis

To what extent did the students follow the instructional guidelines for mapping ideas from informational text? To answer this question, several quantitative and qualitative analyses were carried out. These analyses, however, *do not* evaluate how well the idea maps represent the important text ideas. That level of analysis would involve the consideration of factors beyond the scope of this report, such as the relative importance of text ideas, the nature and extent of the students' topic knowledge prior to reading the text, and the "considerateness" of the text (Armbruster, 1984). These factors were taken up in the dissertation study (Armstrong, 1992). On the other hand, the focus of the analysis in this report is to answer two specific questions: (a) To what extent did the students attempt to build global maps to represent text? and (b) What strategies did they use to build their maps?

As a foundation of analysis, the videotaped recordings of the independent mapping sessions were transcribed. The following aspects of map production were considered in the analysis.

Times of Involvement

The length of each mapping session was calculated. The work period, which began with the first session and ended with the third session, was also determined for each student.

Map Drafts

The number of sheets of paper used by each student to construct a map was counted. Only the sheets that used node-link notation were included in this count. A sheet was counted as a draft if it included map notation, regardless of the extensiveness of the work that appeared on the page. Unless otherwise indicated, all analyses involving particular maps were carried out on the final drafts of the maps produced by the students in their independent mapping sessions.

Total LCPs and Global Maps

The number of LCP units in each idea map was counted. Each node-link-node combination was counted once in the tally. Because the instructional guidelines suggested that a global idea map consists of 10 to 15 concepts and their relationships (that is, 10 to 15 LCPs), the number of LCP units in a map was used as an index of the extent to which the students carried out the suggestion to build a global map.

Student awareness of this purpose was demonstrated in the think alouds from the students' independent mapping sessions. The think-aloud protocols were examined to determine if the students mentioned that they were working on a "global map" or the "big picture." Protocols were also examined to see if students counted the number of nodes that they had used in their maps, an action revealing a student's awareness of the guideline concerning global maps.

Standard Links and Other Links

The instructional sessions on mapping contained information and practice exercises related to the use of Standard Links and Other Links (see the Appendix). I emphasized to the students that the eight specific Standard Links were only a starting point or a reference point in building LCP units. I explicitly reminded them that Standard Links might *not* be the best link in more than half the LCPs in any map. One concern of mine was that the instructional attention given to Standard Links might influence an overuse of them in map production. In fact, in every independent mapping session, the student made sure that the information sheet of Standard Links was visible.

In analyzing map production, therefore, I was interested in whether the idea maps contained both Standard Links and Other Links. Frequency counts of Standard Links and Other Links were carried out for each idea map.

Another point of concern was whether or not students used different arrow forms to distinguish descriptive and dynamic links. In other words, in using Standard Links, did students make single-headed arrows to indicate descriptive links and multi-headed arrows to indicate dynamic links? Idea maps were examined for the consistency of arrow and label correspondence.

Scaffolding

The videotaped mapping sessions were analyzed for the presence and levels of scaffolding provided by the researcher to the students. If I provided a student with no assistance with mapmaking, then no scaffolding was provided. From time to time I answered questions about the task conditions: for example, I requested that students not return to do new work on an earlier draft of a map. I also reminded the students to "keep talking" and to do a "talk through" at the end of the session. These kinds of interactions were not considered scaffolding. In contrast, if I assisted students with developing the big picture for their maps or made suggestions that led students to change their superordinate map concept, then I called these instances of a major level of scaffolding. If I assisted students just with rephrasing LCPs or with reorganizing subordinate map concepts, then these were instances of a minor level of scaffolding. Thus, each mapping session was evaluated as having no scaffolding or as having major or minor levels of scaffolding.

Strategy Use

The self reports of strategy use were analyzed. The strategies that each student reported using to learn from academic text were listed. These formed a base-line of data that I compared to the evidence of the strategies that each student used during independent mapping sessions. The sources of evidence were the transcripts of the videotaped sessions and the artifacts of the mapping sessions. In particular, the transcripts revealed evidence of rereading parts of text that the students had previously marked. The transcripts also revealed oral summaries that some students composed prior to writing on map paper. Text photocopies used by each student were examined for evidence of markings and annotations. General patterns of map production were analyzed in terms of the reported strategies and the ones actually used later in mapping sessions.

RESULTS

Times of Involvement

Work Period

The period of days over which the eight students participated in the study ranged from 9 to 17 (M = 11.88, SD = 2.57).

Length of Mapping Sessions

The length of the mapping sessions is presented in Table 1. All of the sessions occurred in "one sitting," except for Becky's session on the photosynthesis text. After 45 minutes of mapping, Becky left to attend a class. She agreed to try not to think about mapping while she was gone; when she returned, she stated that she had not had any thoughts about the mapping sessions. She resumed her mapping and completed it 61 minutes later.

[Insert Table 1 about here.]

The mean length of sessions on the photosynthesis text was 65.13 minutes (SD = 24.76). The mean length of sessions on the air and weather text was 58.25 minutes (SD = 14.45). The mean length of the students' first mapping session was 67.00 minutes (SD = 19.54); the mean length of the students' second mapping session was 56.38 minutes (SD = 20.18).

Map Drafts

The number of drafts that the students produced of each map is presented in Table 2. For the photosynthesis text, the mean number of map drafts was 6.00 (SD = 2.65). For the text on air and weather, the mean number of drafts was 4.75 (SD = 1.09). It is interesting to note that four students produced more drafts on the photosynthesis text than on the weather text. This pattern was reversed for three other students. Ginny was the only student who produced the same number of drafts on both texts. Most of the analysis in this study is based upon the last draft. Exceptions to this practice are explicitly mentioned for each case.

[Insert Table 2 about here.]

Total LCPs and Global Maps

The number of LCP units for each idea map is reported in Table 3. In the maps representing the photosynthesis text, the number of LCPs ranged from 11 to 27 (M = 16.88, SD = 4.78). In the maps on the weather text, the number of LCPs ranged from 12 to 27 (M = 17.87, SD = 4.14).

[Insert Table 3 about here.]

The guideline was for a global map to consist of 10 to 15 LCPs. Most of the maps were within this range or were nearly within it. That is, five of the eight maps on photosynthesis had 16 or fewer LCPs; six of the eight maps on weather and the atmosphere had 17 or fewer LCPs. Abby was the only student who produced two maps containing more than 17 LCP units. The other seven students appeared to be able to work within the guideline for the number of LCP units in an idea map.

The protocols from the videotaped independent work sessions also indicated that students were guided by the suggested range of 10 to 15 LCPs. Five of the students mentioned at least once the terms "global map" or "big picture" in connection with their process of building a map. Two of the other students counted map nodes at least once during their independent sessions. Only Abby did not reveal the conscious purpose of producing a global map, and as previously mentioned, she was the only student who produced two maps containing more than 17 LCP units.

Standard Links and Other Links

Table 4 reports the frequency counts carried out for the use in idea maps of Standard Links and Other Links. Frequency is reported as the number of links of each type, Standard Links (SL) or Other Links (OL), appearing in each map. Apparently my concern that students would be reluctant to generate non-standard links was unfounded. All the students used Other Links, and .77 of all the links used in the eight maps representing photosynthesis text were Other Links. Of interest in Table 4 is that four of the eight students (Abby, Becky, Eddie, and Flora) used primarily Other Links to map the photosynthesis text, but used primarily Standard Links to map the weather text.

[Insert Table 4 about here.]

Table 4 also shows that the instruction to distinguish descriptive from dynamic arrows was not carried out consistently. As indicated by the superscripts and the table note, six of the maps (produced by four of the students) used non-standard arrows. They either used the same style of arrow for all links or developed a new form that they used along with the standard forms. Because these mapping instructions were so widely disregarded, I did not carry out a detailed analysis of the frequency of "arrow-label" mismatches in the rest of the idea maps.

Scaffolding

The levels of scaffolding that I provided to the students during their independent mapping sessions are shown in Table 5. Perhaps the most striking feature in the data is that the sessions on the photosynthesis text involved either major levels of scaffolding or none at all. In contrast, the sessions on the weather text involved just two instances of minor levels of scaffolding; the rest were completed without aid to the students. A tally of the scaffolding levels provided in the students' first and second sessions reveals a perfect balance of the levels provided between the sessions. That is, instances of major scaffolding (4), minor scaffolding (2), and no scaffolding (10) were evenly divided between the first and second sessions.

[Insert Table 5 about here.]

Strategy Use

The results of the study strategy analysis are presented in Table 6. In the two columns headed by text titles, the strategies are listed from left to right in an order that approximates their sequence of use by students in the mapping sessions. For example, Abby followed this general sequence of strategy use as she started to map the text on weather: She underlined the text as she read and made annotations in the text margins; after reading, she composed an oral summary of the main text ideas; finally, she reread her text markings before starting to map the text.

[Insert Table 6 about here.]

Some of these strategies were used more than once by some students (e.g., instances of rereading text markings), but frequency of use is not indicated in the table. In general, strategies used by students *after* they started using map notation (i.e., links and nodes) are not reported. Table 6 includes just one strategy that was used by some students when they began to use map notation. In particular, an O* in the table indicates that the student began the first map draft with an outline of the whole text, using only one or two superordinate terms and a single level of subordinate relationships. After sketching out a map at this level, the student began to add links and nodes to the subordinate relationships. For example, Becky began her first map draft of the photosynthesis text by writing *How Plants Make Food* at the top of the paper. Then, as she scanned the text, she connected her superordinate idea to nodes for roots, stems and leaves, foodmaking in leaf, and storing food. After generating this single level of subordinate relationships, Becky began to map the details about the roots and then about the stems and leaves, foodmaking, and storing food. Thus, she outlined "the big picture" before mapping the details of any subordinate relationship.

Based on Table 6, a comparison of strategies reported and strategies used in mapping shows that seven of the eight students adapted familiar strategies to the new independent mapping task. The use of these familiar strategies had been encouraged during the instructional sessions, and prior to reading text for independent mapping, students had been reminded to consider using familiar strategies in the forthcoming session. Some students also developed strategies for mapping that they had not reported as typical in their previous learning from academic tasks. In particular, Abby, Carrie, and Dixie used the summarizing strategy (S*) before starting to draft their maps. Also, Becky, Dixie, Flora, and Holly sketched the "big picture" (O*) as a way to start their first map drafts. This strategy also had been emphasized in the instructional session on mapping.

Limitations and Conclusions

An obvious limitation to this report is that it did not address the quality of the maps produced, that is, the faithfulness to the text and the clarity and fluency of the representation. Another limitation is that the maps produced in the independent work sessions were not intended for actual classroom use with particular students. Rather, the students in the study were directed to produce maps for use with a class of average fifth graders.

In general, the data examined here support the idea that the students (preservice teachers) were able to follow the guidelines for making idea maps to represent elementary science text. The purpose of building a global map of about 15 concepts and their interrelationships was manageable for these students. One of the eight students did not limit either of her maps to fewer than 20 concepts. Although the precise number of total concepts is not very important, too much detail could easily defeat a map's purpose of having elementary students focus on the main ideas and the relationships connecting them.

The instructional materials might have contributed in part to the inclusion in some maps of unnecessary detail. That is, the instructional materials might have given a mixed message about mapping priorities and procedures. For example, I modeled global maps, but Exercises 1 and 2 required students to map every sentence of text. Even though I emphasized the desirability of mapping "the big picture" before considering details of subordinate concepts, this strategy was inconsistently attempted in the independent work sessions. For example, considering both maps produced by each student, I found that only five of the eight students attempted to generate an oral summary or a map of the big picture before mapping the details.

All of the data sources presented in this report showed a range of individual differences connected with learning to map. The length of mapping sessions, the number of map drafts and LCP units in the final draft, the amount of scaffolding, and the types of strategies all varied considerably. These data suggest one cannot expect students to learn to map according to a set of prescribed procedures and within prescribed time limits. Of special significance is that major levels of scaffolding were necessary for four of the eight students, and five of the eight were provided some scaffolding in at least one of their independent work sessions. Thus, the materials and individual feedback in the instructional sessions did not permit five of the eight students to develop full independence for their work with the photosynthesis and weather texts.

Implications for Teacher Preparation

In learning to map text, half of the students in this study appeared to need assistance to enable them to complete their work. Based on these and other results of the present study, I would revise the instructional materials. More full-length text samples would be included so that students could identify and outline the overall text structures. In contrast, very little practice material would focus on single sentences or short texts. Descriptive and dynamic mapping links would be presented in the context of full-length texts, not in isolation. Only single-headed arrows would be used. This modified instruction could focus on full texts and the correspondences between them and idea maps.

Besides the materials, the delivery of instruction could be improved. In teaching people how to map, I would modify the present methods to include more thinking aloud to model the strategies of selecting and organizing text information for mapping. Follow-up sessions could serve to refine the techniques of novice mappers. Instruction for preservice teachers could be distributed over a semester. For practicing teachers, an initial session of several hours could be supplemented by a couple of follow-up sessions in which teachers could share their experiences with mapping and get feedback on their work.

At either preservice or inservice level, learning to map would probably be most meaningful if teachers were able to use the texts and mapping materials in their own classrooms with their own students. As students interact with maps and text, I suspect that their teachers would learn important things about what works and what does not work in idea maps. Of course, idea maps are primarily tools which have the purpose of illustrating and clarifying the relationships among key ideas of text. When idea maps fulfill this purpose, they can aid students in becoming aware of the structure of text. This awareness, in turn, can help students in building an understanding of the central meaning of text.

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Author Notes

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Table 1

Length of Independent Mapping Sessions

Student	Length of session on "Plants Make Food"	Length of session on "Weather and the Atmosphere"
Abby	30 (2)	45 (1)
Becky	106 (1)	40 (2)
Carrie	26 (2)	42 (1)
Dixie	61 (1)	74 (2)
Eddie	83 (2)	57 (1)
Flora	73 (2)	83 (1)
Ginny	72 (1)	62 (2)
Holly	70 (1)	63 (2)

Note. Times are expressed in minutes. Numerals in parentheses indicate the first or second independent mapping session.

Table 2

Drafts of Idea Maps

Student	Number of drafts representing "Plants Make Food"	Number of drafts representing "Weather and the Atmosphere"
Abby	2	4
Becky	10	4
Carrie	3	4
Dixie	8	6
Eddie	9	4
Flora	6	7
Ginny	5[a]	5[a]
Holly	5[c]	4[b]

[a]Excludes 1 page of notes student made before starting to map.

[b]Excludes 2 pages of notes student made before starting to map.

[c]Excludes 3 pages of notes student made before starting to map.

Table 3

LCPs in Idea Maps

Student	Text: "Plants Make Food"	Text: "Weather and the Atmosphere"
Abby	27	21
Becky	11	17
Carrie	12	12
Dixie	15	17
Eddie	20	16
Flora	19	17
Ginny	15	27
Holly	16	16

Table 4

Types of Links in Idea Maps

	Text			
	"Plants Make Food"		"Weather and the Atmosphere"	
	Links		Links	
Student	SL	OL	SL	OL
Abby	3	24	20	1
Becky	0	11	10	7
Carrie[ab]	7	5	5	7
Dixie[ab]	2	13	1	16
Eddie[a]	5	15	10	6
Flora[a]	6	13	16	1
Ginny	4	11	10	17
Holly	4	12	2	14
Total	31	104	74	69
Proportion	.23	.77	.52	.48

Note. Standard Links (SL); Other Links (OL).

[a]Map of photosynthesis text included non-standard arrows, or arrows were not differentiated by type of link.

[b]Map of weather text included non-standard arrows, or arrows were not differentiated by type of link.

Table 5

Scaffolding

Student	Level of Scaffolding in Mapping Session: "Plants Make Food"	Level of Scaffolding in Mapping Session: "Weather and the Atmosphere"
Abby	none (2)	none (1)
Becky	major (1)	none (2)
Carrie	none (2)	none (1)
Dixie	none (1)	minor (2)
Eddie	major (2)	none (1)
Flora	major (2)	minor (1)
Ginny	major (1)	none (2)
Holly	none (1)	none (2)

Note. Numerals in parentheses indicate the first or second independent mapping session.

Table 6

Study Strategies and their Use in Mapping Text

Student	Strategies Reported	Strategies Used With "Plants Make Food"	Strategies Used With "Weather and the Atmosphere"
Abby	M R	M S*	M A S* R
Becky	M R	M O* R	M
Carrie	M A R N O	M R S* O*	M A R S* O*
Dixie	M A R N	M A R S* O*	M A R S*
Eddie	A R S	M A S* O* R	M A S* R
Flora	M A R N	O*	S*
Ginny	M R N	M R N	M R N
Holly	M A N	M A R N O*	M A R N

Note. Self-reports of study strategies by the students occurred prior to mapping instruction. The strategies are coded in the table as follows:

M = Marking text (underlining, highlighting, circling)
A = Annotating text margins;
R = Rereading markings (M) in text;
N = Notetaking (on separate paper);
S = Summarizing (in writing).

Additional codes describe the mapping strategies used during independent mapping sessions:

O* = Outlining the "big picture" before mapping details;
S* = Summarizing (orally) main text ideas before mapping.

APPENDIX

Making Idea Maps for Informational Text

* not included in Technical Report.

** partially included in Technical Report

Introduction

Idea mapping is a process of representing the main ideas of informational text. An idea map has a distinctive verbal and spatial arrangement that represents the main text ideas and the relationships between them. Idea maps are related to other graphic organizers, such as concept maps, frames, semantic networks, flow charts, and knowledge maps. Recent educational research has shown that these graphic representations of text structure and content can improve learning from text. Significant results have been obtained at the elementary and middle grades as well as at the high school and college levels. Idea maps can be used as a prereading organizer, as a comprehension guide during reading, or as a postreading learning aid. Their effectiveness further depends on the learners' active participation in creating or completing the map.

A key feature of the idea maps presented here is that the relationships between main ideas are stated explicitly. In fact, these relationships link the ideas as they are visually represented on a map. Figures 1, 4, 5, 6, 7, and 8 show how text ideas are linked on maps. In each of these maps, text concepts are presented in bubbles (called "nodes") and are connected to other concepts by labeled arrows (called "links"). Two other kinds of maps are called frames because they have a set format. These frames (a table and a matrix) are presented in Figures 2 and 3. Instead of nodes and links, frames use rows and columns to present and relate information.

All of these maps correspond to the general structural patterns of informational text. These patterns are description, comparison/contrast, and explanation. The description structure may follow a pattern of a simple list, a classification, or a definition with examples. A comparison/contrast presents the similarities and/or differences between two things. An explanation structure may follow a pattern of time sequence, cause and effect, or problem and solution. Most informational text does not use just one of these structural patterns, but most do have a dominant structure. These instructional materials focus on node-link idea maps, and the frames are presented only to show how the three text types may be represented.

The basic unit of an idea map is the Linked Concept Pair, or LCP. An LCP unit consists of two nodes and the link between them. Each node contains a concept (in general a noun, sometimes with modifiers); each link consists of a label (a verb) and an arrow indicating the type and nature of the relationship that connects the two nodes. Together, any two nodes and their link can be read as a proposition, that is, a clause. How links and nodes may represent text statements is shown in the Presentation Materials which follow this introduction.

The purpose of these materials is to provide information about making link-node idea maps to represent expository text. Although idea maps can be developed to represent all kinds of texts, these materials are focused on mapping the kind of science text typically found in graded series of elementary science textbooks. Many of these books contain "hands on" activities and other materials to supplement the text, but these textbooks typically present complex concepts in a superficial way. Thus, these texts alone are probably inadequate for students to learn about scientific explanations of phenomena. Secondly, these textbooks might better be used as a supplement to science instruction rather than as the centerpiece of instruction. In any case, if science text is used in instruction, then mapping can aid students' understanding of the main text ideas and the relationships between them.

To start a map, a person writes a central text concept at the top of a blank sheet of paper. Then the mapper is guided by the set of standard links and relationships, which are included later in the presentation materials. The mapper uses the links to form questions about the central concept: Does the text describe the main characteristics of the central concept? Does the text explain a process that involves the central concept? Are both description and explanation involved in the way that the text discusses the central concept?

Once the mapper has read the text and has tentatively answered some of these questions, then the mapper can begin either a "top-down" or "bottom-up" process for adding nodes and links to the central concept node until the map is completed.

A mapper begins a top-down process with a gist or summary of the text. The text mapper sketches out the main concepts and links them to the central concept, checking to see if these relationships are confirmed in the text. Most people readily form a summary of text only if they were familiar with the text topic prior to reading.

A mapper begins a bottom-up process by gathering main ideas from the text, distinguishing them from less important ideas and details. With a list or outline of these main ideas, the mapper consults the text for information about the relationships between them. Then the mapper links these concepts to the central concept and checks the text to ensure a faithful, accurate representation.

The mapping materials consist of Presentation Materials, Practice Materials, and Suggestions for Making Idea Maps. What follows is an overview of each of these three parts.

The Presentation Materials start with the basic unit of an idea map, two nodes and a link (or Linked Concept Pair). Because the formation of a map depends on an understanding of the basic relationships between concepts, the Standard Links for Mapping Informational Text and a Supplement to Standard Links are presented first. The examples of text used to illustrate these links are very short. Once a new mapper has become familiar with these linking relationships, then an examination of sample Text Types and Typical Formats is useful. These materials show the correspondence between texts and maps. These texts are longer than those used to illustrate the links and thus are appropriate to the usual purposes of mapping, which is to provide a condensation of developed text.

The Practice Materials consist of a series of exercises. Exercises 1, 2, and 3 could be done in connection with gaining familiarity with the relationships between text and LCP units. My suggestion to prospective mappers is to do only the exercises that will help you establish a facility in using links to join concepts that represent a textual relationship. Suggested Responses to the exercises will provide you with feedback on your mapping of the exercise statements. It is likely that some of your responses will not agree with mine. That is fine, but my responses should make sense to you. Once you feel somewhat comfortable with mapping short statements, then proceed to Exercise 4, which involves mapping paragraphs. Again, spend *only* as much time with this exercise as you need to feel prepared to move on to a full lesson of content area text. Although most new mappers feel that mapping is sometimes a very difficult challenge, most of them feel more comfortable with a developed text than with just a sentence or two of text to map.

From teaching and observing people who were learning to map informational text, I developed Suggestions for Making Idea Maps. These suggestions are simply guidelines because mapping is a complex task; in a sense, each person must discover his or her own best way to learn how to do it. In making a map, I believe that there is no one "best map" to represent a given text. However, I also believe that a map should be a clear and faithful representation of a text and that some maps are more effective than others in achieving this purpose.

Presentation Materials

This section of the mapping materials provides information about how to map individual ideas and passages of text. The section starts off with the links and relationships that are the essence of mapping. Then basic text types are discussed and then illustrated with sample texts and maps.

On the next page, the Standard Links and Relationships are divided into two groups, descriptive links and dynamic links. Descriptive links tell "what" about an object or event. Dynamic links tell "how" or "why." Notice that the arrows take different forms for descriptive and dynamic links. The solid line with a single arrowhead is used with descriptive links and may suggest a static relationship. In contrast, the many-headed arrows used for dynamic links may suggest movement, process, or results.

As you become familiar with the mapping links, please keep in mind that soon you will be mapping developed text of a paragraph or longer. Also remember that you are not restricted to using the "Standard Links." Standard Links may work well only in only about half or two thirds of the LCP units you make. The guideline here is this: If a Standard Link fits, use it. Otherwise, create a better link.

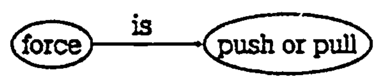
Standard Links & Relationships for Mapping Informational Text

In the examples, the arrowhead indicates direction and type of relationship:
——— indicates descriptive (static) link
- - - - indicates dynamic link

LINKS | RELATIONSHIP | EXAMPLE

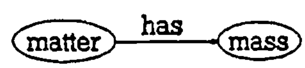
<u>Descriptive</u>

is | equivalence | A force is a push or pull.

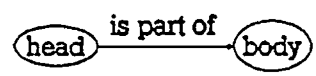


includes | type/example | A dog is a kind of animal.

has | attribute | Mass is a characteristic of matter.



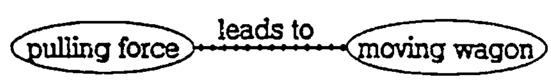
is part of | part-whole | The head is a part of the body.



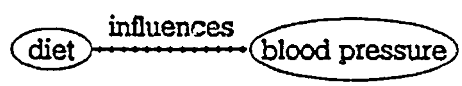
is like | analogy | Hibernation is like deep sleep.

<u>Dynamic</u>

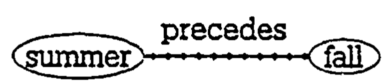
leads to | causal/enabling | A pulling force causes the wagon to move.



influences | affecting | Diet affects blood pressure.



precedes | temporal | Summer comes before fall.



<u>Supplemental</u> (may be Descriptive or Dynamic)

[ ] | [ ] | [<u>Nearly all topic domains and texts will require the use of different or more precise links than the standard ones</u>. See the examples beginning on the next page.]

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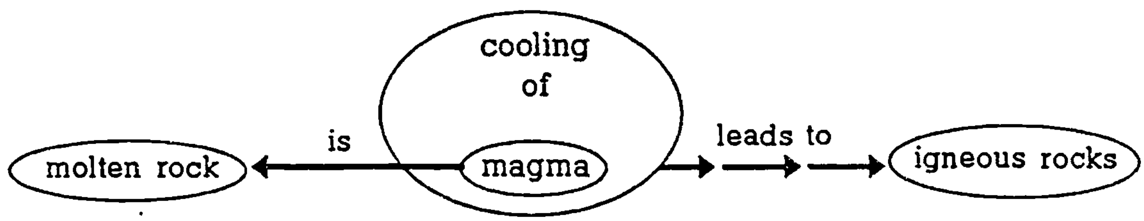
Supplement to Standard Links for Mapping Informational Text

The standard links may not always be sufficient to represent text adequately. Below are listed some of the many situations in which adding information to the standard links or replacing the standard links may be necessary to achieve a clear, accurate representation of the main text ideas.

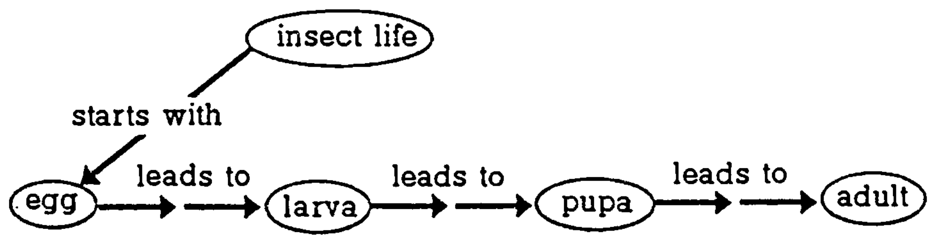
1. Representing both the descriptive and dynamic aspects of a concept

For example: The cooling of magma, or molten rock, results in the formation of igneous rocks.



2A. Using "starts with" to join the name and first node of a sequence

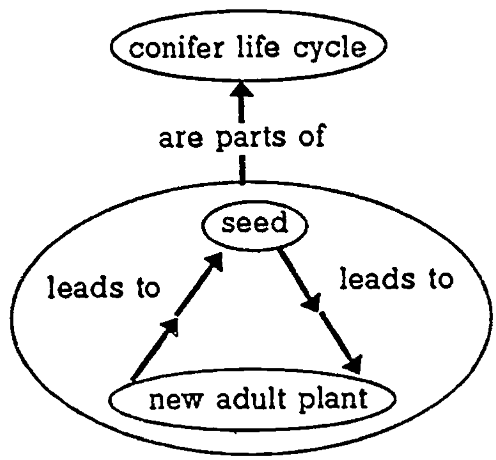
For example: The stages of insect life are egg, larva, pupa, and adult.



Supplement to Standard Links for Mapping Informational Text (continued)

2B. Using "is part of" to join the name of a cycle and its elements

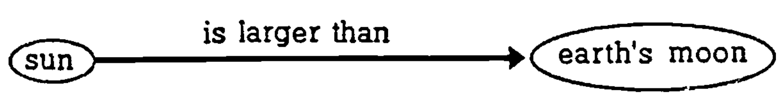
For example: The life cycle of a conifer consists of a seed, which grows into a new adult plant that produces seeds.



3. Using non-standard links for special relationships

A. Using phrases to make comparisons of size, distance, weight, and so on

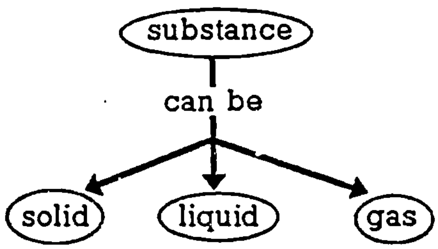
For example: The sun is larger than the earth's moon.



Supplement to Standard Links for Mapping Informational Text (continued)

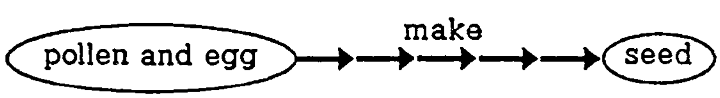
B. Using "can be" to express alternate states

For example: A substance is either a solid, liquid, or gas.

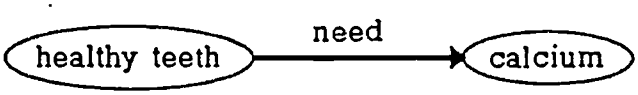


C. Using precise links in specific domains

For example: Some of the pollen joins with an egg to make a seed.



For example: In the topic area of nutrition, "needs" might be a useful link, as in the sentence, Calcium is necessary for healthy teeth.



Text Types and Typical Formats

Sample texts and typical map formats are presented for the three types of informational text: description, comparison/contrast, and explanation. These sample texts are based upon information typically published in textbooks intended for elementary science students. Each of these passages is based upon several sources. Unlike the typical science textbook "lesson," these passages do not generally contain as much detailed information about a topic nor do they contain the usual introductory comments that usually provide continuity with other text lessons. Thus, these sample texts represent mainly the "essential" information that might appear in a textbook.

Figures 5 and 6 are variations of the descriptive maps (Figures 1 and 2) on "Minerals." Figures 2 and 5 contain the same information in very different formats. Whether a teacher chooses a table (Figure 2) or branching tree (Figure 5) depends somewhat on the students' familiarity and facility with each format, but the choice depends largely upon the preference of the teacher. A comparison of the two formats reveals that the branching tree presents many details in a distinctive arrangement. As a result, does the map appear cluttered, or is it memorable? In contrast, the table efficiently presents the same details as the map. However, this table has the same format as every other table and, as such, may not be as memorable as the map.

Figure 3 is accompanied by two versions of the text, "Two Kinds of Volcanoes." The first version of the text is structured by names (shield cones and cinder cones). The second version is structured by attributes (location of formation, movement of lava, kind of lava, and shape of volcano). These organizational schemes correspond to the column labels (names) and row labels (attributes) shown in Figure 3.

Explanation structures are represented by the sample text, "Volcanic Eruptions." This text is organized according to a cause-effect structure, which presents a series of events that are causally connected. The text is represented in Figure 4, which has the typical "chain" format, a series of events connected by dynamic links. Note also that some descriptive links are used in this primarily explanatory map.

Description, Sample Text: "Minerals"

Minerals are solids that are made from one or more chemicals in the earth's crust. Minerals have several characteristics, which include color, streak, luster, hardness, and crystal shape. Minerals can have many colors, such as red, green, blue, black, and white. The second characteristic of minerals is streak. Streak is the color made by the powdered mineral, like a chalk mark. For example, both the black and red kinds of hematite show a brownish-red streak. Another quality of minerals is luster. Luster is the way that light reflects off the surface of a mineral. Some minerals are dull, but others are shiny like metal. Fourth, minerals can be hard, soft, or in between. Talc is one of the softest minerals, and diamonds are one of the hardest. Finally, each kind of mineral has its own crystal shape, a special pattern of the atoms making up the mineral. For example, salt crystals are shaped like cubes, and quartz crystals are shaped like hexagons. These properties of color, streak, luster, hardness, and crystal shape are used by scientists and rock collectors to identify minerals.

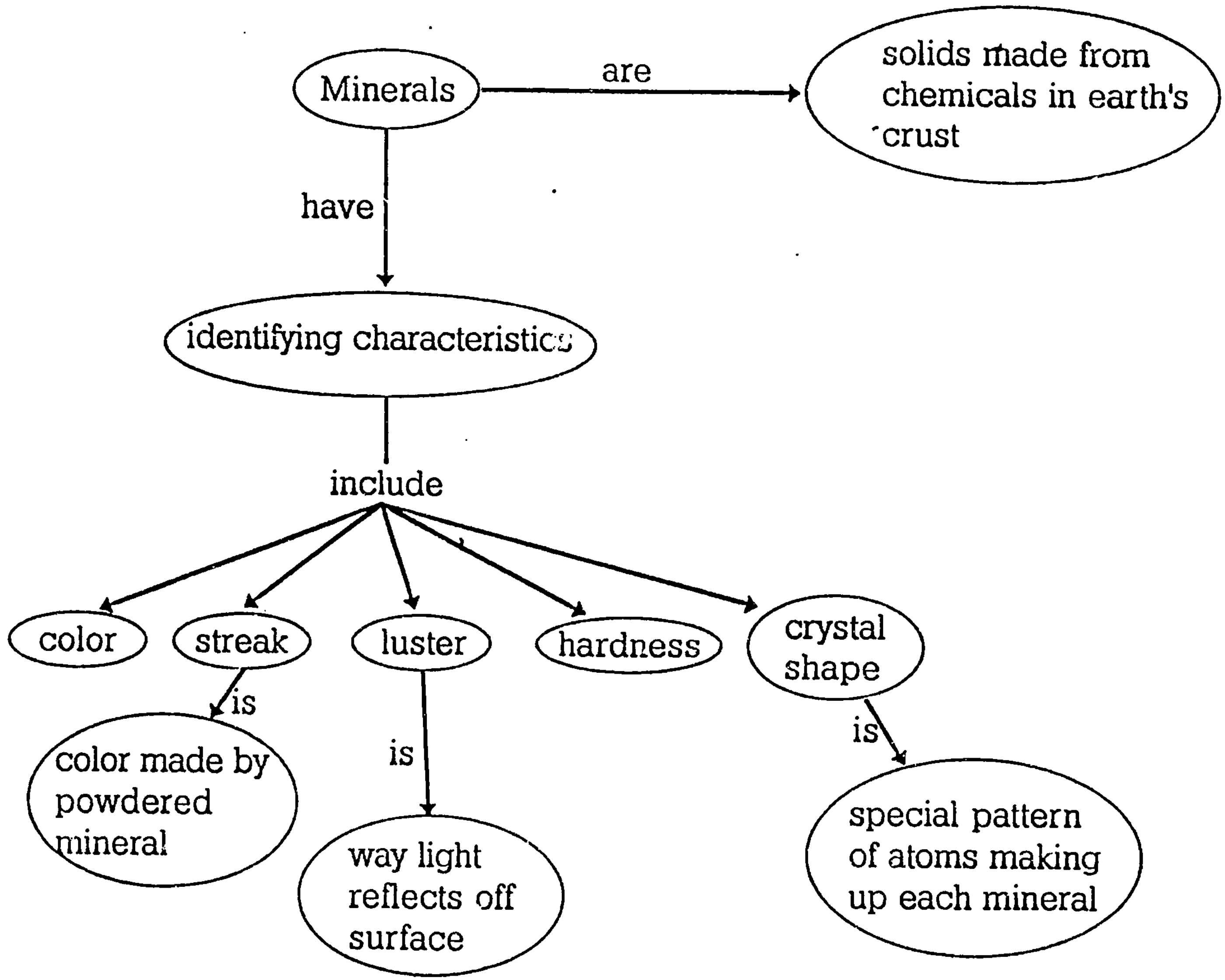


Figure 1. Descriptive map (branching tree)

The Identifying Characteristics of Minerals *				
Color	Streak	Luster	Hardness	Crystal Shape
	Streak is the color made by powdered mineral.	Luster is the way light reflects off surface of a mineral.		Crystal shape is the special pattern of atoms of each mineral.
red, green, blue, black, and many others	like a chalk mark	shiny or dull	soft (talc) medium hard (diamond)	cube (salt) hexagon (quartz)

* *Note*: Minerals are solids made from chemicals in the earth's crust.

Figure 2. Descriptive Frame (Table): "Minerals"

Comparison/Contrast, Sample Text: "Two Kinds of Volcanoes"

Volcanoes form from lava that comes through an opening at the surface of the earth. Over the years, lava piles up around the opening. Two kinds of volcanoes that form are called shield cones and cinder cones. Both of these kinds of volcanoes are found where magma pushes up through the surface of the earth. In other ways, shield cones are different from cinder cones.

Shield cones are built from lava that flows freely from a hole in the surface of the earth. The hole is called a vent. Lava flowing freely from a vent does not explode. It flows quietly. This kind of lava is a runny liquid which contains little gas. After flowing out the vent, the lava cools and hardens to form a kind of rock called obsidian. Obsidian is usually smooth, black, and shiny. Over many years, many lava flows form a shield cone, which is a volcanic mountain with gradually rising slopes.

Unlike shield cones, cinder cones are built from eruptions of lava. These eruptions, or explosions, occur if the vent to the surface is blocked. The kind of lava that explodes is filled with gas and water. After an eruption, the lava cools and hardens, trapping small pockets of gas. This process forms a rock called pumice, which has holes like a sponge. Over many years and after many eruptions, a cinder cone is built from the lava, cinders, and ash. A cinder cone has steep sides that rise to the opening.

Comparison/Contrast, Sample Text: "Two Kinds of Volcanoes"

[structured by attributes]

Volcanoes form from lava that comes through an opening at the surface of the earth. Over the years, lava piles up around the opening, called a vent. Two kinds of volcanoes that form are called shield cones and cinder cones. Both kinds of volcanoes are found where magma pushes up through the surface of the earth. Besides this similarity, shield cones and cinder cones differ according to lava movement, kind of lava, and shape of volcanoes.

During volcanic activity, the movement of lava is different for shield cones and cinder cones. Lava flows freely and quietly from the vent in a shield cone. It does not explode. In contrast, lava explodes (erupts) from a cinder cone. An eruption occurs because the vent to the surface is blocked.

Shield cones and cinder cones also have different kinds of lava. Lava from a shield cone is a runny liquid which contains little gas. After flowing out the vent, the lava cools and hardens to form a kind of rock called obsidian. Obsidian is usually smooth, black, and shiny. In contrast, the kind of lava that explodes is filled with gas and water. After an eruption, the lava cools and hardens, trapping small pockets of gas. This process forms pumice, a rock which has holes like a sponge.

After many years, many lava flows build a shield cone, which is a volcanic mountain with gradually rising slopes. In contrast, many eruptions of lava build a cinder cone, which is a volcanic mountain with steep sides that rise to the opening.

Two Kinds of Volcanoes		
	Shield Cones	Cinder Cones
Location of formation	where magma pushes through surface of earth	where magma pushes through surface of earth
Movement of lava	quiet flow through vent	eruption of lava through blocked vent
Make-up of lava	very little gas	full of gas and water
Rocks formed from lava	obsidian	pumice
Slope of volcanic mountain	gradual	steep

Figure 3. Comparison/Contrast Frame (Matrix): "Two Kinds of Volcanoes"

Explanation, Sample Text: "Volcanic Eruptions"

A volcanic eruption occurs after magma, or melted rock, has been pushed to the surface from deep inside the earth. Heat and pressure in the earth cause magma to rise through cracks in the earth's crust. The magma collects in chambers below the surface of the earth. Heat and pressure continue to build up. Next, magma is pushed up through a crack, called a vent, which leads to the surface. If the vent is blocked, then the pressure builds so much that it causes the surface to break. Hot gas, ash, and lava will finally burst the ground in a volcanic eruption.

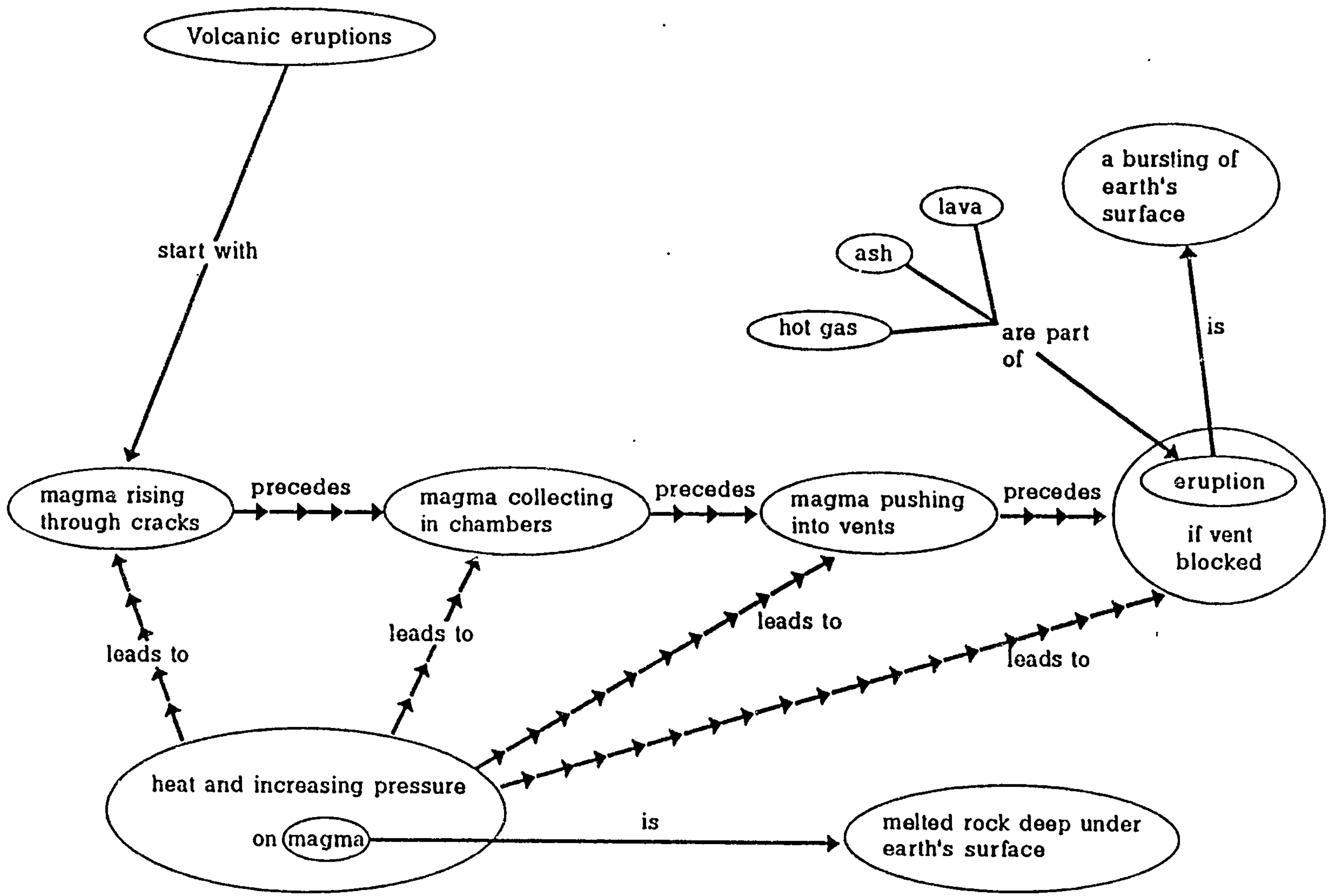


Figure 4. Explanation map (chain)

Variant Maps

The following two maps (Figures 5 and 6) are variations of the map (Figure 1) representing the sample text "Minerals." These three maps can be analyzed with the text, according to the standards of clarity and faithfulness to the text.

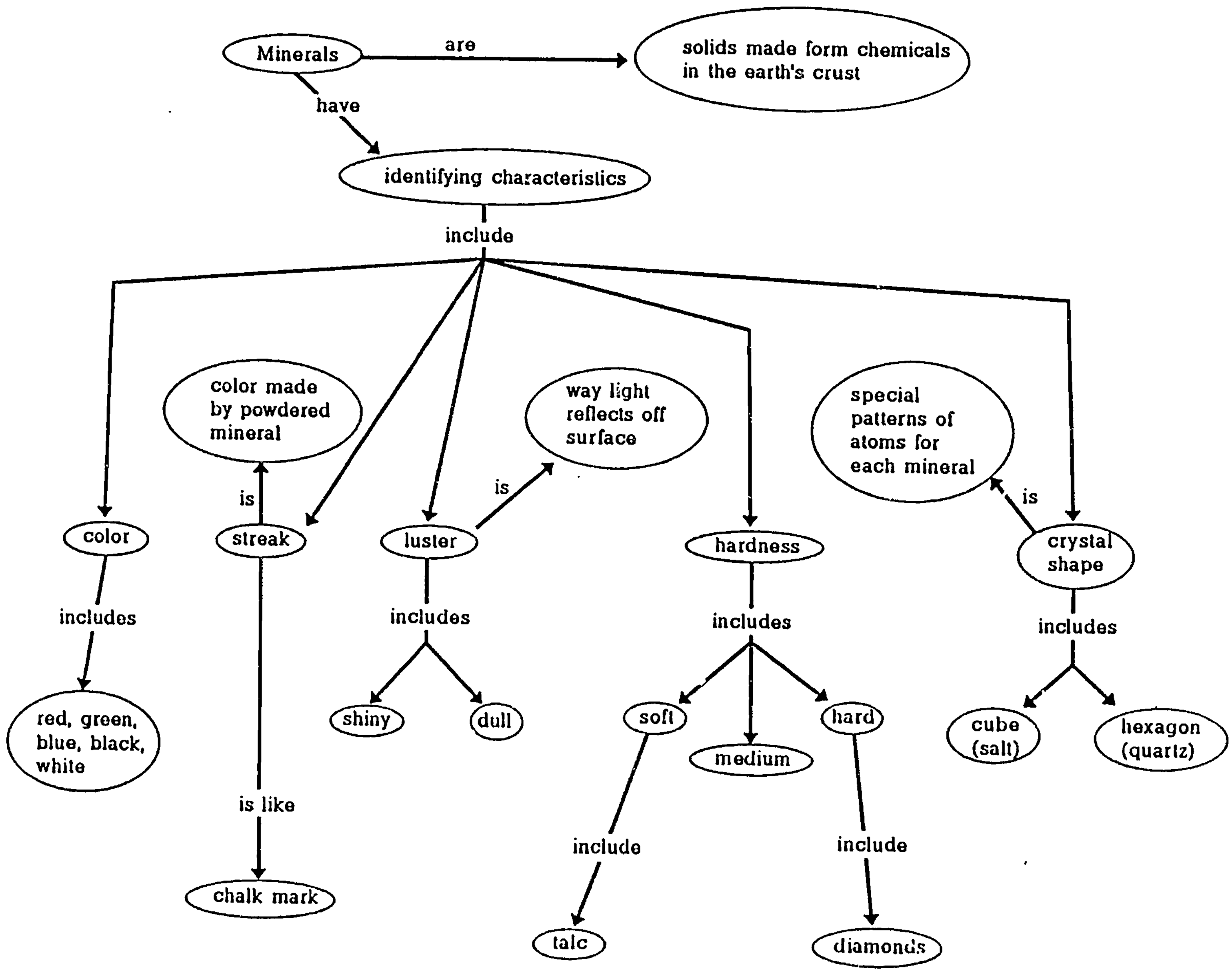


Figure 5. Detailed map of "Minerals "

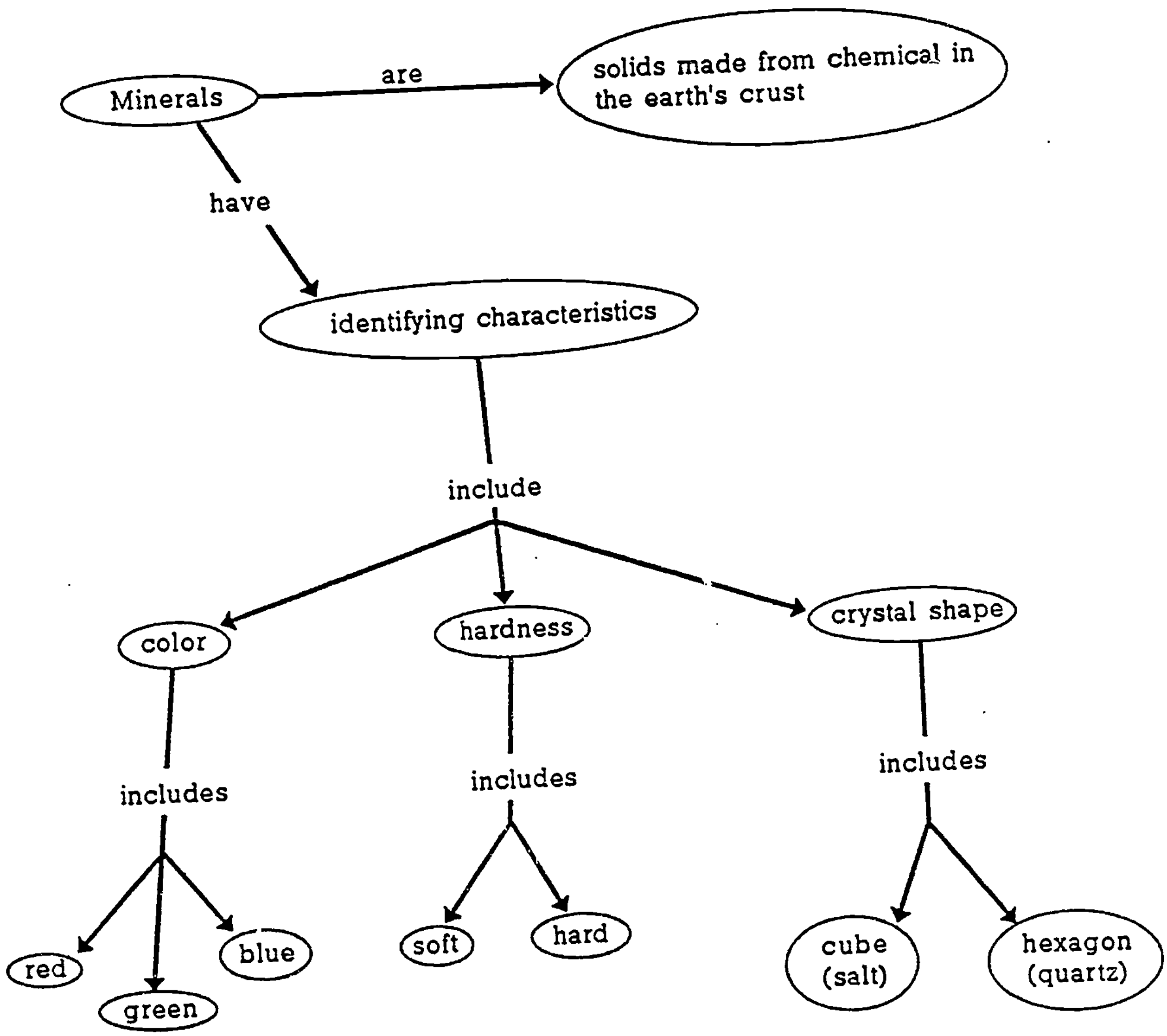


Figure 6. Incomplete map: "Minerals"

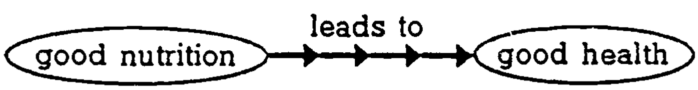
Practice Materials

There are more exercise items here than most people will use. These exercises are intended to develop familiarity and some facility with mapping. However, the text statements are not fully developed. Thus, the exercises may give people the impression that every text statement should be mapped. This is a faulty impression because maps are somewhat like summaries in that they represent just the main text ideas. Please complete only those items that will assist your progress toward mapping fully developed texts. A reminder is that the Suggested Responses to the exercises should make sense to you, if your responses are different.

Standard links are emphasized in Exercise 1. In the last part of Exercise 2 and in Exercise 3, non-standard links are often more useful than the standard ones.

Exercise 1: The Linked Concept Pair: Completion Items

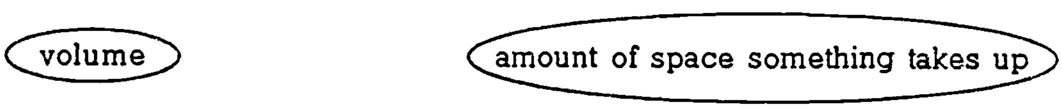
A Linked Concept pair (LCP) consist of two parts of an idea and the link between them. for example, the sentence "Good nutrition is necessary for good health" can be mapped like this:



In the items below, each sentence is represented by an LCP. Each LCP is only partially complete. Complete each LCP, as needed in each item, by labeling the links and filling in the nodes.

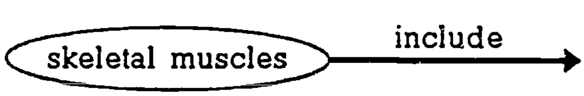
1. Color is one of the properties of minerals.

2. Volume is the amount of space something takes up.



3. The amount of precipitation affects the climate of a region.

4. Your arm muscles, for example, are skeletal muscles.

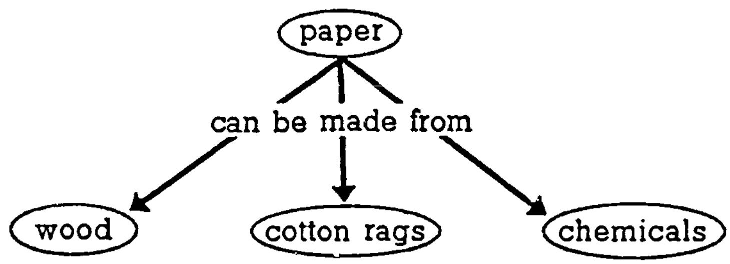


5. A proton is part of the nucleus of an atom.

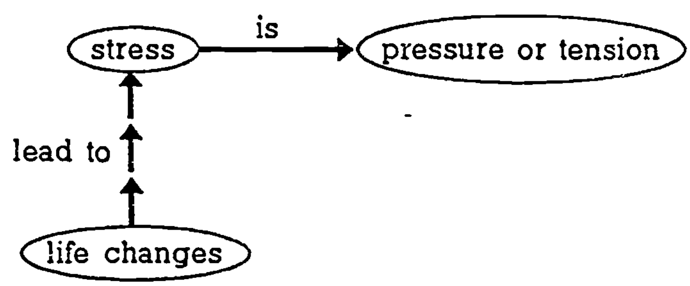
Exercise 3: Simple Maps

Use one or more LCP unit to map each numbered statement. The first two are examples which are completed for you.

A. Paper can be made from wood, cotton rags, or chemicals.



B. Stress is pressure or tension that is caused by changes in our lives.



1. A switch either opens or closes an electrical circuit.

2. The vertebrate animals can be classified into five groups: fish, amphibians, reptiles, birds, and mammals.

Exercise 4: Mapping Paragraphs of Informational Text

In this exercise, you will be mapping full paragraphs of informational text. These passages are based upon information typically published in textbooks intended for elementary science students. Each of these passages is based upon several sources. Unlike the typical science "lesson" found in many textbooks, these passages do not contain illustrations and do not generally contain as much detailed information about a topic. Furthermore, these passages do not contain the usual introductory comments that usually provide continuity with other text lessons and attempt to generate reader interest in the topic. Thus, these exercise passages represent mainly the "essential" information that might appear in a textbook. For this reason, you may be tempted to "put everything" from the passage into your map. Please note that these passages were written so that different levels of importance could be distinguished in the passages. Thus, these passages should allow you to select some passage information for your map but to exclude other passage information.

The passages for Exercise 4 are "Mollusks" and "Pond Succession." Use blank, standard sized (8 1/2 x 11") pieces of paper to draft your maps. After finishing your draft, you may wish to compare your map to the one included later in these materials (Figures 7 and 8). Remember that our mapping goals are clarity and accuracy and that there is no one "best" or "right" way to map a given segment of text.

Practice Text: "Mollusks"

A mollusk is a kind of animal with a soft body that is typically covered by a shell. The shell protects the mollusk's soft body and may help the animal move. Snails, clams, and octopuses are mollusks. Scientists classify mollusks into three groups, according to their shells and "feet." A mollusk's foot is thick and muscular. The mollusk uses its foot to crawl or dig. Slugs and garden snails are examples of one kind of mollusk. Mollusks in this group have one foot and usually have one shell in a spiral shape. A garden snail moves along a trail of slime. This trail has been laid down by the foot of the snail. Clams, oysters, mussels, and scallops belong to the group of mollusks having two shells hinged together. These mollusks use their feet to pull themselves along a lake or ocean bottom. The octopus and squid are examples of the group of mollusks that do not have a shell. Instead of having a single foot, the octopus or squid has tentacles. These tentacles have suckers on them. The octopus uses its tentacles to catch food, mainly crabs. The squid has ten tentacles with suckers. It also has jaws and feeds mainly on fish. Both the squid and octopus can move quickly by forcing a jet of water out of their bodies.

Practice Text: "Pond Succession"

A change in the plants and animals that live in a place is called "succession." An example of succession is pond succession, in which the water environment gradually changes to a land environment. Over time, layers of soil settle in the pond. The remains of plants and animals also help to fill in the pond. When the water is shallow, a marsh develops. Marsh grasses replace pond plants. Marsh animals replace pond animals. In time, the marsh dries up. From the new soil, a meadow gradually develops. Meadow grasses and shrubs replace marsh plants. Then trees start to appear. Eventually, a forest grows where once was a pond.

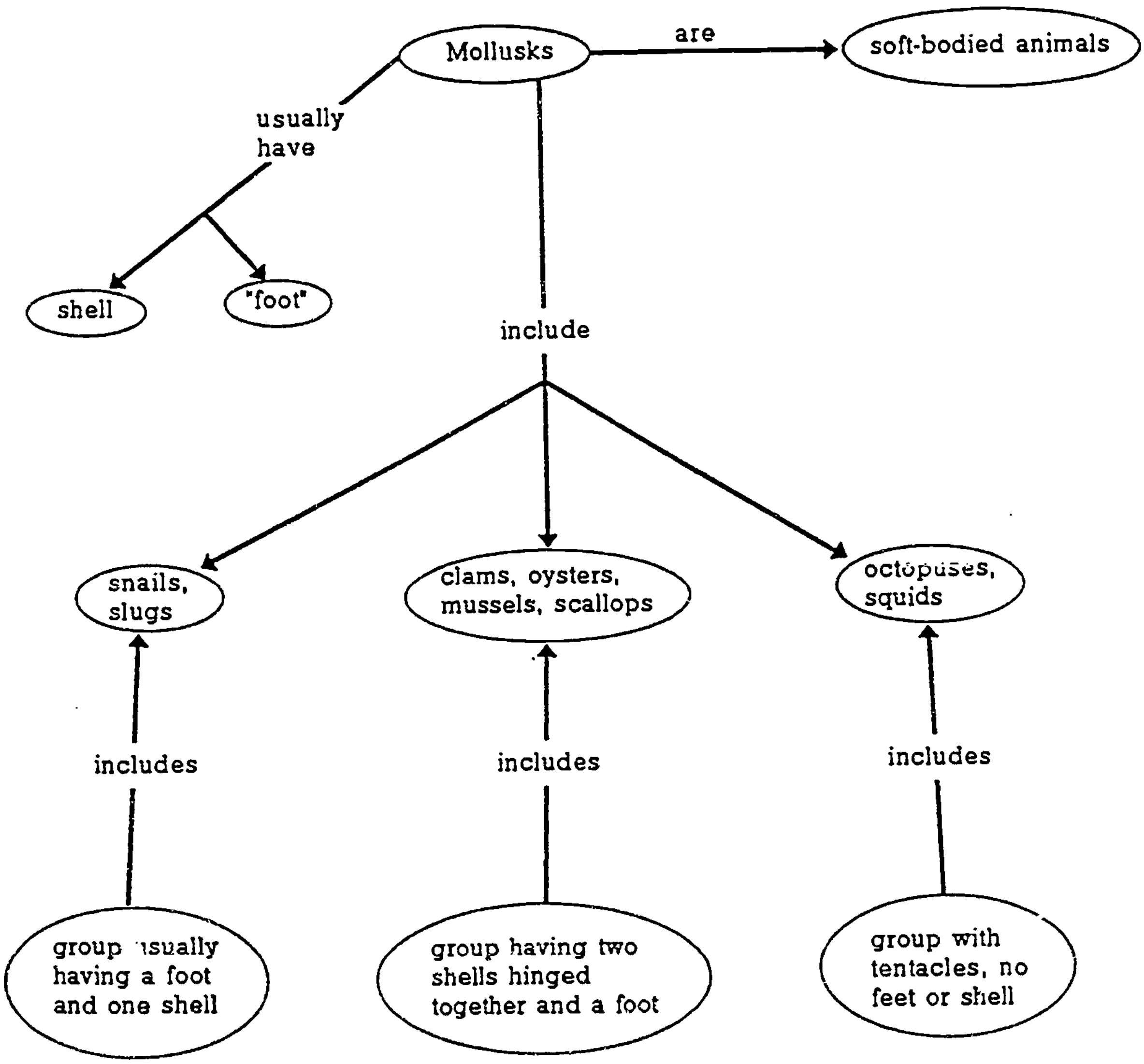


Figure 7. Descriptive map: "Mollusks" (Exercise 4)

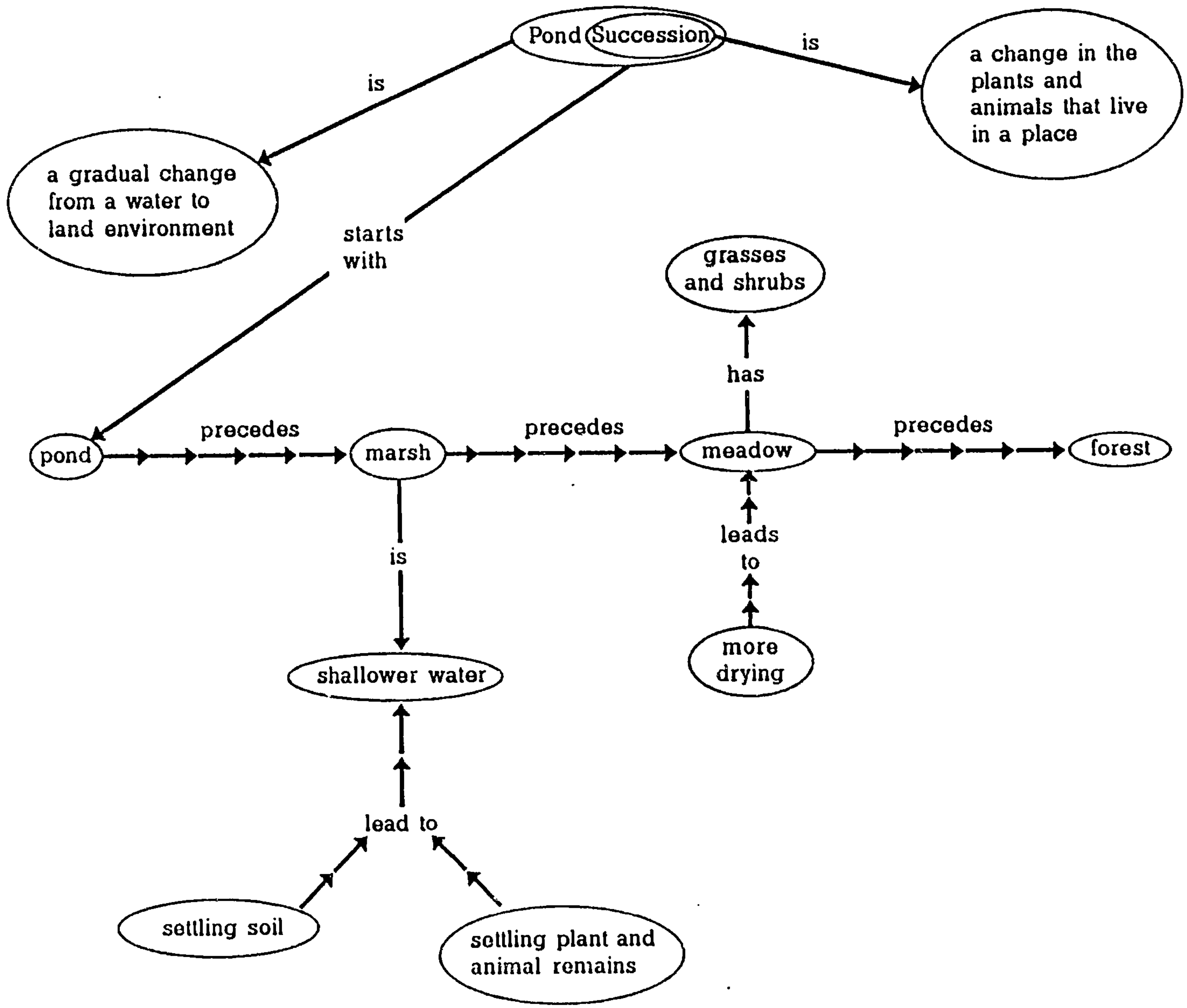


Figure 8. Explanation map: "Pond Succession "

Suggestions for Mapping Informational Text

1. As you read, think about text structure and map formats.

2. A typical idea map will have about 10 to 15 concepts and the relationships between them. (This "global map" may be supplemented by one or more "local maps." The superordinate concept in a local map is a subordinate concept in a global map.) This map can serve as a supplement to the text, not as a substitute for the text.

3. In general, the most important idea or concept occupies the superordinate position at the top of the map page.

4. If you get stuck while mapping, try to keep writing on your map or reread relevant parts of the text. In other words, don't just keep trying to solve the problem "in your head." Work with the map space. You may draft different arrangements of the key ideas on several sheets of paper. Maps are typically redrawn, often several times, until the spatial arrangements of ideas and links have been worked out.

5. As you map, be sensitive to problems with the text. For example, the relationships between main ideas may not be explicitly stated in the text.

6. A map should be faithful to the text, but the map may also include relevant information that is not included in the text.

7. Make maps simple and unified.

8. Upon completing your map, conduct a "talk through"; that is, read aloud the information in the map. Part of the purpose of the "talk through" is for the mapper to verify map information with the text.