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Strategies for Improving Student Abilities to Comprehend Science Textbook Material

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STRATEGIES FOR IMPROVING STUDENT ABILITIES TO COMPREHEND SCIENCE TEXTBOOK MATERIAL

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Fifty-five supplementary lessons were developed to be used in conjunction with a science text entitled Introductory Physical Science (1976). The lessons consisted of the following comprehension strategies: (a) structured overviews, (b) cloze procedures, (c) locational skill strategies, (d) vocabulary reinforcement strategies, and (e) reading guides. The lessons were prepared to enrich and improve the reading and understanding of the science textbook.

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Chapter 1

BACKGROUND OF THE STUDY

A number of articles have been published on the topic of reading for comprehension in the subject areas. Fay and Jared (1975) stated that there has been an extensive body of research literature about content area reading. However, Fay and Jared also found that there was a lack of information on reading as it related to the development of comprehension in the area of science and scientific concepts. There is a need for more research and information to help science teachers develop strategies and techniques to aid students in the use of textbooks as tools to gain information and develop concepts.

Science teachers have not been given instruction on how to help students read and use the textbook effectively. Science teachers need time to acquire help in directing students in the utilization of scientific information and comprehension techniques. Olsen (1968) found that many subject matter instructors believed that they did not have sufficient time to utilize reading comprehension strategies in conjunction with regular subject matter in the classroom. Studies by Olsen (1968) and Otto (1969) found that slightly under 50% of the instructors responding stated that they did not know the special reading skills needed by students to use the textbook to gain information in science. Thelen (1976) emphasized that the result of this study may partially explain why few content teachers stated that they have time to teach reading skills related to their subject.

Time is needed both to help content teachers understand specific comprehension strategies and to help them use these skills in the classroom.

Specific subject information was also emphasized in Olsen's (1968) research when he found that most secondary teachers stated that they were teachers of content first. Thelen (1976) stated that every subject matter teacher should not be a reading instructor alone but rather a teacher of content and learning skills simultaneously. It appears therefore, that there is a need to help teachers learn about the study skills that could make reading science texts more meaningful for students.

Need for the Project

It seems appropriate that instruction in comprehension be combined with the teaching of scientific information. Robinson and Thomas (1977) supported this when they stated, "You can upgrade your students' reading comprehension in any classroom where reading is required" (p. 101). A biology teacher, as reported by Robinson and Thomas, said that instructing science pupils in reading is a necessary part of a science course and pays off all year in increased efficiency for students. However, although the need is great, few materials combining scientific information and instruction in comprehension were found.

Purpose of the Project

The purpose of this project was to prepare a set of materials to be used by ninth grade science teachers in Northshore School District to assist students in reading their science text.

The Project

The project presented 55 student strategies in ninth grade science

which consisted of the following types: (a) advance organizers, (b) cloze procedures, (c) locational skills techniques, (d) vocabulary reinforcement, and (e) reading guides. The materials were based on the content of chapters one through five in Introductory Physical Science (1976).

Limitations of the Project

This study was limited to the following factors: (a) the materials were written primarily for ninth grade students, (b) comprehension materials to enrich the science course of study were taken from a single science text entitled Introductory Physical Science by Abegg, Cross, Dodge, Haber-Schaim, and Walter (1976), and (c) student lessons were limited to chapters one through five of the science text.

Definition of Terms

For the purpose of this paper the following terms are defined.

Advance organizer. An organizational scheme such as this one is often given to students before new ideas or concepts are introduced (Ausubel, 1968).

Cloze procedure. This technique represents, "any of several ways of measuring a person's ability to restore omitted portions of an oral or written message from its remaining context" (Harris & Hodges, 1981, p. 53).

Cognitive structure. Cognitive structure consists of all of an individual's existing knowledge (Thelen, 1976, p. 12).

Content area reading. This represents reading in a specific subject area such as science, mathematics, or social studies (Thelen, 1976).

Content area vocabulary. Content vocabulary consists of the specialized vocabulary within a particular field of study as science, history, and art (Thelen, 1976, p. 1).

Fry formula. A specific technique or formula which determines the reading difficulty of textbooks by utilizing the number of sentences and the number of syllables in sample passages (Burron & Claybaugh, 1974).

Hierarchy of target concept. This paradigm represents a model for concept attainment, and is an extension of the structured overview. Through this hierarchy concepts are clarified by showing conceptual relationships through the use of: (a) examples of the concept, (b) non-examples of the concept, (c) relevant attributes of the concept, and (d) irrelevant attributes of the concept (Frayer, Frederick, & Klausmeier, 1969).

Levels of thinking.

Literal level comprehension. "Literal level comprehension is determining what the authors are saying, and what information their words convey" (Herber, 1970, p. 43).

Interpretive level comprehension. "The readers determine what the authors mean by what they say. They develop intrinsic concepts from the relationships they perceive in the authors' information: (Herber, 1970, p. 45).

Applied level comprehension.

> This is the process of taking what has been known and applying it to what has just been learned, then evolving ideas which encompass both but extend beyond them. These ideas can be called extrinsic concepts, since they are external to the text, even though they embrace ideas in the text (Herber, 1970, p. 47).

Magic square. This represents a set of numerals placed within a square configuration. These numerals when added together, either vertically or horizontally, end up with equal sums (Vacca, 1975).

Physical science. Physical science represents the study of matter and its properties. The particular emphasis for the ninth graders in this study was to comprehend the atomic model of matter (Abegg, Cross, Dodge, Haver-Schaim, & Walter, 1976).

Reading comprehension. Comprehending subject matter materials often involves these skills: understanding of vocabulary, recognizing main ideas, recognizing important details, developing visual images, predicting outcomes, following directions, recognizing the author's organization, and the ability to critically read (Wilson, 1977).

Reading guide. The purpose of a reading guide is to "simulate the inductive process of thinking by asking students to make inferences about what they read, support those inferences from facts supplied in the text, and then apply them to other situations" (Thelen, 1976, p. 22). Specifically, a reading guide helps the student to utilize subject matter information at the literal, interpretive, and applied levels of comprehension (Herber, 1970).

Structured overview. A structured overview is a "visual and verbal representation of the key vocabulary of a learning task in relation to more inclusive or subsuming vocabulary concepts that have been previously learned by the student" (Estes, Thomas, & Barron, 1969, p. 40-48).

Summary of the Following Chapters

Chapter two is a review of the literature related to the study. Chapter three includes the procedures used to develop the science

lessons. Chapter four consists of the project which contains pupil science strategies. Chapter five summarizes the project and offers conclusions and recommendations for future study.

Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

This chapter summarizes research and studies by authorities on the use of reading comprehension techniques on science instruction in the secondary school. The summary was developed under two headings: (a) the student problems in reading scientific material; (b) the development of specific comprehension techniques for student use in the science area.

Much of the reading comprehension research presented by authorities has used the classroom science text as a foundation for measuring the overall readability of science materials and the difficulty of science vocabulary and concepts. Therefore, it is important to substantiate the major function of the science text within the classroom. Gould (1977) surveyed science text use in classrooms. He observed 104 science lessons in 12 secondary schools. He found that 60% of the lessons used the assigned class science text in some manner. Gould divided the way teachers used texts into percentiles. Teachers using their text to support facts in their lessons were ranked 42.3%. Instructors utilizing book illustrations were rated at 36.5%. He also found that 11.5% of the instructors required pupils to use their texts for information not previously mentioned in the class lesson. Gould (1977) stated that, "Teachers made little use of texts for guiding practical work, as a source of data for solving problems, or as a source of questions" (p. 248).

Gould, in his study, found that there was widespread use of the written text as a source of information for pupils in the science area.

Student Reading Related Difficulties with Science Material

Although research has shown widespread use of basic science texts in the classroom, many students experience difficulty dealing with the material in these texts. Summaries of research dealing with pupil difficulty will include the following areas: (a) readability of science materials, and (b) vocabulary difficulties in science texts.

Readability of Science Materials

Daugs (1970), in his research, found that more than 50% of secondary students utilizing common school subject textbook materials could not read these books profitably. He also stated that a large segment of the student population was reading at the frustration level. It appears to be a logical assumption that the publisher-indicated grade level for a text would be an accurate indication of the readability of the text. Unfortunately, this was not always the case. Barnes (1973) found in her study of six different series of content area texts that the publisher's designation of the readability level of the text and the estimated readability level of the text utilizing the Fry Readability Formula differ as much as three grade levels. Results also showed that usually the estimated grade level was higher than the level indicated by the publisher. Barnes (1973) found that only in a few cases did the publisher's designation and the estimated readability level agree. Lockwood (1959) reported that in several studies by Mallison the data

indicated that, "reading difficulty levels in many textbooks in all areas of science are too advanced for the students for whom they are written" (p. 551). Readability levels of texts averaging higher than student ability seems to be a general problem in the science area, as also noted by Gilbert (1973), Gould (1977), and Thelen (1974).

If the publisher's reading level of the science text is different from the actual reading level of the text itself, science instructors need to be aware of this so that adjustments can be made in instruction. Williams reported that when the text reading level was adjusted to the reading level of the students' comprehension scores the reading rates improved significantly (Gilbert, 1973). These findings were also supported in studies by Chall (1954), Dale-Chall (1948), Gates (1961), Lorge (1944), and Yoakam (1951). It appears that science students would comprehend more knowledge if the materials used in their instruction were at their reading levels.

Vocabulary Difficulties in Science Texts

O'Toole and Bedford (1969) found in their study that fifth grade textbook science terminology represented the major contributing factor to raising the readability level of the science texts. Specific readability levels were computed utilizing the Dale Chall Reading Formula. When science terminology was removed reading levels were consistent with student grade level. When science terminology was included some texts raised in difficulty one to two grade levels. Evidently a technical vocabulary can raise the reading difficulty of a science text.

Although science terminology could present a problem for students, specific definitions of scientific terms are often not given in the text

itself. Evans (1968) found in his study of 10 science textbooks that only a portion of scientific terms, between 55% and 73%, were explained in the text. Most of these explanations were through diagrams or words in the text. Few terms were explained using glossaries, footnotes or photographic plates. Most of the books studied, between 28% and 73%, emphasized technical vocabulary by a typography change. However, some of those terms, between 7% and 24%, had not been explained in the text. The Evans (1968) study found that 46% of science terminology was explained only in one way, 24% in two ways, less than 1% in three ways, and none in more than three ways. Evans (1968) summarized his research by stating that communication would be facilitated in a science text if all terminology was thoroughly defined in the text.

Inadequately defined terms may account for some pupil comprehension difficulties. Rate of vocabulary introduction may also be a fact contributing to student lack of comprehension. Robinson (1964) investigated the rate at which scientific terms were introduced in a commonly used science series entitled BSCS Blue Version. He found in his study that an average of 7,000 scientific terms was introduced in one text. This represented a rate of 4 per 100 words, Daugs and Daugs (1974) summarized Robinson's rate of new vocabulary research by stating that new terms presented that quickly were similar in experience to learning foreign languages for students. The studies cited indicate that the rate at which new vocabulary is introduced in science texts may be high.

Daugs and Daugs (1974) in studies found students to be experiencing comprehension difficulties in the science area. Contrary to some of the preceding information they did not find a significant correlation

between technical science vocabulary and comprehension difficulties for students. Daugs and Daugs' research on science passages dealt with surface structure and deep structure within the vocabulary utilized. Surface structure represented literally what the student had seen or heard. Deep structure constituted the subjective interpretation of what the pupil understood the sentence to mean. Daugs and Daugs analyzed passages and determined the number of ways a pupil could interpret each phrase (deep structure). Basically, Daugs found that reading difficulty was not significantly related to the total number of deep structure sentences. The significant findings were that reading difficulty increased with sentence length and with the increased use of abstract vocabulary. They concluded that the difficulty of a science text relates significantly to the author's style, sentence length, and vocabulary usage.

Gardner (1980) found in his study that the use of abstract terminology specifically in the area of logical connectives often posed a comprehension difficulty for secondary science students. Gardner (1980) defined a logical connective as "a term which serves to link a phrase, clause, or sentence to another clause or sentence" (p. 224). A list of 350 of the most frequently used connectives in secondary science texts was formulated by graduate science students at Monash University. Next, secondary science pupils, from grades 7 through 10 in Victoria, Australia, were administered fill-in-the-blank and multiple choice tests to determine difficulty of specific connectives. One significant area of difficulty for students was with connectives which signal similarities, comparisons, and contrast such as: <u>conversely</u>, <u>despite</u>,

in contrast, similarly, as, and like. Gardner (1980) stated that there was a significant use of logical connectives in the science texts examined in his study. Understanding of logical connectives has been shown by the studies to be an important skill in the comprehension of science texts. Therefore, science students need to be instructed specifically about the meanings and uses of logical connectives utilized in science materials.

In summary, research has shown that the majority of science teachers have utilized their science texts for instructional purposes. However, a variety of readability studies have also concluded that numerous science texts were above the publisher's designated grade level. The fact that many science teachers may be teaching from texts which are too difficult for their pupils points to a need for further information dealing with specific areas of difficulty within science materials. One such difficulty surveyed was vocabulary. Problems with science vocabulary include: lack of vocabulary definition within science materials, high rate of science terminology introduction, frequent use of abstract terms in science texts, and the use of difficult grammatical morphemes such as logical connectives in science materials.

Development of Specific Comprehension Techniques in the Science Area

There were several studies that presented techniques to enhance comprehension in science areas. Thelen (1976) stated that if science information and reading comprehension techniques were combined pupils would be further aided in developing the skills necessary to learn and apply science concepts. Gilbert (1973) wrote, "By being able to effectively read the materials presented (by the text) students will

be more able to associate the direct experience of experimentation with the vicarious experiences of reading, thereby developing strong, meaningful relationships" (p. 73). Thelen (1976) has suggested specific comprehension tools which combine reading techniques and scientific information. These include the cloze procedure, advance organizers, vocabulary techniques and reading guides.

Use of the Cloze Procedure

Numerous studies have been conducted utilizing the cloze technique as a comprehension test. Gould (1977) used the cloze procedure as a basis for determining whether secondary pupils could comprehend science text information in his study. Specifically he used 100 word passage comprehension tests with every fifth word deleted. Daugs and Daugs (1974) utilized the cloze procedure as the basis for pinpointing the difficult sections of specific passages and sentences in science materials. They developed five, 713 word cloze procedure tests by deleting every first, second, third, fourth, or fifth word for each of the five forms respectively. They then took the most difficult sentences as depicted by the cloze procedure and analyzed the deep structure involved. Gardner (1980) used the cloze technique with scientific materials. He used this technique as a test to assess student difficulty and as an instructional aid for pupils. First, he blocked out specific logical connectives in a cloze technique fashion. As a test, Gardner could pinpoint logical connection difficulties in specific passages by utilizing cloze procedure results. As a learning tool he gave pupils repeated chances to practice filling in the appropriate

connective in cloze type passages. A variety of studies in the science area have used the cloze procedure as a basis for comprehension testing and as a learning tool.

Research has established a standardized scoring frame for teacher utilization of student cloze test scores. Bormuth (1967), Rankin and Culhane (1969) established a scoring frame of reference for the cloze technique by comparing it to scores on multiple choice tests. Their conclusions indicated that a multiple choice score of 90% was comparable to a 61% score using the cloze. A cloze score of 41% was comparable to a 75% multiple choice score. Thelen (1976) summarized Rankin and Culhane's research by saying that cloze scores between 41 and 60% usually mean that the material presented was at the student's instructional reading level. That is, the material is suitable if the pupil receives teacher guidance. Thelen also stated that a cloze score above 60% may be an indication that the pupil is capable of reading the material without instructor assistance. On the other hand, cloze scores below 40% should be carefully dealt with by the teacher. These pupils may need more background and assistance than the rest of the class. Both Taylor (1953) and Bormuth (1968) found in their studies that cloze tests were more valid in indicating reading ability if correct answers were given only for exact replacements of words rather than for synonyms. However, Thelen stated that for cases where pupils score below 40%, the type of word utilized as a replacement may give significant information on the type of problem the pupil is experiencing. The cloze technique represents a way to determine the

student's ability to comprehend a given textbook and is also a possible learning tool.

Use of Advance Organizers

A study of research indicates that pupil's abilities to understand content area materials can be improved significantly with the use of advance organizers. Ausubel (1968), Raths (1967), and Robinson (1970) found in their studies that new material taught to pupils must be organized in a fashion that "fits" with the previously existing cognitive structure of the students. Ausubel termed the organized information to be taught before new concepts are learned as "advance organizers".

Ausubel (1960) experimented in science with a group of college students on the properties of steel and the relation of its internal structure to temperature, carbon content, and cooling rate. During the experiment the variable or treatment group received a short advance organizer type introduction. Meanwhile, the control group received a short historical passage. Both groups then studied a specific passage in their texts concerning the topic of steel. Three days later both groups took a multiple choice test. The treatment group who had read the written advance organizer performed significantly better on the multiple choice test than did the control group. In another study Ausubel (1960) found that verbal advance organizers increased verbal learning when tested immediately after treatment. Ausubel (1960) in his research, has found the use of advance organizers in written and oral form to significantly increase pupils' test scores.

Kahle and Rastovac (1976) found significant gains for students utilizing advance organizers. The population consisted of 116 subjects enrolled in biology classes in a rural high school. Both the treatment and control groups received identical group lessons, self instructional materials, and audio-tutorial learning tools. Prior to receiving each of three learning units the experimental group received an advance organizer and the control group received an historical narrative. A summative achievement test containing a variety of levels of thinking, as characterized by Herber's thinking levels or Bloom's taxonomy, was utilized to measure student achievement. A significant difference in favor of the advance organizer group was found on the achievement test. Kahle and Rastovac (1976) emphasized the following points of their study: (a) instructional materials were carefully sequenced so that they were compatible with an advance organizer, (b) sufficient instructional time was given for the learner to subsume knowledge, and (c) learning was assessed by a tool which measured several thinking levels of learning. Kahle and Rastovac (1976) found significant positive effects for secondary science students in comprehension at all conceptual levels when utilizing advance organizers.

West (1981) utilized advance organizers in chemistry with high school students. He found significant positive results for the advance organizer group during three different studies using material on solubility product problems. Similar positive results utilizing advance organizers were also found by Novak (1974). Ausubel and Fitzgerald

(1961), Fitzgerald and Ausubel (1963), Koran and Koran (1973), and Nordland and Kahle with Randak and Watts (1975) all found significant comprehension improvement when advance organizers were used with students who scored below-average on standardized reading tests. Kahle and Nordland (1975) and Ausubel and Fitzgerald (1969) found in their studies that the positive effects of the advance organizer can be lost by subsequent learning. Studies have shown that advance organizers can cause a positive effect on comprehension in the classroom.

Use of Vocabulary Techniques and Reading Guides

Numerous authorities such as Barron (1969), Shepherd (1973), and Thelen (1976) have stated that presenting new vocabulary to students in an organized way can help students to more fully comprehend the material to be learned. Although authorities have stated that vocabulary techniques can be helpful, little actual research has been done using procedures such as: (a) structured overviews, (b) concept hierarchies, (c) structural word schemata, (d) vocabulary reinforcement techniques, or (e) reading guides within the classroom. Therefore, suggestions by authorities for reading comprehension techniques in the science area will be surveyed.

Barron (1969) suggested a comprehension technique for all content area subjects called "structured overviews". He stated that an overview is similar to an advance organizer but more directional and practical for teachers. Barron suggested the following steps in preparation for an overview: (a) Once the major concepts to be taught have been selected by the teacher the important vocabulary of the specific

tasks must be analyzed. (b) The instructor must arrange this vocabulary in a scheme which depicts the interrelationships between the new terms and concepts to be learned. (c) The teacher then should add to the scheme already understood vocabulary by pupils in order to depict relationships between the learning task and the discipline as a whole. (d) The instructor should evaluate the organizer for appropriate concept usage and clarity. After the organizer has been introduced to pupils, it should be referred to throughout the learning task as a foundation for developing relationships. Barron suggested the technique of grouping ideas or terms in a scheme as a possible way to teach vocabulary and thus enhance comprehension of the new material.

Structured overviews involve organizing materials to be learned so that they can aid in pupil comprehension. Furukawa (1980) found in his research that organizing concepts enhances student learning. His study was performed with tenth grade biology pupils. Students learned new concepts and ideas by "chunking" terms and ideas together in a schematic fashion. Furukawa found that after completion of two biology units performance of the experimental group was superior to that of the control group on standardized achievement tests. Furukawa (1980), Evans (1973), and Mandell (1974) found in their research that scientific thought processes, laboratory procedures, and vocabulary terms can all be more meaningfully taught by organizing the concepts to be learned into patterns.

Frayer, Frederick, and Klausmeier (1969) tested a model for concept attainment which also involved grouping or organizing the new

material to be learned. They recommended clarifying concepts by showing conceptual relations through citing examples of specific concepts and listing their relevant attributes. Frayer, Frederick, and Klausmeier suggested that students list specific irrelevant attributes and non examples of the concept to be learned to further reinforce concept attainment. Organizing concepts or vocabulary terms into hierarchies was suggested as a technique for vocabulary comprehension.

Shepherd (1973) organized a list of vocabulary terms into schemata to aid students in the comprehension of key paragraph ideas. He took structural words and divided them into four groups of similar meanings. Structural words represent terms which will assist the reader in following the author's transitions from idea to idea or paragraph to paragraph. For example, structural words allow authors to present additional ideas (and, plus, furthermore), contrasting ideas (opposed to, conversely), and concluding ideas (consequently, finally, thus). Shepherd's four major structural word categories are listed under the following headings: (a) structural words indicating additional ideas, (b) structural words indicating idea changes by reversing, qualifying, or modifying, (c) structural words indicating concrete application of thought, and (d) structural words pointing to relationships among and between ideas. Shepherd has suggested a highly organized list of key structural words to aid in pupil concept comprehension.

Thelen (1976) stated that science vocabulary can be comprehended by students through the use of vocabulary reinforcement techniques. Barron (1973) in his research found that using vocabulary reinforcement

techniques enhanced the vocabulary learning outcomes of students. In his study, students were provided with supplementary "expanded directions" before vocabulary assignments. Barron's "expanded directions" defined the purposes and the processes needed for each vocabulary exercise. Students who received the extra directions asked to continue having vocabulary exercises. His study found that reinforcement of vocabulary through "expanded directions" can increase pupil motivation and comprehension of content area materials.

Thelen (1976) suggested the following vocabulary reinforcement techniques to aid in student comprehension in the science area: (a) categorizing, (b) word puzzles, and (c) matching. She defined categorizing as, "a method of taking inventory of how the cognitive structure has incorporated the new material" (p. 31). Thelen suggested numerous ways of having pupils categorize scientific terms and concepts. Word puzzles may be in the form of scrabble games, crossword puzzles, and word search games. Thelen found matching games the most simple for student completion. A sample exercise would be to list the new and related terms in one column with their possible meanings in another column. Students would then be instructed to draw lines connecting the words and their meanings. Thelen suggested categorizing, puzzles and matching games as vocabulary reinforcement techniques as an aid in student comprehension.

Hurd (1970) and Thelen (1976) stated that student comprehension involves the ability to generalize beyond specific stimuli to a variety of new situations. A three-level reading guide attempts to help students learn how to form facts into meaningful concepts.

Herber (1970) named some of the possible thinking levels for students as literal comprehension, interpretive comprehension, and applied comprehension. Thelen suggested that in constructing a guide the literal questions should come first, interpretive level questions second, and applied level questions last. Reading guides can assume many forms as long as they involve the three suggested comprehension levels Thelen has described. She found that the guides are a good basis for homework and student discussion groups. Reading guides represent another way of reinforcing concepts contained within scientific material.

In summary, a review of the research concerning the development of specific comprehension strategies in reading science has shown that the cloze procedure represents a way to determine student ability, and as a possible learning tool. Numerous studies have found that advance organizers are also helpful student learning tools. Although little research has actually used these techniques, many authorities have suggested the following procedures as possible comprehension tools: (a) structured overviews, (b) concept hierarchies, (c) structural word schemata, (d) vocabulary reinforcement techniques such as categorizing, puzzles, and matching games, and (e) reading guides.

Chapter 3

PROCEDURES OF THE STUDY

In the development of this project on science comprehension activities for junior high school students the following procedure was used.

The first step in developing science comprehension strategies was the selection of the basic science text to be utilized. It was found that the adopted text for all Northshore School District's ninth grade physical science pupils was Introductory Physical Science by Abegg, Cross, Dodge, Haber-Schaim, and Walter (1976). Because of Northshore District's trimester system only the information in the first five chapters was taught by teachers in the district. Because of the widespread use of the first five chapters of this text and the use of the text itself in the Northshore Schools, it was decided that science strategies should be written with this text as their science information base. These strategies were designed to supplement the key concepts within this specific science text.

The second step was to apply Fry's readability graph to the beginning, middle, and end of the Introductory Physical Science text. This book was found to be at approximately the mid to upper ninth grade reading level. This text was used primarily with ninth grade pupils. Providing that students were approximately at grade level in basic reading skills, this text should be at the instructional reading

level for most of the students.

The third step in developing science comprehension strategies was to determine specific science comprehension skill areas. The criteria used were taken from Chang, Dallman, DeBoer, and Rouch (1974). Other areas were derived from physical science teacher requested needs. The final list of comprehension skills follows.

1. Reading to find main ideas
2. Reading to select significant details
3. Reading to follow directions
4. Reading to arrive at generalizations
5. Reading to predict outcomes
6. Developing locational skills
7. Understanding scientific vocabulary

The fourth step was selecting strategies that lead to the understanding of science concepts. Thelen's (1976) recommendations were utilized. These recommendations are primarily concerned with the instructions of science information for secondary level pupils through the use of reading comprehension techniques. These strategies were:

1. Structured overviews. One structured overview was written for each of the chapters one through five. These related, in a graphic form, the student's existing cognitive structure to the new information presented (Estes, Thomas, & Barron, 1969). An extension of the structured overview is the "hierarchy of target concept". One hierarchy was written for each of the chapters one through five. These clarified conceptual relationships by showing examples, nonexamples, attributes,

and nonattributes of a specific concept to be learned (Frayer, Frederick, & Klausmeier, 1969).

2. Cloze procedures. At least one cloze procedure was written for each of the chapters one through five. Most of the science passages utilized were 250 words in length or more with every fifth word deleted. This strategy was used to measure the student's ability to restore omitted portions of a written message from its remaining context (Harris & Hodges, 1981).

3. Locational skills techniques. One locational skill student strategy was written for each of the chapters one through five. These were designed to help pupils learn to use their textbooks as a source of information. Learning to use parts of the textbook such as the index, table of contents, preface, headings, and appendices were emphasized.

4. Vocabulary reinforcement strategies. Numerous strategies were used to reinforce scientific terminology. One guided reading strategy was included for each of the chapters one through five. These involved filling in key vocabulary words in selected passages from the text. One categorizing strategy was also included for each of the chapters one through five. These involved grouping together common word meanings and deleting words with meanings that were dissimilar. At least one reading for directions strategy was included for each of the chapters one through five. These emphasized the pupil's ability to follow directions by taking one scientific term and changing it into another through a series of sequenced steps. Finally, there is a word puzzle for each

of the chapters one through five. These puzzles are in the form of magic squares, scrambled letters with hidden scientific terms or cross-word puzzle configurations.

5. Reading guides. One reading guide was written for each of the chapters one through five. These helped pupils to utilize subject matter information at the literal, interpretive, and applied levels of comprehension (Herber, 1970).

The above strategies also represent the format for the student lessons in each chapter.

The fifth step consisted of developing each student comprehension strategy and determining the presentation order of activities. It was decided, through science instructor recommendation, that comprehension activities would be presented in corresponding order with the scientific facts introduced in Introductory Physical Science. Therefore strategies for chapter one will be presented first with the rest of the strategies following in chronological order through chapter five.

Chapter 4

PROJECT

This project provides 55 student comprehension strategies for Introductory Physical Science (1976). The comprehension strategies were designed to increase student understanding of vocabulary, the ability to locate information within the text, and conceptual thinking at the literal, inferential, and applied levels. The preface to the teacher and teacher's guide includes explanations, preparation, and student objectives for using the student comprehension strategies.

PREFACE TO THE TEACHER

The 55 supplementary science strategies contained in this project were divided into the following types of student strategies: (a) structured overviews, (b) cloze procedure, (c) locational skills strategies, (d) vocabulary reinforcement strategies, and (e) reading guides.

The student strategies will be divided into units which will follow the chronological order of materials presented in Introductory Physical Science (1976). This will avoid confusion between designated chapters of the project and chapters of the science text. Units one through five will correspond with chapters one through five in the science text. Student strategies within each unit were placed only in a suggested order. Therefore, altering the presentation of stategies or utilizing only some of the strategies is appropriate. These strategies are supplementary and should be utilized as desired by the instructor in conjunction with the science text. Teacher's guide sheets at the beginning of this chapter will provide explanations, preparation, and general student objectives for using each of the specific strategies in the classroom. Ready to use student strategies were provided for each unit. Teacher answer keys for each student strategy will precede each unit. These strategies are guides to learning. Their major purpose is to help pupils develop skills in comprehending science material. Therefore, it is worthwhile to discuss student answers thoroughly. It is important to discuss how to find the correct answers. However, it

is also important to discuss how the answers were obtained after the strategies were completed. Teachers may wish students to complete many of these strategies in small group or class discussions. In summary, this chapter contains teacher's guides, teacher answer keys and 55 student strategies, as designated by units, for chapters one through five in the science text.

STRUCTURED OVERVIEW TEACHER'S GUIDE

Explanation. Structured overviews were developed so that the new concepts within each chapter can be learned more easily by students. This is accomplished by organizing new information in a way that fits with the student's previously existing cognitive structure. Concept hierarchies are an extension of structured overviews. Students learn concepts more easily by exploring examples, nonexamples, attributes, and nonattributes for specific concepts in each chapter.

Teacher Preparation. It is suggested that teachers make a transparency of each structured overview and concept hierarchy. Overviews and hierarchies can then be projected upon the screen for group explanation and discussion.

Student Objective. Students will verbally participate in a class discussion concerning the new concepts presented within each chapter.

CLOZE PROCEDURE TEACHER'S GUIDE

Explanation. Cloze procedures were developed to help the teacher determine how pupils in the class were comprehending specific chapters within their science texts. It can also be used as a learning tool to emphasize specific words within the text. The cloze procedure helps pupils to feel more comfortable with making educated guesses.

Teacher Preparation. Teachers will need to thermofax and then ditto off individual copies for each student strategy. Student directions for each cloze procedure are contained on each pupil handout. Students should not use their science textbooks as an information resource. Students should be told that cloze procedures are often frustrating to take because they are often difficult to answer and the procedure may be unfamiliar to them. It should be explained that guessing is acceptable.

Scoring. Thelen (1976) summarized Rankin and Culhane's (1969) research by saying that cloze scores between 41% and 60% usually mean that the material presented was at the student's instructional reading level. A cloze score above 60% may indicate that the pupil is capable of reading the material without instructor assistance. Cloze scores below 40% should be carefully dealt with by the teacher. These pupils may need more background and assistance than the rest of the class. Both Taylor (1953) and Bormuth (1968) found that cloze tests were more valid when indicating reading ability if correct answers were given

only for exact replacements of words rather than synonyms.

Student Objective. Students will write the word requested in each blank space without the use of their texts.

LOCATIONAL SKILLS TEACHER'S GUIDE

Explanation. Locational skills strategies were designed to help pupils more effectively utilize their science texts as a tool for finding needed information.

Teacher Preparation. It is suggested that the student strategies be thermofaxed and then dittoed off for each pupil. Student directions are written at the top of each assignment. Therefore, pupils should require little teacher verbal direction. All pupils will need their science texts in order to complete each locational skill strategy.

Student Objective. Students will write the correct answer requested, with the use of their texts, on specific locational skill strategies.

READING FOR DIRECTIONS TEACHER'S GUIDE

Explanation. Word games are designed as a motivational tool to work on the comprehension of specific vocabulary and concepts. They also emphasize the ability to follow directions.

Teacher Preparation. It is suggested that each word game be thermo-faxed and printed on a transparency. The game can then be projected on a screen. While working, each student will need a piece of paper and a pencil to write down the word obtained at each step.

Student Objective. Every student will write the desired word for each specific step requested on the reading for directions strategies.

CATEGORIZING TEACHER'S GUIDE

Explanation. Categorizing strategies aid the pupil to see the various common and uncommon factors concerning key vocabulary terms within each chapter.

Teacher Preparation. Teachers will need to thermofax and then ditto off individual copies for each student assignment. Student directions for the categorizing strategies are contained on each pupil handout. Therefore, pupils should require little teacher verbal direction. Students may work in small groups or individually. Pupils should use their science textbooks as an information resource.

Student Objective. Each student will cross out the term or terms that do not apply within each group and then title the rest of the group for each categorizing strategy.

GUIDED READING TEACHER'S GUIDE

Explanation. Guided reading, or fill in the blanks strategies were developed to help pupils pick out the main ideas and important details and vocabulary terms for each chapter.

Teacher Preparation. Teachers will need to thermofax and then ditto off individual copies for each student assignment. Student directions for guided reading strategies are contained on each pupil handout. Therefore, teachers will need to provide littel verbal direction to pupils. Pupils should have unlimited use of their science textbooks.

Student Objective. Students will write the correct answer requested, with the use of their texts, on specific guided reading strategies.

SCIENTIFIC PUZZLE TEACHER'S GUIDE

Explanation. The scientific word puzzles, such as crossword, word search, and magic square, contained in each chapter serve the purpose of reinforcing new vocabulary words in a way which will be motivating to students.

Teacher Preparation. It is suggested that the student puzzles be dittoed off and passed out to individual pupils. Student directions are written at the top of each strategy. Therefore pupils should require little teacher verbal direction. Pupils may or may not use their science texts according to teacher discretion. Puzzles may be completed individually. However, much positive discussion is generated when the puzzles are completed in partners or group situations.

Student Objective. Each student will write the correct answer requested on specific scientific puzzle strategies.

PREFIX / SUFFIX TEACHER'S GUIDE

Explanation. Prefix and suffix strategies were developed to further enable students to understand new and difficult scientific terms more easily. Numerous prefixes and suffixes are used in scientific terminology.

Teacher Preparation. Teachers will need to thermofax and then ditto off individual copies for each student assignment. Student directions for each prefix and suffix strategy are contained on each pupil handout. Students should use their science textbooks as an information resource. The prefix / suffix strategies were meant to serve as learning tools rather than testing devices. This can be facilitated through group discussions or working in pairs on this strategy.

Student Objective. Students will write the correct answer requested, with the use of their texts and class discussion on specific prefix / suffix strategies.

READING A PICTURE TEACHER'S GUIDE

Explanation. The single "Reading a Picture" strategy is located in the chapter one materials. It represents an excellent beginning of the year activity for students by motivating class discussion and student - teacher interaction. It is suggested that pupils look at the picture for about one minute. Then they are instructed to turn their pictures face down during the following class discussion. The teacher may begin by explaining that in this course scientific concepts will be explored at the literal, inferential, and applied levels of thinking. Then the instructor will lead a brief discussion at each level of thinking. Examples of teacher questions for each level follow. Students should not be allowed to look at their pictures again until after they have discussed the following questions.

1. Literal level comprehension. How many scientists are in the picture? What does he have in his pocket? How many buttons are on his lab coat? How many bubbles are rising out of his flask? What is coming out of his flask? How many dots are on the creature's skin? How many legs does the spider have? Finally, the instructor may want to end by saying, "Literal level comprehension is determining what the author's are saying, and what information their words convey" (Herber, 1970, p. 43).

2. Interpretive level comprehension. How is the scientist feeling? How is the creature feeling? What does the snake want to do? How did

the fire start? Why did the bottle tip over? Where did the creature come from? Finally the instructor may want to end by saying that in interpretive level comprehension "The readers determine what the authors mean by what they say. They develop intrinsic concepts from the relationships they perceive in the authors' information" (Herber, 1970, p. 48).

3. Applied level comprehension. According to your beliefs do you think the scientist had good lab techniques? What would you do next if you were the scientist? What would you do next if you were the creature? What do you think will happen to the fire? When you first looked at this picture how did you feel? Do you like activities like this? Finally, the instructor may want to end by saying that applied level comprehension is "the process of taking what has been known and applying to what has just been learned, then evolving ideas which encompass both but extend beyond them" (Herber, 1970, p. 47).

Teacher preparation. The teacher may run off individual pictures for each pupil or make one transparency to be projected on the overhead.

Student Objective. Students will verbally participate in a class discussion concerning literal, inferential, and applied levels of comprehension.

READING GUIDE TEACHER'S GUIDE

Explanation. A reading guide helps the student to utilize subject matter information at the literal, interpretive, and applied levels of comprehension.

Teacher Preparation. It is suggested that the student reading guides be dittoed off and passed out to individual pupils. Student directions are written at the top of each assignment. Pupils may require extra explanation at the interpretive and applied levels of the strategies due to the increased difficulty and student unfamiliarity with higher thinking levels. The reading guides for each chapter were meant to serve as learning tools rather than testing devices. This is often facilitated through increased student and teacher discussion about the reading guide strategy.

Student Objective. Students will write the correct answer requested, with the use of their texts and class discussion on specific reading guide strategies.

UNIT ONE TEACHER ANSWER KEY

Cloze Procedure One

1.	center	15.	it	29.	did	43.	more
2.	be	16.	that	30.	there	44.	properties
3.	look	17.	of	31.	many	45.	account
4.	are	18.	of	32.	his	46.	meaning
5.	no	19.	different	33.	important	47.	have
6.	earth	20.	made	34.	the	48.	beginning
7.	assumes	21.	by	35.	word	49.	new
8.	of	22.	a	36.	really	50.	step
9.	variety	23.	example	37.	not	51.	with
10.	countless	24.	in	38.	any	52.	will
11.	together	25.	a	39.	to	53.	words
12.	many	26.	or	40.	changes	54.	to
13.	the	27.	paved	41.	take	55.	and
14.	living	28.	ago	42.	physics	56.	on

285 word passage, 56 total answers possible, passage contained on p. 1-2.

Cloze Procedure Two

1.	apart	2.	apart	3.	apart	4.	apart

passage contained on p. 3.

Locational Skills One

1. a) gold, turquoise, yellow, black, white

   b) Introductory Physical Science, Haber, Schaim, Cross, Abegg, Dodge, IPS, Third Edition.

   c) (answers will vary)

   d) (answers will vary)

   e) (answers will vary)

2. 1977; 1976 is the actual date of publishing

3. 4 elements, 3 compounds, 5 molecular motion, 1 volume and mass, 2 characteristic properties

4. contents, or looking through the book

5. same: both use beakers, heat, test tubes, alcohol burners

   different: fig. 1.3 uses a thermometer and displays distillation, fig. 3.4 depicts boiling point (student answers will vary)

6. picture, diagram, figure

7. written answer not required

8. (answers will vary); beakers, test tubes, funnel, flask, thermometer

9. 39

10. - 11. There are no possible false answers

12. Science involves taking things apart as in experimentation

13. a) materials, tools for a specific use

    b) weight, not a characteristic property

    c) dissolve

    d) length x width x height

    e) 1/100 meter

f) experimentation, learning about matter by taking it apart

14. - 15. There are no possible flase answers.

Reading For Directions

One	Two	Three
1. teacher	1. atom	1. experiment
2. cher	2. atm	2. periment
3. cer	3. matm	3. peent
4. ce	4. mattm	4. pent
5. coe	5. matt	5. kent
6. coye	6. matte	6. knowent
7. Coyne	7. matte	7. knowlent
8. Mr. Coyne is my science teacher	8. matter	8. knowlent
	9. All substances are made of matter	9. knowle
		10. knowledge
		11. From experiments we gain knowledge

Categorizing One

Answers will vary. Possible word groupings follow.

1. General Terms Which Describe the Earth's Make-Up

   atoms
   matter
   substances

2. Solids

   solid
   ice cream
   copper

3. Experimental Equipment

   test tube, beaker, flask

4. Apparatus Needed for Wood Distillation Lab

apparatus
solid
splints
wood

5. Components of Wood Distillation Experiment

distillation
purify
alcohol burner
seperate

6. Experimental Terminology

experiment
discover
waste
distillation

Guided Reading One

1. atoms
2. senses
3. a) questions

   b) experiments
4. matter
5. distilling
6. gas
7. displacement
8. experiments

Science is Puzzling One

1. distillation
2. atoms
3. experiment

4. liquid
5. solid
6. gas
7. condense
8. apparatus
9. glycerin
10. tube
11. beaker
12. matter

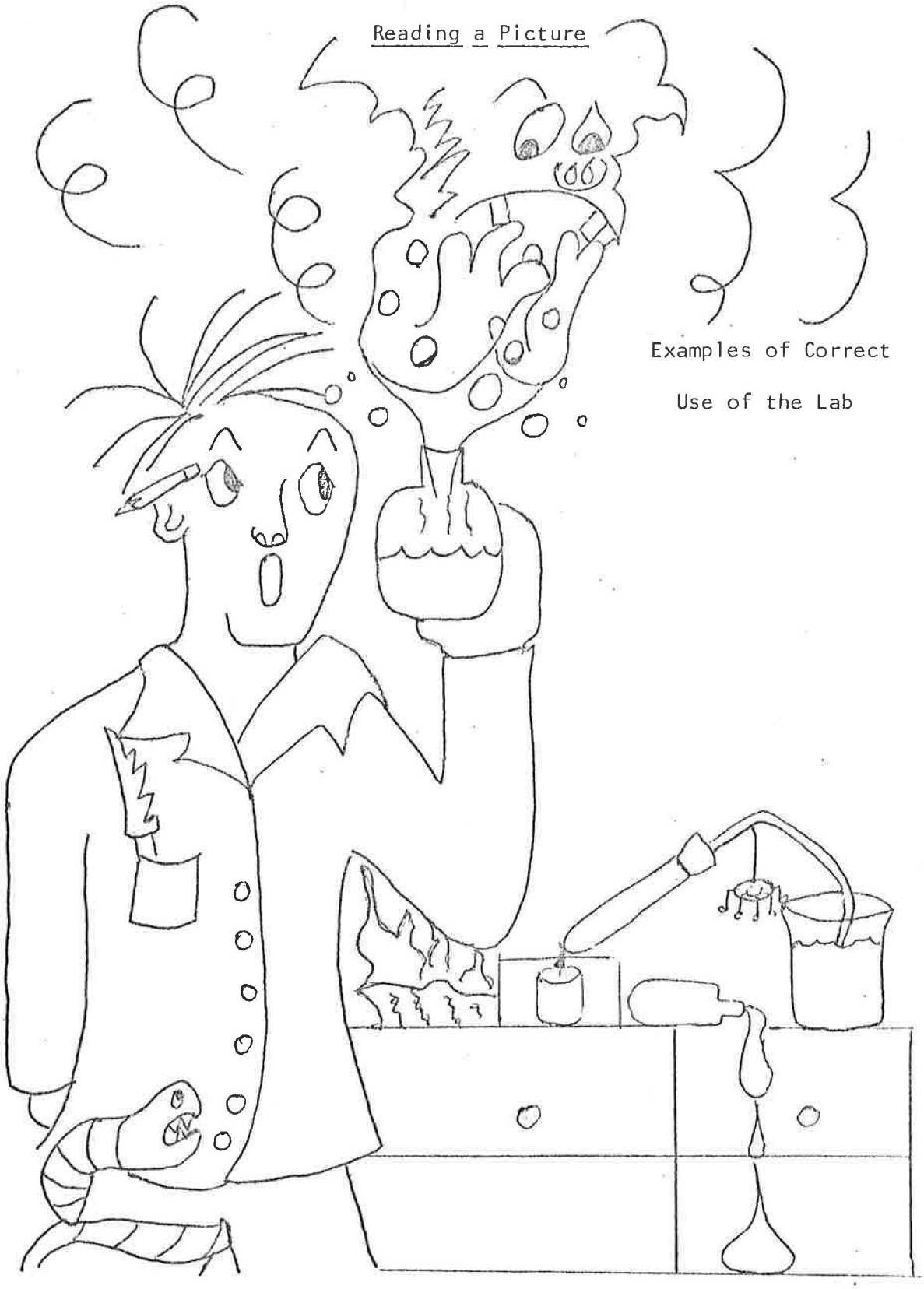
Reading Guide One

I. Literal Level	II. Interpretive Level	III. Applied Level
1. ✓ , p.1	1. True, 2	1. No
2. ✓ , p.1	2. True, 1	2. ✓
3. ✓, p.2	3. False	3. ✓
4. ✓, p.3	4. True, 3	4. ✓
5. ✓, p.3		5. ✓
6. No		
7. ✓, p.3 - 6		

Extra Credit: Student answers will vary. There are no possible false answers.

UNIT ONE

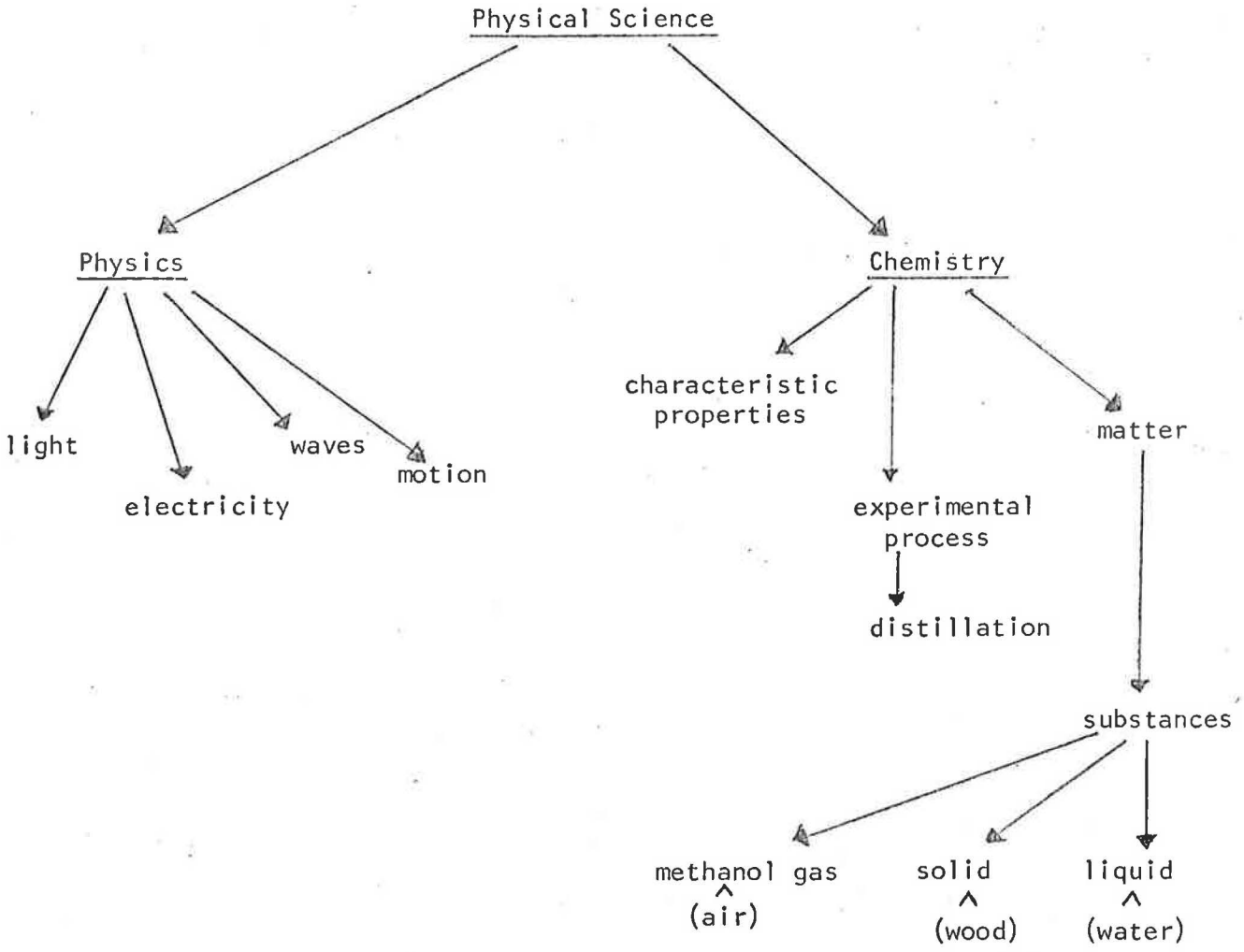
Reading a Picture



Examples of Correct

Use of the Lab

Structured Overview



Hierarchy of Target Concept: Experimentation

1. Examples
   a) distillation
   b) heating substances
   c) cooling substances

   fractional distillation

   fractional crystalization

   paper chromatography

   solubility

2. Relevant Attributes
   a) controlled environment
   b) close observation
   c) taking things apart
   d) asking questiona
   e) seeking answers

3. Irrelevant Attributes
   a) the number of atoms in the piece of wood used in a distillation experiment
   b) the brand name written on a test tube or beaker

4. Nonexamples
   a) smashing a watch with a hammer
   b) reading a friend's experimental results
   c) letting your friends do the experiment for you

Cloze Procedure One

Finding the Missing Words

Directions: Fill in the missing word in each blank below. If you think you do not know the answer do not be afraid to guess. This is not a test!

The scene at the _____ of the sun must _____ very monotonous. Everything must _____ exactly the same. There _____ no rocks, no trees, _____ rivers, no people. On _____, on the contrary, matter _____ an almost endless variety _____ forms. It is the _____ of matter, the almost _____ different substances that go _____ and behave in so _____ different ways, that makes _____ world interesting and enables _____ organisms to exist in _____.

One can invent schemes _____ explain the endless variety _____ material things in terms _____ fewer, simpler things. Many _____ things could conceivably be _____ from the same units _____ putting them together in _____ variety of ways. For _____, one can use brick _____ many ways to make _____ wall or a house _____ a doorstop or a _____ street. Over 2,000 years _____ the Greek philosopher Democritus _____ not really know that _____ were atoms or how _____ different kinds there were. _____ ideas must have been _____, because we still use _____ word atom; but the _____ in itself does not _____ explain anything. It did _____ help people to predict _____ properties of matter or _____ understand what kind of _____ could or could not _____ place.

Modern chemistry and _____ can give a much _____ meaningful account of the _____ of matter. If this _____ is to have any _____ to you, we shall _____ to start at the _____. We cannot just throw _____ words at you. Each _____ must be filled in _____ many experiments that you _____ perform. Then all the _____ and ideas will correspond _____ something real for you, _____ you will reach conclusions _____ your own.

285 Words

Cloze Procedure Two

Finding the Main Idea

Directions: Fill in the missing word in each blank below. If you think you do not know the answer do not be afraid to guess. This is not a test!

One of the best ways to find out how a thing works--and what it is made of--is to take it _____. Sometimes you can even test your understanding of it by trying to put it together again. But, of course, it matters how you take it _____. If you hit a watch with a hammer, it will come _____ all right, but you will not learn much about how it works, and you certainly cannot put it back together. A great deal of modern experimental science is involved in learning how to take things _____ in some instructive fashion.

Often a key word repeated over and over again will tell you the main idea in a paragraph.

Locational Skills One

Getting to Know Your Science Text Number One

1. Take out your science book. Look at it while you count to five. Sit on it and then answer the following upside down questions:

a. What color is the book? (or colors?)

b. Write as many words as you can remember from the cover (11 possible).

c. Draw the picture from the front cover.

d. Draw the picture from the back cover.

e. Check the answers above with the person sitting next to you. (But do not look at your book!)

Now, take your book out again and answer the following questions:

2. Circle the date below that is closest to the copyright date of your book.

1962 1970 1956 1977

3. Number the following topics in the order they are dealt with in your textbook.

_____ Elements

_____ Compounds

_____ Molecular Motion

_____ Volume and Mass

_____ Characteristic Properties

4. The answers to question #3 were found (by me) in

_____ Index _____ Looking through the book

_____ Contents _____ My head

_____ Epilogue _____ Introduction

5. Look at Figure 1.3 and Figure 3.4. State three things that are the same in both pictures and three things that are different.

Same	Different
a. _____	a. _____
b. _____	b. _____
c. _____	c. _____

6. What do you think FIG means in this book?

7. Take exactly 30 seconds and look at the pictures in the book.

8. Now, from your observation of the pictures, list or draw five objects we will be using in science this year. (Don't look back!)

9. Put a circle around the number below that best expresses how many experiments we can deal with in this book.

   36 19 39 29 49 59

10. Without turning around, answer the following:

    a. Is the person seated behind you a boy or a girl? (If you're in the back seat, use the person in the front seat of your row. Do not peak!)

    b. What color eyes does he/she have?

    c. What color clothes is he/she wearing?

11. a. Write the topic of the last article or book you have read concerning anything scientific.

    b. Write the topic of the last TV show you saw concerning anything scientific.

    c. Write the one most interesting thing you remember from your science course last year.

    d. Write the one most boring thing you remember from last year's science course.

12. Look on page 3. Read paragraph #6. It begins with the words, "One of the best ways to find . . ." Then, in one sentence, state the main idea expressed in the paragraph.

13. Write a couple of your own words stating what you think each of the following terms means. Do not look them up. If you don't know, guess.

    a. apparatus
    b. mass
    c. solubility
    d. volume
    e. cm
    f. scientific method

14. a. Write 3-5 words describing your feelings about science courses in general.

    b. What have you heard about what to expect in this course?

15. All of the above questions have somehow attempted to do which of the following:

    a. familiarize you with this year's program
    b. help you learn to fool around with science stuff
    c. help you and your teacher learn your strengths and "not-so-strengths" in what you will be doing this year

Reading for Directions One *

1. Print the word /teacher/.

2. If the vowels are /a, e, i, o, u, and sometimes y/, remove the three letter noun from the beginning of you word which stands for a drink that takes lemon, cream, or sugar.

3. If consonants are all of the letters in the alphabet but the vowels remove the consonant which comes after the letter /c/ in your word.

4. If prefixes are at the beginnings of words and suffixes are at the end then drop the last consonant of your word.

5. If the title of your text is, Introductory Physical Science, then add the vowel /o/ to the middle of your word.

6. If following directions is important during labs, add the vowel /y/ before the letter /e/ in your word.

7. If you think your science teacher is an okay guy, add the consonant /n/ between the letters /y/ and /e/ in your word. Also, make the first consonant of your word a capital.

8. Write a sentence using your new word.

* Falk, unpublished speech, 1981.

Reading for Directions Two

1. Print the word /atom/.

2. If water is a substance, then remove the last vowel in the word /atom/.

3. If a substance can be a solid, liquid, or a gas, put the letter that comes before /n/ in the alphabet in front of the letter /a/.

4. If test tubes are used in some science experiments double the consonant /t/.

5. If taking apart and examining substances is like heating wood splints then remove the last consonant in your word.

6. If heating wood produces a gas, add the first vowel from the word /experiment/ to the end of your word.

7. If scientific experimentation means not to seek answers drop the last two letters of your word.

8. If the opposite of distillation is to freeze, then add the letter /r/ to the end of your word.

9. Write a sentence using your new word.

Reading for Directions Three

1. Print the word /experiment/.

2. If the prefix /dis/ as in distillation means to take apart, remove the two letter prefix from the word experiment.

3. If solid is to gas as copper is to helium, then remove the three letter noun in your word which means the edge of something. Clue: This noun begins with the letter /r/.

4. If atom is to matter as sand is to beach, remove one of the double vowels in your word. Clue: A definition of your word at this point would be, "shut in".

5. If Democritus discovered the atom, drop the first consonant in your word and substitute the letter /k/. Clue: Your present word should now be Superman's last name: Clark _____.

6. If lab is to scientist as kitchen is to cook, add the three letter word which starts with /n/ and means, "right away", after the letter /k/ in your word.

7. If stopper is to test tube as plug is to sink, place the first consonant of the word /laboratory/, after the letter /w/ in your word.

8. If you do <u>not</u> have to follow rules in the science lab erase your word completely.

9. If the distillation of wood involves apparatus, remove the last two consonants from your word.

10. If water is to liquid as ice is to solid, add the letters /dge/ to the end of your word.

11. Write a sentence using your new word.

Categorizing One

Directions: There are five words in each section below. Cross out the one or two words in each that you feel are not related to the others. Explain the relationship by titling each group.

1. _____

distillation

atoms

matter

substances

test tube

2. _____

solid

ice cream

liquid

copper

gas

3. _____

test tube

beaker

flask

volume

mass

4. _____

apparatus

solid

splints

wood

liquid

5. _____

distillation

explode

purify

alcohol burner

seperate

6. _____

experiment

discover

waste

retarded

distillation

Fill in the Blanks - Guided Reading - One

Directions: Read each sentence below. Turn to the page number listed after the sentence and try to locate a word having the same number of letters as spaces provided. Write the word or words on the spaces. The symbol ¶ stands for paragraph number.

1. Over 2,000 years ago the Greek philosopher, Democritus conceived of small units called a _ _ _ _ _. p. 1, ¶ 2

2. When you were a baby, signals from the outside world poured into you through your s _ _ _ _ _ _. p. 2, ¶ 2

3. In this course you will be concerned chiefly with how to ask q _ _ _ _ _ _ _ _ _ of nature and how to carry out e _ _ _ _ _ _ _ _ _ _ _ that will help you find some answers. p. 2, ¶ 5

4. We shall start illustrating this way of learning about m _ _ _ _ _ _ by taking something apart. p. 3, ¶ 6

5. Fig. 1.1 shows that the apparatus used in d _ _ _ _ _ _ _ _ _ _ wood are the distilling tube, glass tubing and the condensing tube. p. 4, ¶ 1

6. Fig. 1.2 displays apparatus for collecting g _ _ from the distillation of wood. p. 4, ¶ 2

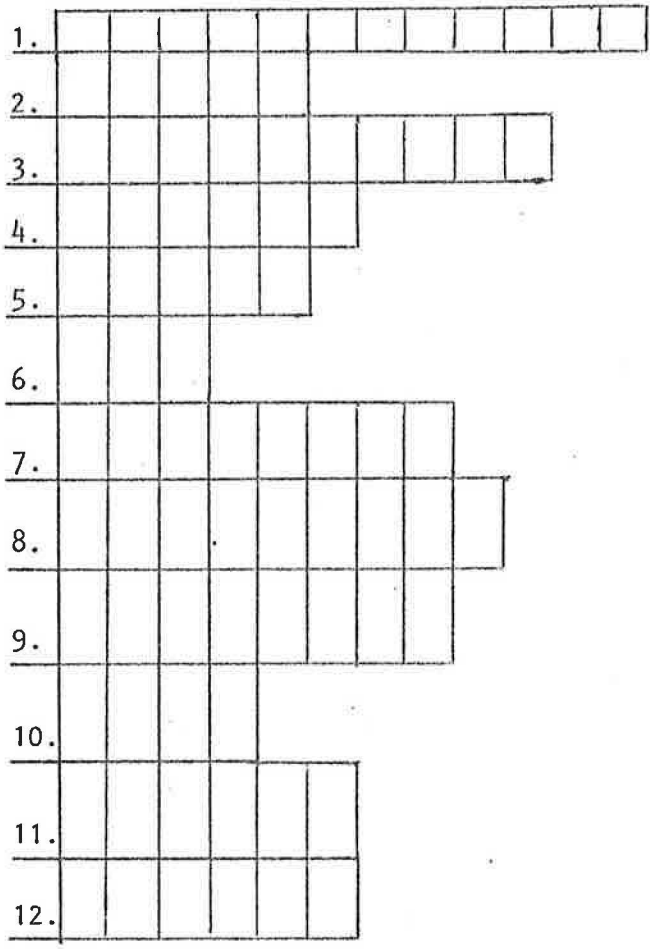
7. Now attach a rubber tube to the apparatus, and collect the gas in a bottle by d _ _ _ _ _ _ _ _ _ _ _ _ _ of water. p. 5, ¶ 1

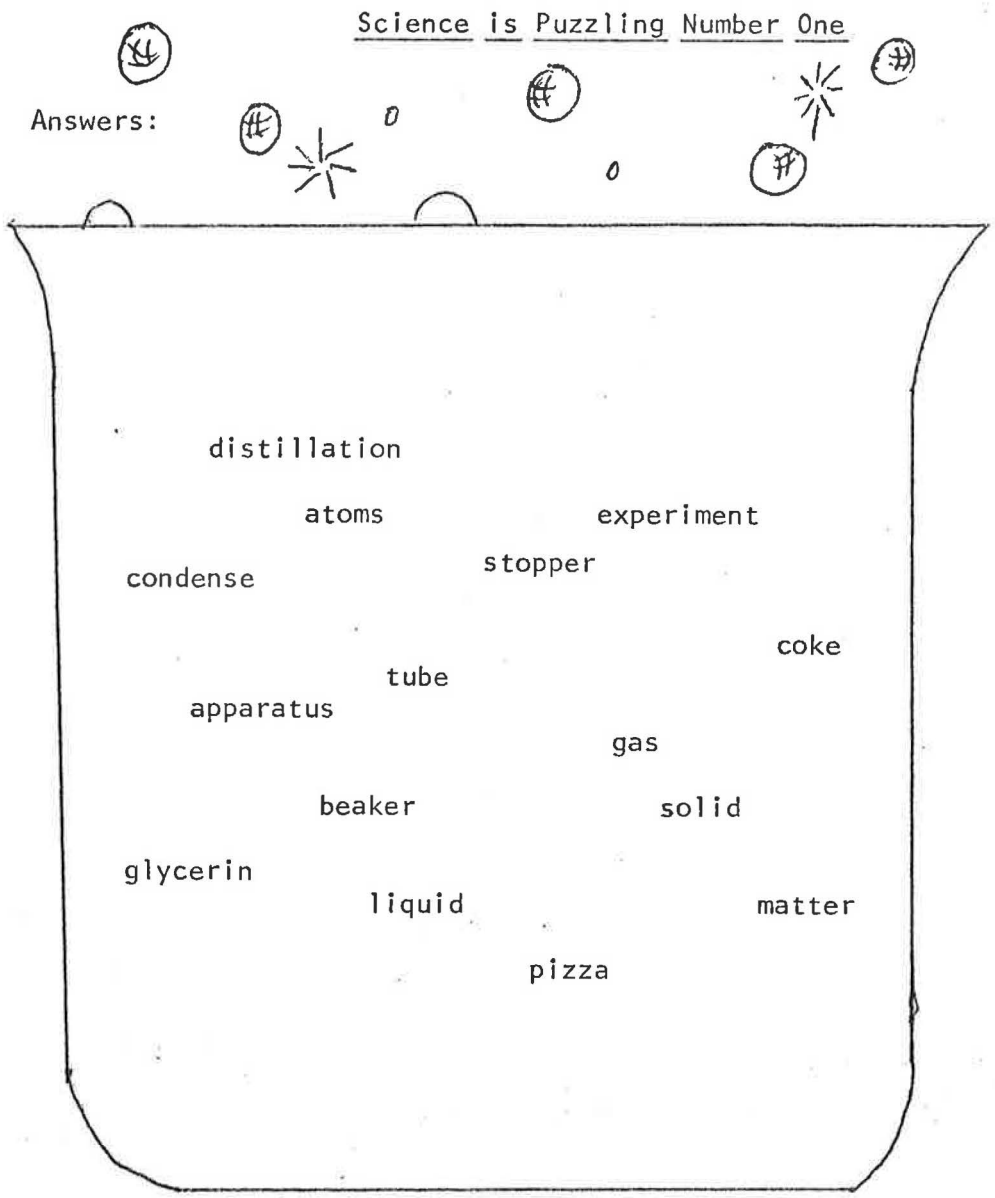
8. In order to get more definite answers to these questions, we shall do e _ _ _ _ _ _ _ _ _ _ _, and these in turn will raise new questions. p. 6, ¶ 3

Science is Puzzling Number One

Directions: Fill in the words that fit with the definitions.

1. to heat and seperate
2. small particles
3. to test or discover
4. readily flowing
5. firm, compact
6. a vapor which can expand forever
7. to compact or compress
8. the materials used in an experiment
9. an odorless, colorless, liquid
10. a slender, hollow glass cylinder
11. a jarlike glass used by chemists
12. whatever occupies space




Science is Puzzling Number One
Answers:
distillation
atoms
experiment
stopper
condense
coke
tube
apparatus
gas
beaker
solid
glycerin
liquid
matter
pizza

Reading Guide One

III Levels of Comprehension:

I. Literal Level

Directions: Below are several statements related to physical science chapter #1. Check those statements (✓) that contain information included in chapter #1. Refer to the chapter to verify your response. Write the page number you found each checked statement on.

____ 1. The earth is made of a variety of matter.

____ 2. The Greek philosopher, Democritus conceived of small units called atoms.

____ 3. As a baby, signals from the outside world poured into you through your senses.

____ 4. Substances have properties which differ.

____ 5. Often, to find out how something works; we take it apart.

____ 6. Smashing a watch with a hammer is a good way to find out how it works.

____ 7. Heating a tube of wood splints produces a gas.

II. Interpretive Level

Directions: Below are statements that contain some possible "hidden meanings" actually contained in the chapter. Match the statements you have checked to the phrases at the right which might provide support for your answers. You may refer to the chapter to find where these items appear.

true/false	statement #		
_____	_____	1. Experimentation with your environment is a good and natural process.	1. "It certainly helps to have the help of a friend who already knows how to ride."
_____	_____	2. Your science teacher and text will be a great help in teaching you the process of experimentation.	2. "When you were a baby, signals from the outside world poured into you. These early activities gave you a sense of size, location, and weight."

_____	_____	3. Democritus' only reason for conceiving small units called atoms was because he wanted to be famous.	3. "Could you predict, just by looking at and handling wood that all these gases, liquids could be obtained from it? Were these substances formed by heat?"
_____	_____	4. Many substances such as wood can be seperated into gases, liquids and solids by heating.	4. "But Democritus did not really know that there were atoms or how many different kinds there were".

III. Applied Level

Directions: Below are statements that according to your beliefs, may or may not be true. Check those with which you agree based on your reading of the chapter and what you believe. Next, answer the extra credit questions based upon your own experiences and thoughts.

_____ 1. If students know how to heat wood they will understand all scientific theory.

_____ 2. Heating wood helps us to understand some of the properties of wood.

_____ 3. The author of your text feels it is good to ask questions.

_____ 4. Science students can gain valuable insights about the world around them through experimentation.

_____ 5. Scientific theory is often complex. Experimentation helps pupils to learn by doing and therefore attach greater meaning to what they learn.

Extra Credit:

1. If you did not follow the experimental procedures properly, in the distillation of wood experiement, what might have happened?

2. If you lived your life never asking questions; what kind of a person might you be?

3. Did you enjoy the wood distillation lab? Explain your yes or no answer.

UNIT TWO TEACHER ANSWER KEY

Cloze Procedure Three

1.	as	14.	very	27.	of	40.	though
2.	amount	15.	the	28.	objects	41.	in
3.	been	16.	dust	29.	the	42.	objects
4.	centuries	17.	that	30.	hang	43.	chunk
5.	a	18.	best	31.	was	44.	number
6.	amounts	19.	amount	32.	on	45.	it
7.	independent-ly	20.	could	33.	arm	46.	small
8.	an	21.	of	34.	by	47.	the
9.	years	22.	pile	35.	of	48.	to
10.	a	23.	the	36.	of	49.	the
11.	carved	24.	by	37.	using	50.	what
12.	made	25.	that	38.	learned	51.	call
13.	almost	26.	divided	39.	bar		

266 word passage, 51 total answers, passage contained on p. 16.

Locational Skills Two

1. Introductory Physical Science
2. 10
3. vii - ix
4. There is no such page
5. 1977, New Jersey
6. Appendix, p. 205 - 206

7. p. 57

8. Preface, p. v -vi; Introduction is also the title of Chapter One.

9. Preface

10. Yes, student answers will vary. There are no wrong answers.

11. There is no such chapter.

12. Student answers will vary. Some possible answers are: volume, mass, laws of nature.

13. For home, desk, and lab.

Categorizing Two

Answers will vary. Possible word groupings follow.

1. An experiment is not a physical measuring tool.

   metric ruler
   graduated cylinder
   thermometer
   yardstick

2. Screens do not hold liquids.

   test tube
   beaker
   flask
   graduated cylinder

3. Ice is not a liquid.

   water
   liquid
   methyl alcohol
   mercury

4. Water is not a solid.

   candle wax
   sand
   ice
   alka seltzer tablet
   gold
   lead

5. Copper is not a gas.

oxygen
air
nitrogen
helium
hydrogen
carbon dioxide

6. Beqas are not based on the meter.

centimeter
millimeter
decimeter
micrometer

7. Volume does not deal with weight.

mass
weight
calibration
balance
scale

8. A copper bar is not a granular solid.

sand
sugar
salt
granular solid

9. The laws of human society differ from the laws of nature.

laws of nature
gravity
conservation of mass
survival of the fittest

10. Student answers will vary. As long as the student can justify the grouping, there are no possible false answers.

Reading for Directions

Four

1. science
2. sience
3. sene
4. ene
5. fene
6. fn
7. fun
8. Science is fun.

Five

1. volume
2. vlum
3. mevum
4. meum
5. meum
6. measum
7. measure
8. Volume is a type of measurement.

Guided Reading One

1. calibration
2. volume
3. a) length
   b) width
   c) height
4. centimeter
5. a) mass
   b) mass

Magic Squares One

The magic number is (15).

1. A = 7
2. B = 3
3. C = 5
4. D = 2
5. E = 4
6. F = 9
7. G = 6
8. H = 8
9. I = 1

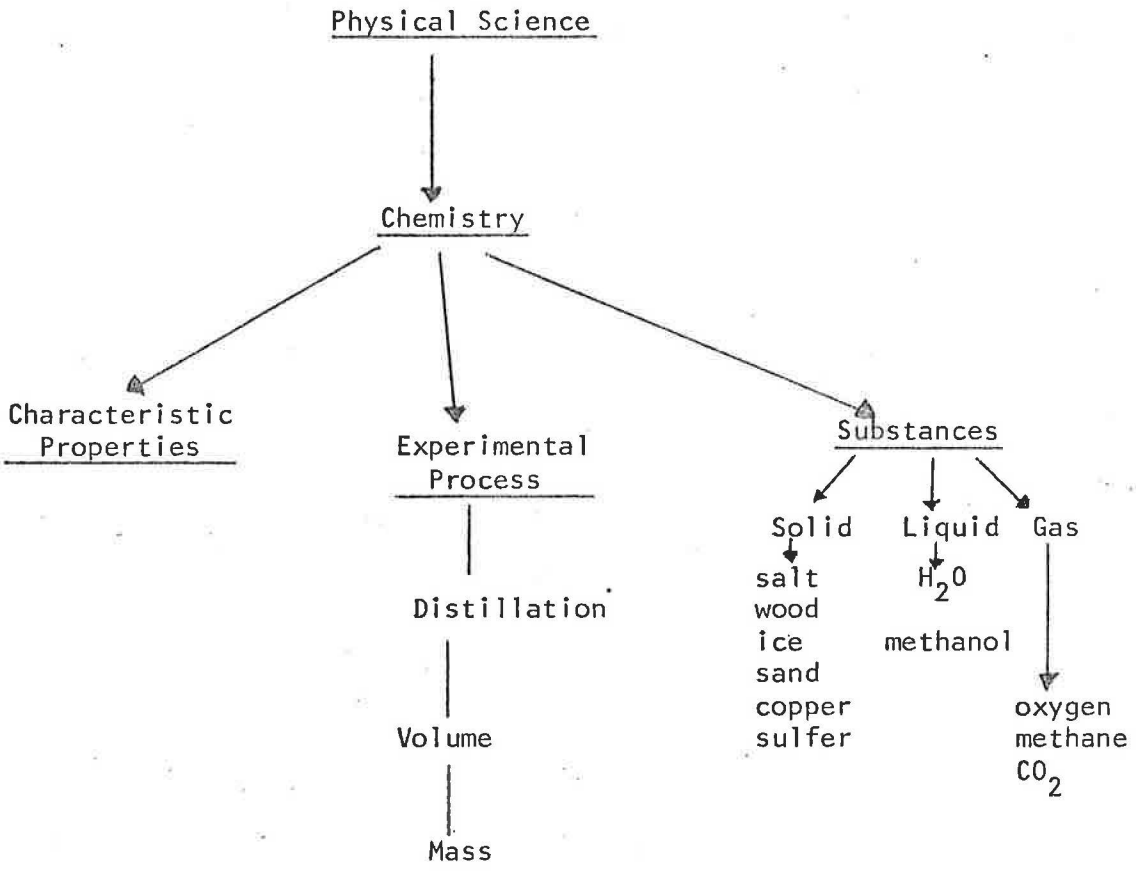
7	3	5
2	4	9
6	8	1

Reading Guide Two

I. Literal Level	II. Interpretive Level	III. Applied Level
1. ✓, p. 9	1. True, 2	1. ✓
2. ✓, p. 9	2. False	2. False
3. ✓, p. 10	3. True, 6	3. False
4. ✓, p. 11	4. True, 3	4. ✓
5. ✓, p. 13-15	5. True, 1	
6. No	6. True, 5	
7. ✓, p. 16-17		
8. ✓, p. 17		
9. ✓, p. 23		
10. ✓, p. 23		

Extra Credit: Student answers will vary. There are no possible false answers.

Structured Overview



Hierarchy of Target Concept: The Measurement of Matter Through Mass

1. Examples

   a) weight of a substance

   b) measuring the mass of ice & water, mixed solutions, and gasses

2. Relevant Attributes

   a) often measured with an equal arm balance

   b) measured by the fundamental unit of mass in the metric system called the gram

   c) calibration of the equal arm balance

   d) in all changes mass is exactly conserved provided nothing is added or taken away

3. Irrelevant Attributes

   a) size

   b) shape

   c) substance form (liquid or solid)

   d) volume changes

4. Nonexamples

   a) volume

   b) boiling

   c) melting

   d) dissolving

Cloze Procedure Three

Finding the Missing Words

Directions: Fill in the missing word in each blank below. If you think you do not know the answer, do not be afraid to guess. This is not a test!

The limitations of volume _____ a measure for the _____ of matter must have _____ known to people many _____ ago because they developed _____ method for measuring the _____ of different substances quite _____ of their volumes. From _____ Egyptian tomb several thousand _____ old, archaeologists have recovered _____ little balance arm of _____ stone, with its carefully _____ stone masses. It was _____ surely used, in the _____ dawn of history, for _____ careful measurement or gold _____. Goldsmiths knew even then _____ the balance was the _____ way to determine the _____ of solid gold they _____ cast from any heap _____ dust or from any _____ of irregularly shaped nuggets.

_____ balance would be hung _____ the upper loop so _____ the horizontal bar was _____ exactly into two arms _____ equal length. With no _____ suspended from either arm, _____ balance bar would then _____ horizontally. When an object _____ hung from the loop _____ the end of one _____, it could be balanced _____ hanging some other pieces _____ matter from the end _____ the other arm.

In _____ the balance, people soon _____, no doubt, that the _____ would remain horizontal even _____ there were

drastic changes _____ the shapes of the _____ being balanced. Dividing a _____ of iron into a _____ of pieces or filing _____ into a pile of _____ grains does not affect _____ balance. A balance responds _____ something quite independent of _____ form of the object. _____ it responds to we _____ "mass".

Locational Skills Two

Getting to Know Your Science Text Number Two

1. What is the title of the great looking science book in your class?
2. How many chapters are there?
3. What pages are the table of contents on?
4. What is the number of the page containing a map of the MacDonalds restaurants around the country?
5. What was the last date this book was published and where?
6. If you come to problems marked with a dagger (†), in which section can you find the answer?
7. You have been assigned to do a report on, "wine". What page number would you start on?
8. Does this book have a preface or introduction? If so, what pages is it on?
9. Uri Haber-Schain wrote a section describing and thanking the resources used for this text. What is the name of that section?
10. Are there pictures in this book? If so write the topic and page number of the most interesting picture in the book.
11. What is the name of the chapter containing information about creatures from outer space?
12. Chapter #2 is divided into 15 parts depicted by numbers 1 - 15. Write down one title of a subheading that looks boring.
13. Now for your favorite part of the book! At the end of each chapter there are homework questions. Write the title of these sections.

Directions: Briefly write your answers in the space after each question.

Categorizing Two

Directions: Circle the word or words that do not fit. Justify why you circled a certain word.

1. metric ruler, experiment, graduated cylinder, thermometer, yard stick

2. test tube, beaker, flask, screen, graduated cylinder

3. ice, water, liquid, methyl alcohol, mercury

4. candle wax, sand, ice, alka seltzer tablet, gold, lead, water

5. oxygen, copper, air, nitrogen, helium, hydrogen, carbon dioxide

6. centimeter, beqa, millimeter, decimeter, micrometer

7. mass, weight, calibration, volume, balance, scale

8. sand, sugar, copper bar, salt, granular solid

9. laws of nature, court of law in Olympia, gravity, conservation of mass, survival of the fittest

10. Now write your own set of words, using at least five terms. Remember, four words must have some similarity and one must not. Justify your list.

Reading for Directions Five

1. Print the word /volume/.

2. If millimeter is to centimeter as a penny is to a dime remove the first and last vowels in the word volume.

3. If a graduated cylinder can measure the volume of liquids, put the pronoun that means yourself in front of the letter /v/ in your word. Clue: This pronoun starts with /m/ and has two letters.

4. If the suffix /ment/ as in displacement means, "the result of", remove the consonant that comes before the letter /m/ in the alphabet.

5. If rulers, thermometers, and barometers all measure something, drop the middle consonant in your word.

6. If the suffix /meter/ means, "to measure", put the adverb /as/ after the first vowel.

7. If your science text has an index, add the letters /re/ to the end of your word, and drop the second /m/.

8. Write a sentence using your new word.

Magic Squares Activity One *

Directions: Select from the answer column at the left the word which best answers each of the statements at the right. Put the number of the word in the proper space in the magic square answer box. If your answers are correct, they will form a magic square. The total of the numbers will be the same in each row across and down to form a magic number. Add up the rows across as you do them to check if you're coming out with the same number for each row. If not, better check your answers in the row that doesn't have the same number as the majority (Herber, 1970).

ANSWERS		VOCABULARY TERMS
A.	This instrument often has two equal arms and is calibrated for accuracy when measuring mass.	1. Volume
B.	The volume of a granular solid or an irregularly shaped solid is often measured by water d _ _ _ _ _ _ _ _ _ _ _ _.	2. Mass
C.	This specific cylinder type is marked off in units of volume.	3. Displacement
D.	The weight of an object.	4, Centimeter
E.	1/100 of a meter.	5. Graduated
F.	When matter changes form, there is no change in mass. Thus mass is conserved.	6. Meter
G.	This is a suffix or word ending that stands for a person or apparatus that measures, ie. thermometer, barometer, millimeter.	7. Balance
H.	This process will enable your equal arm balance to measure masses to less than 0.1g.	8. Calibration
I.	This is often determined by computing length x width x height of substances.	9. Conservation

A	B	C
D	E	F
G	H	I

The Magic Number is ( ).

* Vacca, 1975.

Reading Guide Two

III Levels of Comprehension

I. Literal Level

Directions: Below are several statements related to physical science chapter #2. Check those statements (✓) that contain information included in chapter #2. Refer to the chapter to varify your response. Write the page number you found each checked statement on.

_____ 1. The volume of a unit cube is length x width x height.

_____ 2. Volume is the amount of space a substance occupies.

_____ 3. The volume of a liquid can be determined by pouring it into a graduated cylinder.

_____ 4. The smallest divisions on a metric ruler are 1 millimeter apart.

_____ 5. The volume of sand can be measured by liquid displacement.

_____ 6. Volume is always a good measure of the amount of substance.

_____ 7. The equal arm balance can compare masses of objects of any kind.

_____ 8. The fundamental unit of mass in the metric system is a gram.

_____ 9. The changes of mass shown were within experimental error of your equipment.

_____ 10. When matter changes, such as salt dissolving, the volume may observably change but not the mass.

II. Interpretive Level

Directions: Below are statements that contain some possible "hidden meanings" actually contained in the chapter. Match the statements you have checked to the phrases at the right which might provide support for your answers. You may refer to the chapter to find where these items appear.

True/False	Statement #		
_____	_____	1. Specific laws of nature are rarely changed completely. Only experimental data can alter them. Laws of nature are much more lasting and significant than our legislative laws.	1. "In all changes mass is exactly conserved, provided nothing is added or allowed to escape".
_____	_____	2. A snowball thrown into the principal's office was preserved in a glass jar as evidence of foul play. Unfortunately, when the principal came back he found only water. When he lifted it; the jar was the same mass but the volume had changed. The evidence was gone!	2. "If you present convincing evidence that the law is not quite true, the law is changed to take into account the new experience. Rarely does this amount to a complete repeal of the law".
_____	_____	3. The volume of gas cannot be determined. One reason is because it expands indefinitely.	3. "If you measure the volume of salt by displacement, you will see that the total volume is less".
_____	_____	4. The volumes of all solids can be determined by the displacement of water.	4. "Either way you will not be off by more than $\pm$ 0.02."
_____	_____	5. $\pm$ 0.02 simply refers to the fact that the human eye and our measuring devious can be slightly in error up to that amount. Any error greater than this shows impercise experimentation.	5. "If a cubes fit along the length of the box, b along the width, and c along the height, then the total number of cubes in the box is $a \times b \times c$".
_____	_____	6. The volume of a cube of butter with a length of 10 centimeters, width of 4 and a height of 3, would be 120 centimeters.	6. "Gas is very compressible. As you push more and more gas into the tire, its volume remains unchanged".

III. Applied Level

Directions: Below are statements that according to your beliefs, may or may not be true. Check those with which you agree based on your reading of the chapter and what you believe. Next, answer the extra credit questions based upon your own experiences and thoughts.

_____ 1. The author of your text feels that the laws of nature are more important than legislative laws. Do you agree?

_____ 2. From your class experiments the students did not predict with certainty that mass will never change. This means that with the right materials some pupils might someday change the mass of materials in closed, experimental conditions.

_____ 3. From your salt dissolving in H_2O experiment, the student can say that measuring volumes were inaccurate in this case, and therefore a waste of time in any other experiment.

_____ 4. A large piece of canadian bacon pizza is weighed with a small ceramic mug of coke with ice. The long pointer on the center of the balance is swinging the same distance from each side of the center of the scale. The scale has not been calibrated. The student can then determine that the two are of equal mass up to 0.1 grams.

Extra Credit:

1. Of the five experiments in chapter 2, which one did you like best? Please explain why.

2. What new concepts did you learn in your favorite experiment?

UNIT THREE TEACHER ANSWER KEY

Cloze Procedure Four

1.	when	16.	the	31.	two	46.	bend
2.	it	17.	answer	32.	masses	47.	be
3.	distinguish	18.	have	33.	the	48.	bend
4.	rock	19.	substances	34.	two	49.	be
5.	milk	20.	not	35.	steel	50.	bend
6.	cases	21.	the	36.	and	51.	be
7.	not	22.	will	37.	than	52.	substance
8.	you	23.	can	38.	a	53.	you
9.	of	24.	materials	39.	it.	54.	pieces
10.	shiny	25.	same	40	of	55.	thicknesses
11.	in	26.	of	41.	the	56.	substances
12.	the	27.	steel	42.	find	57.	thus
13.	of	28.	brass	43.	of	58.	is
14.	both	29.	used	44.	are	59.	the
15.	have	30.	balance	45.	substance	60.	the

300 word passage, 60 possible answers, passage contained on p. 29-30

Cloze Procedure Five

1. Melting point
2. Melted
3. Melting point
4. Melting point (above passage contained on p. 34, paragraph number 3)
5. Density

6. Density

7. Density

8. Density (above passage contained on p. 43, paragraph number 2)

9. Properties

10. Properties

11. Properties (above passage contained on p. 44, paragraph number 1)

Locational Skills Three

1. a) Characteristic Properties

   b) Table of Contents, or looking through the book

   c) melting point, boiling point, density, freezing, identifying specific substances

2. a) yes

   b) p. 49 - 64; p. 67 - 84

   c) contents, just looking through the book

3. a) 4
      1
      3
      2
      not in chapter three

   b) Contents or looking through the book

Reading for Directions Six

1. Property

2. Crocerty

3. Charocerty

4. Charoctery

5. Charocteris

6. Charocteristic

7. Characteristic

8. Examples of characteristic properties from chapter three are melting point, boiling point, and density.

Categorizing Three

Answers will vary. Possible word groupings follow.

1. Characteristic Properties

   freezing point
   melting point
   boiling point
   density

2. Properties which Candle Wax does not Possess

   boiling point
   plateau
   freezing point
   micro melting point

3. Decimals Containing Two Significant Numbers

   1.3
   0.2
   5.6
   7.8

4. The Point at which a Solid is becoming a Liquid or Vice Versa

   melting point
   freezing point
   micro melting point
   solid to liquid

5. Properties of Substances which are not Considered Characteristic

   texture
   shape
   mass
   authenticity

6. Specific Characteristic Properties of Substances

   boiling point
   density
   cooling curve
   freezing point

Guided Reading Three

1. Characteristic properties
2. Freezing point
3. Density
4. Melting point
5. Boiling point
6. Boiling point
7. 2, significant
8. Temperature

Prefix/Suffix One

1. Millimeter
2. Centimeter
3. Carbon dioxide, divide, digit
4. Experiment, exit
5. Substance, substitute
6. Micro melting point, microscope, microscopic
7. Proton, protein, proportion
8. Displacement, distillation
9. Prepare, prefix, preface
10. Millimeter, centimeter, thermometer, barometer
11. Measurement, establishment
12. Temperature, measure
13. Substance, distance, performance
14. Predictable, compatible

Science is Puzzling Two

Directions: Circle the hidden words, scientific or otherwise including prefixes and suffixes, within the scrambles letters above.

Scoring: If you found 30 word and prefixes and suffixes you are a scientific genius!

If you found 15 words, prefixes, and suffixes you are average.

If you found 10 or less words, prefixes, and suffixes you need to search for more words a little longer.

Reading Guide Three

I. Literal Level

1. ✓
2. ✓
3. ✓
4. ✓
5. No
6. ✓
7. ✓
8. No

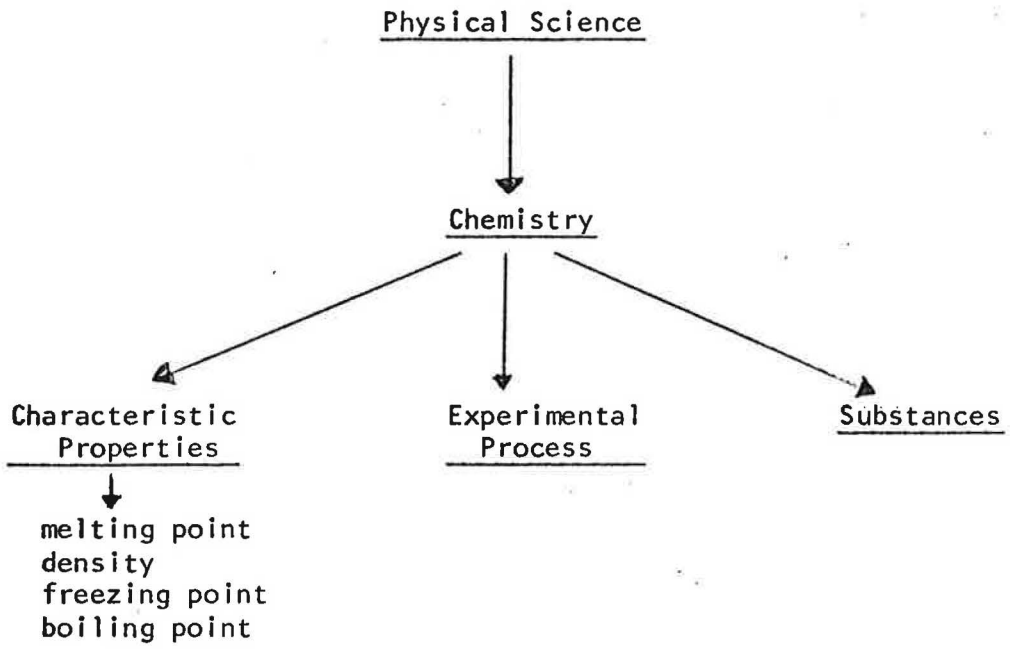
II. Interpretive Level

1. No
2. ✓, A
3. 3, D
4. ✓, C
5. ✓, E

III. Applied Level

1. 3
2. Water displacement using a graduated cylinder
3. Multiply length x width x height
4. - 5. Student answers will vary. There are no possible false answers.

Structured Overview



Hierarchy of Target Concept: Characteristic Properties

1. Examples
   a) boiling point
   b) melting point
   c) density
   d) solubility
   e) freezing point
2. Relevant Attributes
   a) Determination of characteristic properties aids in distinguishing between almost all substances
3. Irrelevant Attributes
   a) smell
   b) taste
   c) color
4. Nonexamples
   a) shape of substance
   b) weight of substance
   c) size of substance
   d) mass
   e) volume

Cloze Procedure Four

Directions: Fill in the missing words below. If you do not know the answers, guess. This is not a test!

How do we know _____ two substances are different? _____ is easy enough to _____ between wood, iron, and _____ or between water and _____; but there are other _____ in which it is _____ so easy. Suppose that _____ are given two pieces _____ metal. Both look equally _____ and feel equally hard _____ your hand. Are they _____ same metal? Or think _____ _____ two glasses containing liquids. _____ liquids are transparent and _____ no smell. Are they _____ same or different?

To _____ such questions we shall _____ to do things to _____ that will reveal differences _____ directly apparent. Merely massing _____ two pieces of metal _____ not do; two objects _____ be made of different _____ and yet have the _____ mass. Think, for example, _____ a 100-g _____ cylinder of the kind _____ as masses on a _____. On the other hand, _____ objects can have different _____ and be made of _____ same materials; for example, _____ hammers, both made of _____ but one much larger _____ with a greater mass _____ the other. Mass is _____ property of an object; _____ is not a property _____ the substance of which _____ object is made.

To _____ out if two pieces _____ metal that look alike _____ made of the same _____, you may try to _____ them.

Again, one can _____ thick and hard to _____, and the other can _____ thin and easy, to _____. Yet they can both _____ _____ made of the same _____. On the other hand, _____ may find that two _____ of metal of different _____ but made of different _____ bend with equal ease. _____ the ease of bending _____ also a property of _____ object and not of _____ substance.

300 words

Cloze Procedure Five

Finding Key Words

Directions: Fill in the missing words below. If you do not know the answers guess! Hint: In each paragraph below the blanks represent the same missing word or words used repeatedly in the paragraph.

1. How does the _____ _____ compare with the freezing point you found when you cooled a large mass of the same substance? Estimate how many times larger the large mass was than one of the small crystals you _____. Does the _____ _____ of a substance depend on the mass of the sample you use when you measure the _____ _____? Is it a characteristic property?

2. Is the _____ of a substance always the same? Most substances expand when heated but their mass remains the same. Therefore, the _____ depends on the temperature, becoming less as the material expands and increases in volume. But, as we shall see in Chapter 9, the expansion is very small for solids and liquids and has little effect on the _____. The situation is quite different with gases, which show a large thermal expansion. Moreover, we find it difficult to compress solids and liquids, but we can easily compress gases, as you know from pumping up a bicycle tire. Therefore, when measuring the _____ of a gas, we have to state the temperature and the pressure at which it was measured.

3. We have looked for _____ that can help us to distinguish between substances that appear to be the same. So far we have found three _____ that do not depend on how much of a substance we have or on its shape. These _____ are melting point, boiling point, and density.

Locational Skills Three

Getting to Know Your Science Text Number Three

Directions: Briefly write your answers in the space after each question.

1. a) What is the title of chapter three?

   b) In what part of the book did you find the title?

   c) What do you think the chapter will be about just from reading the title?

2. Characteristic properties are discussed in chapter three extensively.

   a) Are they discussed in any other chapters in the book?

   b) If so, write at least one page number where characteristic properties are discussed which is not in chapter three.

   c) Circle the term which refers to the place where you found your answer:
      Contents, Index, just looking through the book, Preface, Appendix

3. a) Number the following experiments in the order they will be dealt with in chapter three. Hint: One of the experiments below is not in chapter three.

      _____ The density of a gas
      _____ Freezing and melting
      _____ Boiling point
      _____ Micro melting point
      _____ Distillation of wood

   b) The answers to the above question were found in:

      _____ Epilogue
      _____ Appendix
      _____ Looking through the book
      _____ Introduction
      _____ Contents

Reading for Directions Six

1. Print the word /property/.

2. If melting and freezing point mean basically the same thing; remove the only 2 consonants that are the same in your word, besides letter /r/; then replace both letter /p/s with letter /c/s.

3. If the freezing point of a substance is often indicated by a plateau on a graph then; after the first /c/ add the two letter interjection that exclaims wonder, surprise or anger and begins with letter /h/.

4. If micro, as in micro melting point, is the opposite of large then; remove the suffix /er/ from your word and place it after the letter /t/.

5. If freezing, melting, and boiling points are all usually represented by plateaus on graphs then; remove the letter /y/ and replace it with the two letter verb beginning with /i/ which means, "to be", in your word.

6. The mass per unit volume of a substance is called the density. If the density of a substance usually becomes less when it is heated then; add the three noun beginning with /ti/ which can mean the spasmodic contraction of a muscle, to the end of your word.

7. If melting point, boiling point, and density are properties that do not depend on amount or shape of a substance then; replace the vowel /o/ in your word for the vowel /a/.

8. Write your word in a sentence.

Categorizing Three

Directions: There are five words in each section below. Cross out the one or two words in each that you feel are not related to the others. Explain the relationship by titling each group.

1. _____

freezing point

mass

melting point

boiling point

density

2. _____

candle wax

boiling point

plateau

freezing point

micro melting point

3. _____

1.3

0.2

2.0

5.6

7.8

4. _____

melting point

freezing point

micro melting point

solid to liquid

boiling point

5. _____

texture

shape

mass

authenticity

melting point

6. _____

boiling point

density

size

cooling curve

freezing point

7. Extra: Write your own group of five terms on the back of this paper. Explain in your title which words are related and which are not.

Fill in the Blanks - Guided Reading Three

Directions: Read each sentence below. Turn to the page number listed after the sentence and try to locate a word having the same number of letters as spaces provided. Write the word or words on the spaces.

1. Properties that do not depend upon the amount of the substance or on the shape of the sample. (p. 30, 2)
   c _ _ _ _ _ _ _ _ _ _ _ _ _ _ p _ _ _ _ _ _ _ _ _

2. The plateau on a graph indicates the f _ _ _ _ _ _ _ _ _ p _ _ _ _ of a substance in a cooling curve. (p. 31, 2)

3. The mass per unit volume of a substance is called the d _ _ _ _ _ _ _. (p. 37, 1)

4. Heating a solid slowly and evenly till it becomes a liquid enables scientists to determine the solid's m _ _ _ _ _ _ _ p _ _ _ _. (p. 33, 1)

5. The temperature at which a pot of water just begins to turn to steam is called its b _ _ _ _ _ _ _ p _ _ _ _. (p. 35, 1)

6. The temperature at which a pot of water is 2/3 steam is called it's _ _ _ _ _ _ _ _ _ _ _ _ _ _. (p. 35, 1)

7. The problem: 6.10cm x 0.73cm x 8.745 will have _. _ _ _ _ _ _ _ _ _ _ _ digits. (p. 37, 2)

8. The density of a substance depends on the _ _ _ _ _ _ _ _ _ _ _ _ of the substance. (p. 43, 2)

Prefix and Suffix One

Directions: Below are some common prefixes and suffixes which are used many times in your science book. Part of many words we use today originated from the languages of Latin and Greek. The study of prefixes and suffixes is important in science because it can help us understand new and difficult scientific terms more easily. While using your book, read the prefixes and suffixes below. Then write two words containing each prefix or suffix. You may need to use the back of this paper!

Prefix (before)

1. milli - 1000
2. centi - 100
3. di - 2
4. ex - from or out
5. sub - division into smaller parts
6. micro - little or small
7. pro - substituting or acting for
8. dis - denoting seperation, negation or reversal
9. pre - before

Suffix (after)

10. meter - person or apparatus that measures
11. ment - state or condition
12. ure - state of being
13. ance - the quality or state of being
14. able - suitable to

Science is Puzzling Two

Directions: Circle the hidden words, scientific or otherwise including prefixes and suffixes, within the scrambles letters above.

P R O P E R T I E S C H A R A C T E R I S T I C
R E D Y V I P O L U H Y T R A N S X B I U E G O
E V E R A C E T O N E D E N S E I P R O B M L O
C E N T P O I N T S R R E A C T M E T H S P I L
I S O B O I L I N G P O I N T R I R D Y T E R I
P R O U R M E L T I N G P O I N T I I D A R U N
I D E T A E C A O F R E E Z I N G M S R N A O G
T R I A T T E B U T A N E O L U M E T O C T P A
A L U N E E N O T H I N G S O M E N I M E U R S
T E T E A R I D E C A W G S V E L T L I S R E D
E X P A N S I O N I T R O G E N T R V O L U M E

Scoring: If you found 30 words and prefixes and suffixes you are a scientific genius!

If you found 15 sords, prefixes, and suffixes you are average.

If you found 10 or less words, prefixes, and suffixes you need to search for more words a little longer.

Reading Guide Three

III Levels of Comprehension

I. Literal Level

Directions: Below are several statements related to the chapter. Check those statements (✓) that contain information included in the chapter. Leave false or statements not included in chapter 3, blank. Refer to the chapter to verify your response.

_____ 1. Properties that show differences between substances are called characteristic properties.

_____ 2. The freezing point of a substance is often determined by a plateau on a graph.

_____ 3. A solid melts at the same temperature as its liquid freezes.

_____ 4. It is less difficult to measure the density of a gas than that of a liquid or solid.

_____ 5. The density of a substance is always the same.

_____ 6. When calculating experimental data. The result should have as many digits as the measured number with the smallest number of digits.

_____ 7. We can determine between most substances if we can measure their densities, melting points, and boiling points.

_____ 8. Smelling, shaking, and testing samples of substances are good methods to help identify them.

II. Interpretive Level

Directions: Below are statements that contain some possible "hidden meanings" in the chapter. Check those statements that represent "hidden meanings" actually contained in the chapter. Match the statements that you have schecked to the phrases at the right which might provide support for your answers. You may refer to your text to find where these items appear.

True/False	Statement #		
_____	_____	1. Candle wax does not have a melting point because wax can never become a liquid completely.	1. "From your data on boiling water in experiment 3.4 we can infer that . . . "

_____	_____	2. The boiling point of a liquid is the same no matter what the amount.	2. "Candle wax has no freezing point; that is, there is no temperature at which it changes from liquid to hard solid with-continuing to cool down during the process".
_____	_____	3. Significant numbers are determined in experimental calculations because numbers carried out too far to the right of the decimal point may be inaccurate.	3. "If we can determine the densities, melting points, and boiling points of materials, we can distinguish between <u>almost</u> all substances".
_____	_____	4. If we can determine density, melting point, and boiling point we cannot necessarily distinguish between all materials.	4. "Not even a calculator can produce numbers that are more accurate than the data used in the calculations".
_____	_____	5. Characteristic properties are: freezing point, boiling point, melting point, and density.	5. "Characteristic properties are properties that do not depend on the amount or shape of the sample".

III. <u>Applied Level</u>

Directions: Answer, in a few sentences, the questions below. Note: Some questions do not necessarily have a right or wrong answer but should be answered according to your beliefs.

1. 4.72 x 0.52 has how many significant digits?

2. Briefly describe how you would find the density of an irregularly shaped stone.

3. Briefly describe how you would find the density of a 1" square cube.

4. Your text, in the boiling point experiment, asks you to share your graph with other classmates. Was this so you could cheat and copy each others' work? Why do you suppose the authors wanted you to compare?

5. There were about five experiments in this chapter dealing with density, melting, freezing and boiling point. Which experiment did you like best and why? Which experiment was the most boring and why?

UNIT FOUR TEACHER ANSWER KEY

Cloze Procedure Six

1.	dissolving	15.	of	28.	of	41.	you
2.	know	16.	you	29.	more	42.	to
3.	a	17.	dissolves	30.	the	43.	the
4.	solute	18.	off	31.	concentration	44.	do
5.	solvent	19.	liquid	32.	solutions	45.	solution
6.	the	20.	try	33.	liquid	46.	classmates
7.	is	21.	two	34.	of	47.	pour
8.	to	22.	tubes	35.	mass	48.	solution
9.	a	23.	for	36.	solid	49.	evaporating
10.	could	24.	have	37.	the	50.	to
11.	of	25.	the	38.	the	51.	solution
12.	and	26.	process	39.	volume	52.	carried
13.	a	27.	your	40.	your	53.	tube
14.	begin						

277 word passage, 53 possible answers, passage contained on p. 51.

Cloze Procedure Seven

1. dissolve
2. dissolves
3. dissolves (above passage contained on p. 49)
4. solvent
5. solvents
6. solvents (above passage contained on p. 64)

Locational Skills Four

1, a) solubility

b) Table of Contents or looking through the book

c) Characteristic properties, dissolving substances. Student answers will vary.

2. Yes

filtering, p. 74.
of salt, p. 14 - 15, 21, 92
of sodiumchlorate, p. 92
frozen, p. 143
mass of, p. 22 - 23

Information could have been found through the Index or by looking through the book.

3. a) 4
5
3
1
2

b) Contents or looking through the book

Reading for Directions Seven

1. solubility
2. solublty
3. solulty
4. solvlty
5. solvlty
6. solvety
7. solvet
8. solvent
9. Solvents help determine the solubility of substances

Categorizing Four

Answers will vary. Possible word groupings follow.

1. Alcohols

   fruit alcohol
   methanol
   ethanol
   wine
   grain alcohol

2. Solvents

   H_2O
   methanol
   solvent
   sulfuric acid
   oil of vitriol

3. Gases which will not Dissolve in Water

   hydrogen
   carbon dioxide
   insoluble in water

4. Characteristic Properties

   density
   melting point
   boiling point
   solubility

5. Water Soluble

   salt
   sugar
   water soluble substances

6. Saturated Solutions

   saturated solutions
   water containing orange solid chunks
   liquid containing precipitate

Magic Squares Activity Two

A. 9

B. 2

C. 7

D. 4

E. 6

F. 8

G. 5

H. 10

I. 3

9	2	7
4	6	8
5	10	3

Guided Reading Four

1. concentration
2. saturated
3. temperature
4. solute
5. hydro
6. gen
7. hydrogen

Prefix/Suffix Two

1. methanol, ethanol, alcohol, oil of vitriol
2. sulfuric acid, hydrochloric acid, nitric acid
3. potassium nitrate, saturate
4. dioxide
5. oxygen, hydrogen
6. hydrogen

Guided Reading Four

III Levels of Comprehension

I. Literal Level

1. ✓, p. 50
2. ✓, p. 50
3. ✓, p. 50
4. ✓, p. 51
5. No
6. ✓, p. 57
7. ✓, p. 62
8. No

II. Interpretive Level

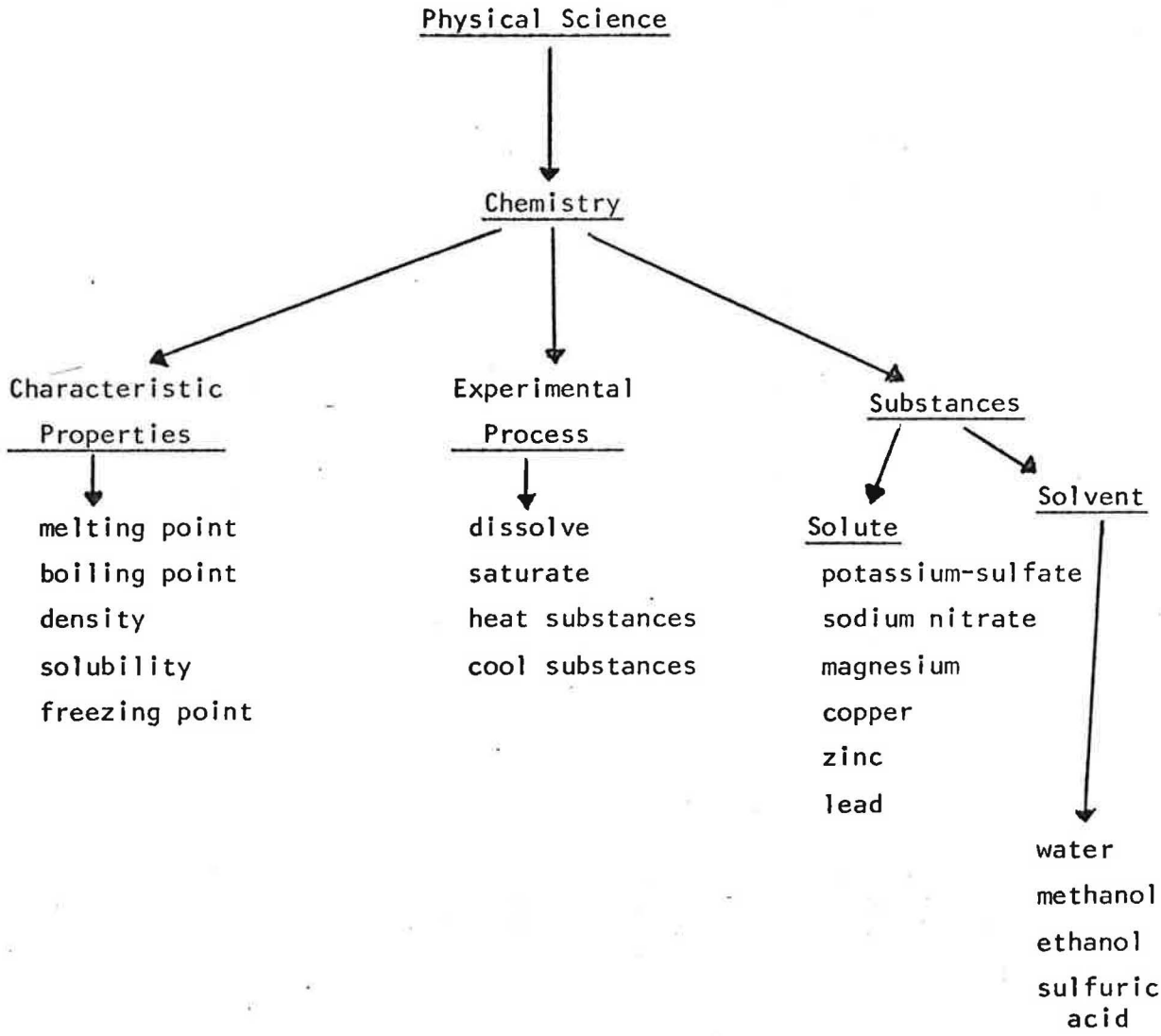
1. T, 2
2. T, 4
3. T, 1
4. T, 3

III. Applied Level

1. Answer is dependent upon student preference.
2. solubility
3. The warmer H_2O gets the less oxygen will dissolve in it.
4. a) yes

   b) no

Structured Overview



Hierarchy of Target Concept: Solubility

1. Examples

   a) Solute dissolving into a solvent

   b) A solid (solute) dissolving into a liquid (solvent)

   c) Sodium chloride (salt) dissolving in water

   d) Orange solid dissolving in water

   e) Potassium nitrate dissolving in water

2. Relevant Attributes

   a) Concentration of the solution

   b) Solutions in which no more solids can be dissolved are called saturated solutions.

   c) Subtracting the mass of the remaining dry solid from the mass of the solution will give you the mass and therefore the volume of your sample. From this you can calculate the concentration of your saturated solution.

   d) A saturated solution is called the solubility of a solution.

   e) Solubility changes with temperature

   f) The solvents discussed in chapter four are water, hydrochloric acid, nitric acid, methanol, ethanol, and green vitriol.

   g) Gases are less soluble when the temperature of the liquids they are to be dissolved in are raised.

   h) If the dissolving liquid is cool, then heating the gas itself will cause the gas to dissolve faster.

   i) Finding the solubilities of substances is a controlled experimental procedure.

   j) Solubility is a characteristic property.

3. Irrelevant Attributes

   a) Shape of the solute or solvent

   b) Texture of the solute or solvent

c) Smell of the solute or solvent

d) Taste of the solute or solvent

4. Nonexamples

a) Sand dissolving in water

b) Chalk dissolving in water

c) Explosion of two substances

d) Lighting your clothes on fire with your alcohol burner

e) Freezing two liquids

f) Boiling two liquids

g) Melting a solid

Locational Skills Four

Getting to Know your Science Text Number Four

Directions: Briefly write your answers in the space after each question. You must use your book as a reference.

1. a) What is the title of chapter four?

   b) What part of the book did you find the title?

   c) What do you think the chapter will be about just from reading the title?

2. a) Solubility is discussed in chapter four extensively. Is it discussed in any other chapters in the book?

   b) If so, write at least one page number down where it is discussed which is not in chapter four. Also explain how you found your information.

3. a) Number the following experiments in the order they will be dealt with in chapter four.

   _____ Methanol as a Solvent

   _____ Solubility of Ammonia Gas

   _____ The Effect of Temperature on Solubility

   _____ Dissolving a Solid in Water

   _____ Comparing the Concentration of Saturated Solutions

   b) The answers to the above questions were found in:

   _____ Index

   _____ Table of Contents

   _____ Epilogue

   _____ Preface

   _____ Looking through the book

Cloze Procedure Six

Finding the Missing Words

Directions: Fill in the missing word in each blank below. If you think you do not know the answer do not be afraid to guess. This is not a test!

From your results of _____ the orange solid (Expt. 4.1) you _____ that you will reach _____ point where no more _____ will dissolve in the _____. The solution then has _____ largest possible concentration and _____ called a saturated solution.

_____ find the concentration of _____ saturated solution experimentally you _____ add a tiny amount _____ solid at a time _____ see whether it dissolves. _____ better method is to _____ with a large mass _____ solid and shake until _____ judge that no more _____. Then you can pour _____ some of the clear _____ and determine the concentration.

_____ dissolving 5g of _____ solids in seperate test _____, each vigorously _____ several minutes until you _____ _____ a saturated solution. If _____ tube cools during the _____, keep it warm with _____ hand. Does one sample _____ solid appear to be _____ soluble in water than _____ other?

To find the _____ of the two saturated _____ you can evaporate the _____ from a known mass _____ each solution. Subtracting the _____ of the remaining dry _____ from the mass of _____ solution will give you _____ mass and, therefore,

the _____ of the water of _____ sample. This will give _____ the data you need _____ calculate the concentration of _____ saturated solution. You can _____ the experiment for one _____ while some of your _____ work with the other solution.

_____ almost all the saturated _____ into a previously massed _____ dish, being careful not _____ pour out so much _____ that undissolved solids _____ over from the test _____ into the dish.

277 words

Cloze Procedure Seven

Finding the Main Idea

Directions: Fill in the missing word in each blank below. If you think you do not know the answer do not be afraid to guess. This is not a test! Often a key word repeated over and over again will tell you the main idea in a paragraph. Hint: In each paragraph below the blanks represent the same missing word or words used repeatedly in the paragraph.

You know from daily experience that sand and chalk do not _____ in water but that sugar and table salt do. Of course, these are only qualitative observations. Are you sure that not even a tiny amount of chalk _____ in a gallon of water? Can you _____ as much salt in a glass of water as you wish? p. 49

Except for water and the two alcohols we have discussed in this chapter, sulfuric acid was the first and most widely used _____. Later it was found that additional _____ could be prepared by heating green vitriol with common salt and by heating it with potassium nitrate. The _____ thus obtained are called hydrochloric acid and nitric acid respectively. p. 64

Reading for Directions

1. Print the word /solubility/.

2. If solubility is a characteristic property, remove the only two vowels that are the same in your word.

3. If sugar dissolves in chocolate milk as salt dissolves in water, then remove the first consonant in the alphabet from your word. (Clue: This consonant comes after the letter /a/.)

4. If sand or chalk react the opposite of ammonia gas or citric acid in water, then remove the middle vowel of your word, and replace it with the first letter of the word; vitriol.

5. If gases will not dissolve in water, remove the two letter word that begins with /s/ from your word.

6. If methanol, sulfuric acid, green vitriol, hydrochloric acid and nitric acid are used to dissolve solutes, then remove the second /l/ in your word and replace it with the vowel /e/.

7. If citric acid will no longer dissolve in a beaker of H_2O; the solubility would be called saturated. If this statement is true remove the last letter of your word.

8. If the mass of dissolved solid is called the concentration of a solution, then add the consonant which comes after the letter /m/ in the alphabet after the vowel /e/ in your word.

9. Write a sentence using your word.

Categorizing Four

Directions: Cross out the word or words which do not fit in each group. Justify the remaining group by giving it a title.

1. _____

fruit alcohol

methanol

ethanol

wine

grain alcohol

2. _____

H_2O

methanol

solvent

sulfuric acid

solute

oil of vitriol

3. _____

hydrogen

carbon dioxide

insoluble in water

oxygen

amonia gas

4. _____

density

melting point

mass

boiling point

solubility

5. _____

salt

sugar

sand

chalk

water soluble substances

6. _____

water containing orange solid completely dissolved

saturated solution

water containing orange solid chunks

liquid containing precipitate

Fill in the Blanks - Guided Reading

Directions: Read each sentence below. Turn to the page number listed after the sentence and try to locate a word having the same number of letters as spaces provided. Write the word or words on the spaces. This symbol ¶ means paragraph.

1. Mass of solid dissolved per unit volume of liquid is called c _ _ _ _ _ _ _ _ _ _ _ _ _ _. (p. 50, ¶ 4)

2. A solution in which no more solid can be dissolved is called a s _ _ _ _ _ _ _ _ _ solution. (p. 50, ¶ 2)

3. Graphed data clearly shows that how the solubility of a substance ghanges with t _ _ _ _ _ _ _ _ _ _ _ _ is a characteristic property. (p. 53, ¶ 5)

4. In the case of concentration the mass refers to the dissolved solid called the _ _ _ _ _ _ _ and the volume refers to the liquid which is called the _ _ _ _ _ _ _ _. (p. 50, ¶ 4)

5. _ _ _ _ _ is a prefix that means water. (p. 61, ¶ 1)

6. _ _ _ is a suffix meaning to generate. (p. 61, ¶ 1)

7. The gas that produces water when burned is called _ _ _ _ _ _ _ _. (p. 61, ¶ 1)

Prefix/Suffix Two

1. The suffix /ol/ often means in chapter four that the substance is a type of alcohol. Name two solvents from this chapter which are types of alcohols.

2. The definition of an /acid/ is, any compound that reacts with a base to form a salt. Typically a substance name ending with the word acid represents a solvent which will dissolve other materials. Name three solvents which were discussed in chapter four, and end with the word acid.

3. The word /ate/ is a suffix meaning to cause or to become. For example, look at the term evaporate. Evaporation of liquids can cause some substances to become gases. Name one other word ending in /ate/ from chapter four.

Fill in the blanks:

4. The prefix /di/ means two as in carbon _ _ o x i d e.

5. The suffix /gen/ means to generate as in the gases o x y _ _ _.

6. The prefix /hydro/ means water as in the gas _ _ _ _ _ g e n.

Magic Squares Activity Two

Directions: Select from the answer column at the left the word which best answers each of the statements at the right. Put the number of the word in the proper space in the magic square answer box. If your answers are correct, they will form a magic square. The total of the numbers will be the same in each row across and down to form a magic number. Add up the rows across as you do them to check if you're coming out with the same number for each row. If not, better check your answers in the row that doesn't have the same number as the majority (Herber, 1970).

Answers

A. The liquids which enable some solids to dissolve, ie. water, hydrochloric acid.

B. A solution in which no more solid can be dissolved.

C. Specific properties that can help distinguish between substances that appear the same.

D. The mass of solid dissolved per unit volume of liquid is called the _____ of the solution.

E. An alcohol made from wood.

F. A gas which is very soluble in water.

G. The concentration of a saturated solution.

H. The dissolved solid is called the _____.

I. When a solid is mixed with a solvent and becomes a liquid; the solid went through the process of _____.

Vocabulary Terms

2. Saturated
3. Dissolving
4. Concentration
5. Solubility
6. Methanol
7. Characteristic properties
8. Ammonia Gas
9. Solvents
10. Solute

A	B	C
D	E	F
G	H	I

Reading Guide Four

III Levels of Comprehension:

I. Literal Level

Directions: Below are several statements related to physical science chapter #4. Check those statements (✓) that contain information included in chapter #4. Refer to the chapter to verify your response. Write the page number you found each checked statement on.

_____ 1. The mass of solid dissolved per unit volume of liquid is called the concentration of the solution.

_____ 2. The dissolved solid in a solution is called the solute.

_____ 3. The solvent, normally a liquid, is a substance in which another substance dissolves.

_____ 4. The solution that has the largest possible concentration is called a saturated solution.

_____ 5. The concentration of a non-saturated solution is called the solubility.

_____ 6. Wood alcohol is called "methanol" and grain alcohol is called "ethanol".

_____ 7. Ammonia is a gas which dissolves in water. Therefore, it is considered very soluble in water.

_____ 8. Carbon dioxide and hydrogen are not very soluble in water. Therefore, they easily dissolve in water.

II. Interpretive Level

Directions: Below are statements that contain some possible "hidden meanings" actually contained in the chapter. Match the statements you have checked to the phrases at the right which might provide support for your answers. You may refer to the chapter to find where these items appear.

True/False	Statement #		
_____	_____	1. Substances can be the same color, density, and physical appearance and still be different.	1. The melting point of methanol is -98° C and the melting point of ethanol is -117°C.

_____	_____	2. As the temperature of ammonia and water increases the solubility of the ammonia will decrease. This is due primarily to the increased temperature of the solvent or water.	2. Sugar and citric acid look the same. They are both white. Their densities differ only slightly. They are both granular solids, and yet they are both different.
_____	_____	3. If you cooked a mixture of wood alcohol and grain alcohol to -100°C, the liquid obtained would consist of ethanol and the precipitate would consist primarily of methanol.	3. The term solution refers to the dissolved solid (called the solute) and to the liquid (called the solvent).
_____	_____	4. A solution consists of a solute plus a solvent. Therefore a solution will always contain two or more elements.	4. "Figure 4.5, page 64, shows how ammonia gas can be produced by slowly heating a water solution of ammonia. The gas can then be collected in a dry test tube. What can you conclude about the solubility of the gas as the temperature is raised?"

III. Applied Level

Directions: To apply what we read, we need to combine what we read, see, and hear with personal ideas or experiences. Below are questions which ask for your personal answers based upon your readings of chapter #4, your laboratory experiences, and thoughts. Answer each question briefly in several sentences. Do not be frustrated! The exact answers to most of these questions can not be found in your book. Do not be afraid to make an educated guess! Some questions do not have a specific right or wrong answer.

1. There were six experiments contained in chapter #4. Which one did you like the least and why?

2. All six experiments were emphasizing an important characteristic property. In your opinion, which property was emphasized in chapter #4?

3. Why will fish tend to die in warmer water than cold?

4. When gases are added to cool solvents, such as water, more gases will usually dissolve. Conversely, if the solvents are heated, gases will tend to decrease in solubility. Answer the following questions concerning the validity of the above statements:

   a) Is the above statement usually the general pattern for gases?

   b) Is the above statement usually true with solids as well as gases?

UNIT FIVE TEACHER ANSWER KEY

Cloze Procedure Eight

1.	may	16.	some	30.	at	44.	and
2.	thick	17.	point	31.	the	45.	engines
3.	difficult	18.	tarry	32.	in	46.	petroleum
4.	this	19.	these	33.	squeezed	47.	methods
5.	the	20.	the	34.	time	48.	drilling
6.	is	21.	for	35.	of	49.	also
7.	where	22.	purposes	36.	of	50.	petroleum
8.	and	23.	as	37.	wool	51.	this
9.	to	24.	substances	38.	mouth	52.	fractions
10.	some	25.	of	39.	a	53.	familiar
11.	salt	26.	ancient	40.	wick	54.	heating
12.	always	27.	crude	41.	of	55.	and
13.	discovered	28.	the	42.	of	56.	less
14.	the	29.	urn	43.	over	57.	industry
15.	once						

Locational Skills Five

1. a) The separation of substances

   b) Table of Contents

   c) Taking things apart, distillation

2. 4
   1
   2
   3
   5

3. Contents or, looking through the book

4. a) no

   b) yes, p. 72

   c) no

Reading for Directions Eight

1. fractional
2. dractional
3. dractiol
4. dactiol
5. dactiol
6. dictiola
7. dictilla
8. dictillation
9. distillation
10. Fractional distillation is an experimental process which separates substances.

Categorizing Five

Answers will vary. Possible word groupings follow.

1. Solvents

   sulfuric acid
   hydrochloric acid
   nitric acid
   methanol

2. Gases

   nitrogen
   hydrogen
   ammonia gas
   oxygen

3. Solvents or Alcohols

   wood alcohol
   methanol
   grain alcohol
   ethanol

4. Petroleum Substances

   methane
   ethane
   propane
   butane

5. Compounds, Substances, or Mixtures Found Under the Earth's Crust

   porous rock
   nonporous rock
   oil
   water

6. Experiments Which Involve Separation of Substances

   paper chromatography
   fractional crystallization
   fractional distillation
   separation of substances

Guided Reading Five

1. characteristic, properties, substances
2. liquids, distill, fractions, mixture
3. vapor, distills
4. petroleum, fractions
5. earth, compresses
6. boiling point, evaporated
7. soluble, solubilities
8. dissolved, precipitated
9. temperature, separate
10. crystals
11. gases, condenses, boiling points, plateaus

12. compressed, cool
13. pure, substances
14. mixture

Science is Puzzling Three

1. substance
2. hydrogen
3. gas
4. petroleum
5. fractional crystallization
6. cool
7. heat
8. melting point
9. fractional distillation
10. micro melting point
11. science
12. distillation
13. solid
14. centimeters
15. experiment
16. mixture
17. boiling point
18. precipitate
19. freezing point
20. vapor
21. solute

22. liquid

23. density

24. solubility

Word Definitions

1. oxygen, nitrogen, chloride, toluene, mercury, helium
2. sugar and water, sodium chloride and water, potassium nitrate and water
3. petroleum, potassium nitrate, and sodium chloride
4. methane, ethane, propane, butane, mercuric oxide
5. two parts are added together to make a whole

Reading Guide Five

I. Literal Level

1. ✓, p. 71
2. ✓, p. 72
3. No
4. ✓, p. 81
5. ✓, p. 81
6. ✓, p. 82
7. ✓, p. 85
8. ✓, p. 69

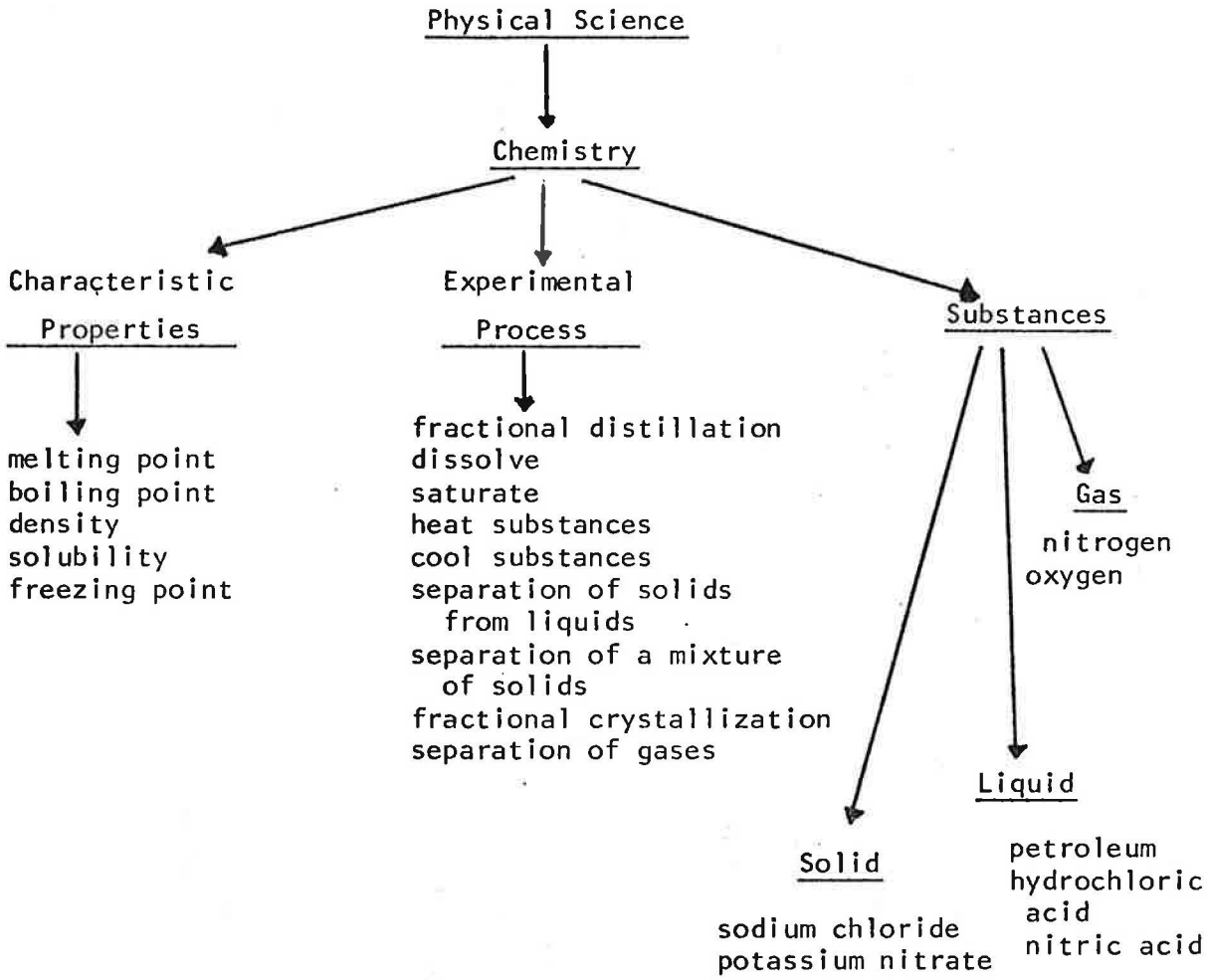
II. Interpretive Level

1. ✓, 4
2. No
3. ✓, 2
4. ✓, 1

III. Applied Level

1. Student answers will vary. There are no possible false answers.
2. Some substances would probably boil off leaving a more pure substance. This process is called fractional distillation.
3. Icebergs are formed through the process of fractional crystallization. The salt precipitates out.
4. tridecane
5. fractional crystallization

Structured Overview



Hierarchy of Target Concept: The Seperation of Substances

1. Examples

   a) The fractional distillation of petroleum

   b) The separation of a mixture of soluble solids: sodium chloride and potassium nitrate

   c) Paper chromatography

   d) The fractional crystallization of sodium chloride

2. Relevant Attributes

   a) The solubility of specific substances

   b) The heat of the solute and solvent

   c) The resulting precipitate

   d) Controlled experimental procedure

   e) Mixtures of gases, liquids, and solids can all be separated by using the characteristic properties.

   f) The varying colors on your filter paper during paper chromatography

3. Irrelevant Attributes

   a) How the mixture looks

   b) How the mixture feels

   c) How the mixture tastes

   d) The texture of your filter paper

4. Nonexamples

   a) Separating salt from sand with tweezers

   b) Crushing sodium chloride crystals with your fingers

   c) Breathing in ammonia gas

   d) Dissolving ammonia gas into water

Finding the Missing Words

Directions: Fill in the missing word in each blank below. If you think you do not know the answer do not be afraid to guess. This is not a test!

The nonporous "cap rock" _____ be thousands of feet _____. It is expensive and _____ to drill through all _____ rock to get to _____ petroleum below, and it _____ not easy to predict _____ oil is trapped. Deep _____ expensive wells often fail _____ reach oil or gas. _____ wells produce nothing but _____ water, whereas others remain _____ dry.

Petroleum was first _____ where it seeped to _____ surface in shallow pools. _____ exposed to the air, _____ of the lower-boiling-_____ substances slowly evaporated, leaving _____, almost solid, asphalt behind. _____ tars, as well as _____ liquid petroleum, were used _____ many of the same _____ in the ancient world _____ the tars and watery _____ obtained from the distillation _____ wood.

One of the _____ methods used to distill _____ oil consisted of heating _____ oil in a copper _____ with a wool "sponge" _____ the narrow mouth of _____ vessel. The vapors condensed _____ the sponge, which was _____ out into containers from _____ to time. A variation _____ this method made use _____ a heavy wick of _____ that led from the _____ of the urn into _____ collecting vessel. Such a _____ was a crude form _____ condenser.

The widespread use _____kerosene lamps a little _____

100 years ago - _____, more recently, of gasoline _____ - created a demand for _____. This led to improved _____ of locating oil and _____ wells. Better apparatus was _____ developed for fractionally distilling _____ on a large scale. _____ apparatus gives the useful _____ with which we are _____ - gasoline, kerosene, diesel fuel, _____ and lubricating oils, paraffin, _____ asphalt as well as _____ familiar fractions used in _____.

250 words

Locational Skills Five

Getting to Know Your Science Text Five

Directions: Briefly write your answers in the space after each question. Be sure to use your science text.

1. a) What is the title of Chapter Five?

   b) In what part of the book did you find the title?

   c) What do you think this chapter may be about just from reading the title?

2. Number the following experiments in the order they will be dealt with in chapter five.

   _____ Low Temperatures

   _____ Petroleum

   _____ Fractional Crystallization

   _____ Paper Chromatography

   _____ Mixtures and Pure Substances

3. The answers to the above questions were found in:

   _____ Index

   _____ Table of Contents

   _____ Looking through the book

   _____ Epilogue

   _____ Introduction

4. Check the correct answer or answers below.
   From Figure 5.2 the student can derive information about:

   _____ The solubility curves of sodium chloride and potassium nitrate

   _____ The earth's surface which consists of layers of porous and nonporous rock.

   _____ Chemical breakdown information concerning substances found in petroleum

Reading for Directions

1. Print the word /fractional/.

2. If the word fractional means a small part of the whole; remove the beginning consonant from your word and replace it with the consonant that comes after the letter /c/ in the alphabet.

3. If fusion or the bringing together of substances is the opposite of fractional crystallization or distillation; then remove the last vowel of the only two vowels which are the same in your word. Also, remove the consonant /n/ as in nitrogen from your word.

4. If methane, ethane, and propane are all substances found in petroleum by the process of distillation; then remove the first consonant from the word "reaction" in your word.

5. If fractional distillation is the opposite of fractional crystallization; then change the initial letter /d/ in your word to the letter /f/.

6. If melting point and freezing point mean basically the same thing; move the vowel /a/ behind the consonant /l/ and add the short vowel /i/ in the original place that vowel /a/ occupied.
   Hint: The first four letters of your word are often the abbreviation for dictator or dictionary.

7. If ammonia gas reacts the same in water as sodium chloride reacts in water then; remove the second to last vowel in your word and replace it with the consonant /l/.

8. If paper chromatography separates substances by separating out their varying colors then; add the suffix /tion/ which often means "the act of" to the end of your word.

9. If two solids differ in the characteristic property of solubility, then they can usually be seperated by dissolving and filtering at room temperature. If this statement is true then replace letter /c/ for letter /s/ in your word.

10. Write your new word in a sentence.

Categorizing Five

Directions: There are five words in each section below. Cross out the one word in each group that you feel is not related to the others Explain the relationship by titling each group.

1. _____

sulfuric acid

hydrochloric acid

sand

nitric acid

methanol

2. _____

nitrogen

magnesium

hydrogen

ammonia gas

oxygen

3. _____

wood alcohol

methanol

grain alcohol

ethanol

metals

4. _____

methane

ethane

propane

rock

butane

5. _____

porous rock

nonporous rock

atmosphere

oil

water

6. _____

fusion

paper chromatography

fractional crystallization

fractional distillation

separation of substances

Fill in the Blanks - Guided Reading

Directions: Read each sentence below. Turn to the page number listed after the sentence and try to locate a word having the same number of letters as spaces provided. Write the word or words on the spaces. The symbol ¶ stands for paragraph number.

1. In this chapter, we shall use the c _ _ _ _ _ _ _ _ _ _ _ _ _ _ p _ _ _ _ _ _ _ _ _ we have studied to work out a variety of methods for separating mixtures of different s _ _ _ _ _ _ _ _ _. (p. 67, ¶1)

2. Experiment Fractional Distillation

   In this experiment you will determine some of the properties of a mixture of l _ _ _ _ _ _ _. Then you will d _ _ _ _ _ _ _ the mixture and examine the properties of the f _ _ _ _ _ _ _ _ _ to see if you succeeded in separating the liquids that made up the original m _ _ _ _ _ _ _. (p. 67, ¶ 2)

3. Record the temperature of the v _ _ _ _ from the boiling liquid every half minute it d _ _ _ _ _ _ _ _. (p. 69, ¶ 1)

4. P _ _ _ _ _ _ _ _ _ is another example of such a mixture; the composition of typical f _ _ _ _ _ _ _ _ _ distilled from petroleum is shown in table 5.1. (p. 71, ¶ 1)

5. In the course of more millions of years, the slow but ever-changing crust of the e _ _ _ _-buckling in some places, rising in others, and sinking in still others-moves and c _ _ _ _ _ _ _ _ _ _ _ the rock layers that were on the ocean bottom. (p. 72, ¶ 2)

6. Once exposed to the air, some of the lower b _ _ _ _ _ _ _-p _ _ _ _ _ substances slowly e _ _ _ _ _ _ _ _ _, leaving tarry, almost solid, asphalt behind. (p. 73, ¶ 2)

7. If one solid is s _ _ _ _ _ _ _ in water and the other is not, you can separate them easily by taking advantage of the difference in s _ _ _ _ _ _ _ _ _ _ _ _ _. (p. 74, ¶ 4)

8. Do you think either substance d _ _ _ _ _ _ _ _ _? To find out, filter out the undissolved material as shown in Fig. 5.3. Wash the p _ _ _ _ _ _ _ _ _ _ _ _ left on the filter paper by pouring an additional 10cm3 of water into the funnel. (p. 74, ¶ 5)

9. We can make use of the effect of t _ _ _ _ _ _ _ _ _ _ _ on the solubility of these two substances to s _ _ _ _ _ _ _ them. (p. 77, ¶ 1)

10. When solids precipitate slowly out of solution, the c _ _ _ _ _ _ _

they form will have characteristic shapes. (p. 79, ¶ 6)

11. There are a number of ways of separating g _ _ _ _. One of them which is widely used, is to cool the mixture until it c _ _ _ _ _ _ _ _ _ to form a liquid. Then we can make use of the different b _ _ _ _ _ _ _ _ p _ _ _ _ _ _ of the various liquids and fractionally distill the cold liquid. The gases are then collected one by one, as the boiling temperature levels off at new p _ _ _ _ _ _ _ _. (p. 81, ¶ 3)

12. One method of cooling gases depends on the fact that very highly c _ _ _ _ _ _ _ _ _ _ gases c _ _ _ when allowed to expand. (p. 82, ¶ 3)

13. We have thus arrived at a collection of three substances whose properties are not changed by repeating any of these procedures. We call such substances "p _ _ _ s _ _ _ _ _ _ _ _ _". (p. 85, ¶ 3)

14. Then we say that the original sample was a m _ _ _ _ _ _ of the pure substances. (p. 85, ¶ 4)

Science is Puzzling

Directions: Using the clues at the bottom of the page, complete the spelling of each word.

1. _ _ _ _ _ _ _ _ C _
2. H _ _ _ _ _ _ _
3. _ A _
4. _ _ _ R _ _ _ _ _
5. _ _ A _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
6. C _ _ _
7. _ _ _ T
8. _ E _ _ _ _ _ _ _ _ _ _ _ _ _
9. _ R _
10. _ I _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
11. S _ _ _ _ _ _
12. _ _ _ T _ _ _ _ _ _ _ _
13. _ _ _ I _
14. C _ _ _ _ _ _ _ _ _
15. _ _ P _ _ _ _ _ _ _
16. _ _ _ _ _ _ R _
17. _ O _ _ _ _ _ _ _ _ _ _
18. P _ _ _ _ _ _ _ _ _ _
19. _ _ E _ _ _ _ _ _ _ _ _
20. _ _ _ _ R
21. _ _ _ _ _ T _
22. _ I _ _ _ _
23. _ E _ _ _ _ _
24. S _ _ _ _ _ _ _ _ _

Word Clues - Science is Puzzling

1. The physical matter of which a thing consists
2. A flammable, colorless, odorless gas
3. A substance which can expand indefinitely, ie. vapor
4. A liquid solution of hydrocarbons occuring naturally under the earth's crust.
5. This represents the experimental process of separating solids through heating and cooling. Crystals are then formed.
6. To lower in temperature
7. To raise in temperature
8. To change from a solid to a liquid state generally by heat
9. This represents the experimental process of seperating a mixture of liquids, usually through heating and filtering processes.
10. The melting point of a small amount of substance
11. A field which uses systematized knowledge derived from observation, ie., experimentation.
12. An experimental process which separates substances usually through heating.
13. Firm, compact, neither liquid nor gas
14. 1/100 of a meter, unit of measure
15. A trial or test undertaken to discover or demonstrate something.
16. A combination of pure substances
17. The vaporization of a substance through heat
18. A solid which is separated out of a solution
19. When a liquid changes to a solid, often through a cooling process.
20. Gases which are often released through heating.
21. The substance which is dissolved in a solution
22. Readily flowing fluid

23. The ratio of the mass of an object to its volume.

24. The conditions under which specific substances can be dissolved.

Chapter Five Word Definitions

1. Element. This consists of one pure ingredient such as hydrogen. Name two such elements from chapter five.

2. Solution. This usually consists of a solute plus a solvent. In your textbook this often means a solid dissolved in a liquid. Name two solutions from chapter five.

3. Mixtures. In your book this is usually talking about a mixture of solids but one can have a mixture of liquids also. Name two mixtures from chapter five.

4. Substance. In your text a substance usually consists of more than one pure ingredient. Name two substances used in chapter five.

5. Extra Credit

   Although this has not been mentioned in chapters one through five, another term widely used to describe scientific ingredients is the word compound. Try to define, in a few words, the meaning of this new term.

Reading Guide Five

III Levels of Comprehension

I. Literal Level

Directions: Below are several statements related to physical science chapter #5. Check those statements (✓) that contain information included in chapter #5. Refer to the chapter to verify your response. Write the page number you found each checked statement on.

_____ 1. Petroleum is believed to be produced naturally from dead animal and vegetable matter.

_____ 2. Most of the petroleum in the earth's crust is stored in nonporous rock formations.

_____ 3. All solids can be separated by dissolving them in water.

_____ 4. One way of separating gases is to cool the mixture until it condenses for form a liquid.

_____ 5. Oxygen and nitrogen make up 99% of the gases in the air we breathe.

_____ 6. Very highly compressed gases cool when they expand.

_____ 7. An original sample is usually a mixture of pure substances.

_____ 8. Fractional distillation represents a way of separating mixtures through boiling.

II. Interpretive Level

Directions: Below are statements that contain some possible "hidden meanings" actually contained in the chapter. Match the statements you have checked to the phrases at the right which might provide support for your answers. You may refer to the chapter to find where these items appear.

True/False	Statement #		
_____	_____	1. Paper chromatography is a way of separating the colors of substances but not necessarily the specific identification of substance names.	1. To observe sodium chloride crystals you can prepare a saturated solution of it and allow it to evaporate overnight.

_____	_____	2. The notation 1°C stands for: one degree calibrated.	2. "It is not always easy to separate a mixture into pure substances by fractional distillation. Petroleum is another example of such a mixture; the composition of typical fractions distilled from petroleum is shown in table 5.1"
_____	_____	3. The petroleum substances found in table 5.1 represent materials found in petroleum by the process of fractional distillation.	3. Thermometers are often calibrated in degrees Celsius.
_____	_____	4. Sodium chloride or table salt is formed by evaporation or by the process of fractional crystallization in experiment 5.6	4. Hang a strip of filter paper streaked with ink in a graduated cylinder containing H_2O. When the color has risen up the paper remove the paper and hang it up to dry. How many different substances can you identify?

III. Applied Level

Directions: To apply what we read, we need to combine what we read, see, and hear with personal ideas or experiences. Below are questions which ask for your personal answers based upon your readings of chapter #5, your laboratory experiences, and thoughts. Answer each question briefly in several sentences. Do not be frustrated! The exact answers to most of these questions can not be found in your book. Do not be afraid to make an educated guess! Finally, you may wish to answer the extra credit question based again upon your personal experiences and thoughts.

1. There were four experiements in chapter #5. Which one did you like the best and why?

2. If you had a solution made up of several materials, and began to boil it, what would happen? What is this process called?

3. Icebergs are formed from salt water. However, the ice itself contains no salt. How do you explain this?

4. Considering petroleum; if you reached a temperature of 70°C you could have fractionally distilled off which one or ones of the following: hexane, heptane, tridecane?

Extra Credit

1. Freeze dried coffee is formed by one of the following processes: fractional distillation, chromatography, or fractional crystallization. Name the correct process and why you think you are right.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A review of the literature revealed that texts were widely utilized by instructors in secondary science. These science texts often had reading difficulty levels which were too advanced for the students for whom they were written. The type of science terminology utilized and the rate with which terms were introduced represented factors which led to students having difficulty in reading science textbooks. A variety of strategies were recommended by numerous authorities to help pupils comprehend difficult science material. Some of the methods suggested were: a) structured overviews, b) cloze procedures, c) locational skills strategies, d) vocabulary reinforcement strategies, and e) reading guides. Although these methods were widely suggested, little actual research was found implementing them. Instruction in comprehension using reading seldom occurred through the use of science textbooks, according to teacher survey and research. However, a number of authorities have stated that comprehension skills necessary to all general reading were also necessary to reading a science text.

The purpose of this project was to construct a set of student strategies in the form of systematic lessons in reading skills utilizing supplementary science material. The strategies were

developed to increase student ability to comprehend and utilize the science text as a tool for finding information. Various comprehension strategies were designed for each of the chapters one through five of the science text. The comprehension strategies were designed to increase student understanding of vocabulary, the ability to locate information within the text, and conceptual thinking at the literal, inferential, and applied levels.

Conclusions

The comprehension strategies developed in this project were used in two ninth grade classrooms. The following conclusions were based upon student and science teacher use of these strategies within the classroom. Based upon discussions with science teachers concerning comprehension strategies, it was found that there was a need for more science teacher instruction and input concerning comprehension strategies needed to read the science text. It was also found that the ninth grade students were not highly motivated to read their science texts. During testing, cloze procedure scores from chapter one showed that 44% of the students were reading their science text at the independent reading level, 44% of the students were reading their texts at the instructional reading level and 11% of the students were reading their science texts at the frustration reading level. During testing, with the cloze procedure with materials from chapter three, student scores were as follows: 22% of the students were reading their science text at the independent reading level, 67% of the students were reading their science texts at the instructional

reading level, and 11% of the students were reading their science texts at the frustration reading level. These results showed that the majority of the class was handling their text at the instructional level or above, according to standardized cloze procedure scoring. Student cloze test scores did not improve on chapter three although they had taken three prior cloze tests on information contained in chapters one through three. This showed that repeated use of the cloze technique, using different passages each time, did not increase subsequent cloze scores with these pupils. The science teacher administering the cloze tests also noted that there was a lack of student motivation to complete the cloze tests. Science teachers interviewed emphasized the importance of the cloze technique as an ability indicator for students to handle the text but not as a motivational or instructional tool.

Although cloze techniques appeared to stimulate little pupil motivation, the science teacher using the materials observed that students were motivated to complete and participate in the vocabulary and reading guide exercises in this project. Specifically, the science is puzzling, reading for directions, and reading guide strategies appeared to be the most popular with pupils. By observing student attitude and motivation during comprehension lessons, it was found that certain lesson types were more motivating than others.

Pre and post standardized science test scores were compared between two ninth grade physical science classes. One class had received systematic comprehension lessons as described in this project

and the other had not. There was no significant difference found between the scores of the two classes on the standardized science test.

Recommendations

Research is needed to substantiate using the comprehension strategies suggested in this project. The student strategies should be utilized in several science classrooms to further test their effectiveness. Science teachers also need more exposure to student comprehension strategies in their subject area. Reading and science teachers could benefit from sharing strategies which might help them deal with content area concerns. Modifications of and additions to the student materials developed for this project should be made as the science teachers use them.

BIBLIOGRAPHY

Abegg, G. L., Cross, J. B., Dodge, J. H., Haber-Schaim, U., & Walter, J. A. Introductory Physical Science. (3rd ed.). Englewood Cliffs, New Jersey: Prentice Hall, 1977.

Ausubel, D. P. "The Use of Advance Organizers in Learning and Retention of Meaningful Verbal Material". Journal of Educational Psychology, 1960, 51, 267 - 274.

Ausubel, D. P., & Fitzgerald, J. "Role of Discriminability in Meaningful Verbal Learning Retention". Journal of Educational Psychology, 1961, 52, 266 - 274.

Ausubel, D. P. Educational Psychology: A Cognitive View. New York: Holt, Rinehart, and Winston, 1968.

Ausubel, D. P., & Fitzgerald, J. "Organizer, General Background and Anticedent Learning Variables in Sequential Verbal Learning". Journal of Educational Psychology, 1969, 53, 243 - 249.

Barnes, Gail. An Analysis of the Readability Levels of Basic Textbooks in Science, English, and Social Studies Through the Application of the Fry Readability Formula. Honors Project, University of Northern Colorado, 1973.

Barron, Richard F. "The Use of Vocabulary as an Advance Organizer". In Harold L. Herber and Peter L. Sanders (Eds.), Research in Reading in the Content Areas: First Year Report. Syracuse, New York: Syracuse University Press, 1969, 29 - 39.

Barron, Richard F., & Earle, Richard. "An Approach to Teaching Vocabulary in Content Subjects". In Harold L. Herber and Richard F. Barron (Eds.), Research in Reading the Content Areas: Second Year Report. Syracuse, New York: Syracuse University Press, 1973, 84 - 99.

Bloom, B. S. Taxonomy of Educational Objectives. New York: David McKay Company, Inc., 1956.

Bormuth, John R. "The Implications and Use of Cloze Procedure in the Evaluation of Instructional Programs". CSEIP Occasional Report No. 1, University of California, Los Angeles, April 1967, 50p. (EDO 12, 674).

Bormuth, J. R. "Cloze Test Readability: Criterion Reference Scores". Journal of Educational Measurement, 1968, 5, 189 - 196.

Burron, Arnold, Claybaugh, Amos L. Using Reading to Teach Subject Matter. Columbus, Ohio: Charles E. Merrill Publishing Company, 1974.

Chall, Leanne. "The Measurement of Readability", "Readability Finding Reading for Children". Tenth Annual Conference on Reading, University of Pittsburgh, 1954, 26 - 37.

Chang, Lynette Y. C., Dallmann, Martha, DeBoer, John J., & Rouch, Roger L. The Teaching of Reading. New York: Holt, Rinehart, and Winston, Inc., 1974.

Dale, E., & Chall, J. S. "A Formula for Predicting Readability". Educational Research Bulletin, 1948, 27 (28), 11 - 20.

Daugs, Donald R., & Daugs, Fred. "Readability of High School Biology Materials". Science Education, 1974, 58 (4), 471 - 482.

Daugs, Donald R. "Student Ability to Read and Comprehend Science Textbooks". Unpublished paper, University of Victoria, British Columbia, Canada, 1970.

Estes, Thomas, Mills, Don, & Barron, Richard. "Three Methods of Introducing Students to a Reading - Learning Task in Two Content Subjects". In Harold Herber and Peter Sanders (Eds.), Research in Reading in the Content Areas: First Year Report. Syracuse, New York: Syracuse University Press, 1973, 84 - 99.

Evans, Daryll J. "Towards a Theory of Technical Communication". School Science Review, 1973, 55, 191 - 233.

Evans, Daryll J. The Occurrence and Treatment of Technical Terms in Certain School Biology Textbooks. MA Thesis (Wales, 1968).

Falk, L. Reading for Directions. Unpublished speech, Tacoma, Washington, 1981.

Fay, L., & Jared, L. A. Reading in the Content Fields. Newark, Delaware: International Reading Association, 1975.

Fitzgerald, D., & Ausubel, D. P. "Cognitive Verses Affective Factors in the Learning Retention of Controversial Material". Journal of Educational Psychology, 1963, 54 (2), 73 - 84.

Frayer, D., Frederick, W. G., & Klausmeier. A Schema for Testing the Level of Cognitive Mastery. Madison, Wisconsin: Wisconsin Research and Development Center for Cognitive Learning, Working paper no. 16, 1969.

Fry, Edward. "A Readability Formula that Saves Time". Journal of Reading, April 1968, 513 - 515, 575 - 577.

Furukawa, James M. "A Cognitive Processing Capacity Model of Teaching and Studying Applied Biology". Unpublished research report, St. Louis, Mo., 1980.

Gardner, P. L. "The Identification of Specific Difficulties with Logical Connectives in Science Among Secondary School Students". Journal of Research in Science Teaching, 1980, 17 (3), 223 - 229.

Gates, Aurthur. "Vocabulary Control in Basal Reading Material". The Reading Teacher, 1961, 15, 81 - 85.

Gilbert, C. D. "An Examination of Readability Levels for Selected Basic Science Texts". School Science and Mathematics, 1973, 73, 178 - 182.

Gould, C. D. "The Readability of School Biology Textbooks". Journal of Biological Education, 1977, 11 (4), 248 - 252.

Harris, Theodore L., & Hodges, Richard E. A Dictionary of Reading and Related Terms. Newark, Delaware: International Reading Association, Inc., 1981.

Herber, Harold L. Teaching Reading in the Content Areas. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1970.

Herber, Harold L. Teaching Reading in the Content Areas. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1978.

Hurd, Paul. New Directions in Teaching Secondary School Science. Chicago, Illinois: Rand McNally, 1970.

Kahle, J. B., & Nordland, F. H. "The Effect of an Advanced Organizer when Utilized with Carefully Sequenced Audio - Tutorial Units". Journal of Research in Science Teaching, 1975, 12 (1), 63 - 67.

Kahle, Jane B., & Rastovac, John J. "The Effect of a Series of Advanced Organizers in Increasing Meaningful Learning". Science Education, 1976, 60 (3), 365 -371.

Koran, J. J., Jr., & Koran, M. L. "Differential Response to Structure of Advanced Organizers in Science Instruction". Journal of Research in Science Teaching, 1973, 10 (4), 347 - 353.

Lockwood, J. B. "Research on Problems in Reading Science". School Science and Mathematics, 1959, 14, 551 - 556.

Lorge, Irving. "Predicting Readability". Teachers College Record, 1944, 45, 404 - 419.

Mandell, Alan. The Language of Science. Washington D. C.: National Science Teacher's Association, 1974.

Mallison, G. G. "Textbook and Reading Difficulty in Science Teaching". The Science Teacher, 1958, 25, 474 - 475.

Nordland, F. H., Kahle, J. B., Randak, S., & Watts, T. "An Analysis of the Effectiveness of Audio - Tutorial Instruction: Measured by Student Achievement and Predicted by Standardized Measures". School Science and Mathematics, 1975, 75 (3), 277 - 284.

Novak, J. D. Education: Theory and Practice. Unpublished manuscript, Cornell University, 1974.

Olsen, Arthur V. "Attitude of High School Content Area Teachers Toward the Teaching of Reading". In George B. Schick and Merrill M. May (Eds.), Multidisciplinary Aspects of College - Adult Reading. Milwaukee, Wisconsin: National Reading Conference, 1968.

O'Toole, Raymond J., & Bedford, John P. "Science Vocabulary and Readability Level". Journal of Research in Science Teaching, 1969, 6, 161 - 163.

Otto, Wayne. "Junior and Senior High School Teacher's Attitudes Toward Teaching Reading in the Content Areas". In George B. Schick and Merrill M. May (Eds.), The Psychology of Reading Behavior. Milwaukee, Wisconsin: National Reading Conference, 1969.

Rankin, Earle, & Culhane, Joseph. "Comparable Cloze and Multiple - Choice Comprehension Test Scores". Journal of Reading, 1969, 13, 193 - 198.

Raths, James, Pancell, & VanNess, J. S. Studying Teaching. Englewood Cliffs, New Jersey: Prentice Hall, 1967.

Robinson, Alan H., & Thomas, Ellen Lamar. Improving Reading in Every Class. Boston, Massachusetts: Allyn and Bacon Inc., 1977.