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AUTHOR Hofmeister, Alan M.
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ABSTRACT

This project explored the potential of applying the technologies of computer-assisted instruction and expert systems to implementation of cognitive and metacognitive strategy instruction programs. A prototype program consisting of three computer-assisted instruction modules was developed to teach procedures required for the use of skimming, summarizing, and notetaking study strategies. After prototype field testing, the modules were adapted from an independent study format toward a teacher-directed and/or group-based format. Hypertext programming was used to provide a structure to assist teachers in explaining the steps and rationale of study strategies and to prompt the application of those strategies to sample reading passages. Expert system programming technology was used in a fourth module to provide a guide for group-based discussion of the application of metacognitive strategies. The fourth module demonstrated how the skimming, summarizing, and notetaking strategies could be used to complete common school tasks, such as preparing for instruction, completing written assignments, and studying for tests. This program was presented to 89 reading-delayed junior and senior high school students in Utah and Wyoming, and was largely successful in meeting established student learning objectives. Hypertext computer-presented instruction alone produced significant increases in strategy application scores in two of three strategies for each teacher. The expert system-based discussion guides produced significant increases in five of six measures of metacognitive strategy knowledge. However, with one exception, the program did not produce significant increases in standardized test scores. Appendices contain sample tests, instructional scripts, worksheets, and student and teacher satisfaction questionnaires. (approximately 45 references). (PB)

FINAL REPORT

Intelligent Computer-Aided Instruction of Study and Metacognitive Strategies

Grant #G008730290

Principal Investigator

Alan M. Hofmeister

Utah State University

Logan, UT 84322-6800

COMPUTER-AIDED INSTRUCTION OF STUDY AND METACOGNITIVE STRATEGIES

Abstract

Researchers have discovered that students with learning disabilities have difficulty analyzing academic tasks and employing effective performance strategies. There have been concentrated efforts in the fields of special education and psychology to develop instructional programs to teach these students the means for analyzing academic tasks and applying useful study and metacognitive strategies. However, they have not been extensively used.

Implementation of these programs has depended heavily on teachers' background knowledge in cognitive and metacognitive strategy use and on their resources for producing instructional materials. The difficulties of training teachers in study and metacognitive strategies, as well as the need for them to produce well-structured instructional presentations have restricted implementations of strategy instruction programs. The purpose of the present project was to explore the potential of applying the technologies of computer-assisted instruction and expert systems to alleviate these teacher-related difficulties.

A review of the literature indicated that computer-assisted instruction might provide teachers with an important instructional resource. A prototype program consisting of three computer-assisted instruction modules was developed on the Macintosh "Hypercard" programming environment to teach procedures

required for the use of skimming, summarizing, and notetaking study strategies.

Initially, these modules were designed to be used independently by students. To ensure reading difficulties did not interfere with tutorial completion, instructional frames were read to students via synthesized speech software.

A prototype evaluation was conducted to collect feedback related to content deficiencies and to identify potential format or design problems. The modules were presented to two reading-delayed secondary students in an alternative high school program in Rock Springs, Wyoming. Unfortunately, the individualized approach to computer-assisted instruction was found to be inadequate for several reasons. First, the technology was not sensitive to, and could not anticipate the kinds of responses that must be made in the application of study and metacognitive strategies. Secondly, the technology did not provide useful models for the application of strategies. As the field test teacher observed, "it failed to provide the process experience of learning to think through content."

In view of the feedback received from the field test teacher and information gained from a further review of the literature, the instructional modules of the prototype program were revised to facilitate teacher-directed and group-based instruction. Computer technology was used to assist instruction in two ways. "Hypercard" programming technology was used to provide a structure to assist teachers in explaining the steps and rationale of study strategies and to prompt the application of those strategies to example reading passages.

Expert system programming technology was used in a fourth module to provide a guide for group-based discussion of the application of metacognitive strategies. The fourth module demonstrated how the skimming, summarizing, and notetaking strategies could be used to complete common school tasks, such as preparing for instruction, gathering information from instruction, completing written assignments, and studying for tests.

A main field test was conducted to evaluate the educational effectiveness of the revised training program, and student and teacher satisfaction with the program. The program was presented to a total of 89 reading delayed junior and senior high school students attending classes at the Logan Middle School in Logan, Utah, and Rock Springs High School in Rock Springs, Wyoming.

The revised training program was largely successful in meeting the student learning objectives established for it. "Hypercard" computer-presented instruction alone produced significant increases in strategy application scores in two of three strategies for each teacher. The expert system-based discussion guides produced significant increases in five of six measures of metacognitive strategy knowledge. However, with one exception, the program did not produce significant increases in standardized test scores.

Applications of computer technology in the revised product could be considered successful in addressing many of the teacher-related difficulties that have been identified as restricting the implementation of strategy instruction programs in the past. The product provided a vehicle for teachers to learn study and metacognitive strategies as they initially presented strategies to students. It also reduced a demand on teachers' time required for the initial preparation of structured presentations by supplying necessary examples and guides for instruction.

The product developed was considered to be a means by which teachers could systematically initiate instruction in several important study strategies. It assists this initial instruction because it provides examples and a guide for group-based discussion.

In future implementations of the product, the developers would urge users to ensure the content examples used in the program were relevant to the content being taught in the class in which the program is to be used. The developers would also emphasize the need for teachers to provide additional strategy application practice beyond that prompted in the computer-based program.

INTRODUCTION

Students with learning disabilities perform poorly on tasks requiring active information processing (Torgesen, 1981). They do not attend to or remember central information as well as normal peers, and tend to make little use of mnemonic aids, such as labeling, verbal rehearsal, clustering, chunking, and selective attention. Their difficulty in focusing attention may reflect inadequate executive control functions (for example, rules and strategies used to understand, remember, and solve problems). In fact, the major problem of students with learning disabilities may be an inability to analyze tasks in ways that result in the best performance strategy (Sattler, 1989).

Successful students employ strategies as they read. For example, they may follow a set of specific steps to skim a reading passage, develop a list of the key points in the passage, and develop an organized set of notes that will enable them to remember and apply what they have read. More importantly, successful students employ what are known as metacognitive strategies as they solve learning problems. They may analyze and characterize a problem before them, reflect on what they know or do not know about solving the problem, devise a plan, and check or monitor their progress as they solve the problem.

Sattler, as well as other authors (e.g., Derry, 1990; Deschler & Schumaker, 1986; Paris & Winograd, 1990; Sheinker & Sheinker, 1989) have argued that learning-disabled children can be taught to use more efficient learning strategies. Most often, two distinct types of strategy instruction are recommended:

training in the use of specific study tactics and training in the use of metacognitive strategies (Derry, 1990).

Study tactics can be highly specific and may apply to only one or a few types of study tasks. For example, students may be taught to direct their attention to headings, topic sentences, and other signals provided in a reading passage in order to focus their attention on the most important information. Students who employ effective study tactics are more likely to discover or make use of the organization present in the material.

Metacognitive strategies, on the other hand, involve the use of broad control processes in problem-solving, such as awareness of one's own cognitive processes or reflective problem-solving activities (Derry, 1990). Metacognition has been defined as "knowledge and cognition about cognitive phenomena" (Flavell, 1979, p. 906). While study tactics constitute the actual continuing processes and strategies a person uses to solve a problem, metacognition refers both to what individuals know about their own cognitions and to their ability to control those cognitions (Meichenbaum, 1980). A great deal of research supports the importance of metacognitive thinking skills in reading comprehension and the application of content information (e.g., Brown, Bransford, Ferrara & Campione, 1983; Paris, Wasik & Van der Westhuizen, 1988; Pressley, Borkowski & O'Sullivan, 1985).

There have been concentrated efforts in the fields of special education and psychology to develop curricula to teach students with learning disabilities useful study and

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metacognitive problem-solving strategies. For example, McCabe (1982) developed a curriculum for "attacking" reading assignments and for the instruction of study skills. Schumaker, Deschler, Alley and Warner (1983) developed the "Learning Strategies Curriculum," a set of instructional packets to teach students with learning disabilities how to acquire information from learning materials, identify and store pertinent information, and prepare written assignments. Sheinker and Sheinker (1989) developed "Metacognitive Approach to Study Strategies," a program designed to teach generalizable study and metacognitive skills. Research supports the effectiveness of these curricula (e.g., Deshler & Schumaker, 1986).

Difficulties Restricting the Implementation of Strategy Instruction

Although curricula have been developed to teach study and metacognitive strategies, their use has not been extensive. In fact, studies suggest there has been little strategy instruction in special education or remedial settings (Swanson, 1984; Ysseldyke, Thurlow, O'Sullivan & Christenson, 1989).

It should be pointed out that, until now, effective implementations of study strategy curricula have depended heavily on teachers' background knowledge in cognitive and metacognitive strategy use and on their resources for producing instructional materials. Palinscar (1990) noted that effective strategy instruction depends on teachers' understanding of the specific knowledge and skills that underlie performance in academic areas. This understanding entails a different kind of knowledge on the part of a teacher. Teachers must be aware of the cognitive processes that are recruited by specific academic tasks.

Also, modeling the use of these processes can be difficult for teachers. For example, Duffy (1987) reported that teachers have difficulty providing an appropriate level of detail and explanation about mental strategies. Pearson and Billingsley (1987) suggested that teachers may be reluctant to engage in thinking-aloud processes because it is not part of their usual teaching repertoire. Modeling these processes may feel awkward for them. Deshler and Schumaker (1986) reported that careful staff development was required in order to make using the Learning Strategies Curriculum effective.

And, effective curriculum implementations have depended on the ability of teachers to provide a structured presentation of explanations and examples. Derry (1990) indicated that the success of strategy instruction depends heavily on the development of a well-structured, considerate instructional presentation.

Statement of the Problem

The difficulties of training teachers in study and metacognitive strategies, as well as the need for them to produce well-structured instructional presentations have restricted implementations of strategy instruction curricula.

COMPUTER TECHNOLOGY AND STRATEGY INSTRUCTION

Two computer technologies may have the potential to alleviate the teacher-related difficulties that have restricted use of strategy instruction curricula. They are: computer-assisted instruction and artificial intelligence programming techniques.

Computer-Assisted Instruction

Computer-assisted instruction actually consists of three categories of instructional programs: drill and practice, tutorials, and simulations (Gordon et al., 1984; Hofmeister, 1983; Vargas, 1986). Most of the computer-assisted instruction programs being used in schools today consist of drill and practice programs. In fact, there are almost twice as many drill and practice programs being used as simulation or tutorial programs (Educational Software Evaluation Consortium, 1987).

Although drill and practice programs are an appropriate computer-assisted instruction application for students with learning disabilities (Gerber, 1986), other applications may be even more appropriate. Tutorial CAI programs are designed to teach new subject matter (Vargas, 1986). Tutorial programs offer an advantage to educators because they provide the means by which complex instructional content can be analyzed and presented to learners in a logical and comprehensive fashion. Following the development of a carefully constructed CAI tutorial program, a well-structured sequence of examples and practice exercises is available as a tool for use by a teacher.

Educational simulations, on the other hand, are computer imitations of processes and offer the means by which students can practice the application of newly acquired skills. Vargas (1986) recommended the use of simulation programs because they encourage active responding and provide continual, immediate feedback and realistic consequences.

Recently, a convenient authoring tool for the creation of computer-assisted instruction programs has become available. "Hypercard," a program that operates on Macintosh computers, allows educational programmers to develop and easily modify sequences of computer-assisted instruction.

Computer-assisted instruction programs can provide teachers with an important instructional resource. Completed programs may be used independently. Thus, a teacher may direct students to complete program sequences in order to obtain necessary review of program content. Alternatively, a teacher may direct new students to complete program sequences to "catch up" with the remainder of the class.

Although much has been written about the use of traditional computer-assisted instruction programs for students with learning disabilities (e.g., Haynes & Malouf, 1986; Lent, 1983; Meyer, 1985; Schiffman, Tobin, & Buchanan, 1984), very few tutorial or simulation software programs validated for learning disabled students have been located. In fact, the Educational Software Evaluation Consortium (1987) could find no software emphasizing strategies for effective learning in a review of educational software available to schools.

In addition, the quality of most existing educational software is suspect. Members of the Educational Software Evaluation Consortium (1987) rated nearly half of the computer-assisted instruction software existing in schools as less than desirable. Van Lengen (1985) suggested that existing educational software may be poor because the authors of these programs may be unfamiliar with learning theories and proper methods of instructional design. To improve the quality of educational software, Vargas (1986) identified four basic principles of instructional design that should be applied to construct effective instructional programs. First, learners should be required to demonstrate a high rate of relevant overt responses. Second, appropriate cues and discrimination problems must be presented such that learners are forced to discriminate between appropriate stimuli. Third, immediate feedback should be provided such that the consequence of one response precedes the next required response. Finally, items must be presented in a carefully constructed sequence to teach new behavior.

Haynes and Malouf (1986) cautioned that students with learning disabilities may have difficulty learning from computer-assisted instruction programs for the same reasons they have difficulty learning from traditional instruction. These students may lack the strategies necessary to retain the information presented in the visual format of traditional computer-assisted instruction. One means by which computer-assisted instruction programs may be modified to assist the learning of students with learning disabilities is to provide an auditory version of the visually presented content. Computers may be programmed to "read" instructional frames to students, via synthesized speech, at the same time they are presenting visual information.

Artificial Intelligence Programming Techniques

Artificial intelligence programming techniques may also provide a useful tool in teaching students with learning disabilities study and metacognitive strategies. Professionals in the field of artificial intelligence are concerned with the development of computer programs that mimic human characteristics such as: understanding, learning, language, reasoning, and solvving problems-- characteristics commonly associated with intelligent behavior (Barr & Feigenbaum, 1981). The development of expert systems, an application of artificial intelligence, involve attempts to replicate the decision-making or problem-solving processes used by those knowledgeable and experienced in a given field (Hofmeister & Ferrara, 1986).

Sowizral and Kipps (1986) pointed out that human experts use two types of knowledge: "facts, or assertions about their area of expertise... and... rules of inference that allow them to reason within that domain" (p. 28-29). Both types of knowledge are used to develop expert systems (Stefik, Aikins, Balzar, Benoit, Birnbaum, Hayes-Roth, & Sacerdoti, 1983).

Hayes-Roth, Waterman and Lenat (1983) documented applications of expert systems to problems in prediction, interpretation, diagnosis, remediation, planning, monitoring, and instructional tasks. Although expert systems are designed primarily to solve problems for the user, this is not their only function. For example, Waterman and Jenkins (1986) pointed out that an expert system can be used, "as a tool that guides and simulates decision-making by its ability to explain the lines of reasoning it uses to arrive at each decision it makes" (p. 95).

A number of expert systems have been developed for use in special education. For example, in 1982 Colbourn developed a prototype system to assist in diagnosing children with learning disabilities. This system provided the user with a dianostic report which could then be used in the development of a remedial program. In 1984, Hofmeister developed "Class.LD," a system designed to provide a "second opinion" regarding the accuracy of a "learning disabled" classification. Subsequently, diagnostic systems were developed to provide second opinions regarding the accuracy of "behavior disordered" classifications (Ferrara, Baer, & Althouse, 1987) and "intellectually handicapped classifications (Giere, Williams, & Ferrara, 1988). Systems have been developed to provide instructional programming prescriptions prior to placing students in special education (Ferrara, Serna, & Baer, 1986; Haynes, Pilato, & Malouf, 1987), and to prescribe the type of training needed by regular educators who serve handicapped students (Haynes, Pilato, & Malouf, 1987). Systems have also been developed to assess the appropriateness of procedures followed in developing an individualized education plan (Parry, 1986a).

Hofmeister and Ferrara (1986) emphasized the training value of the "intelligent knowledge base" of an expert system. They pointed out that this knowledge base is a "model of reality" and can be used to help learners test their diagnostic and classification skills. The knowledge bases of expert systems have been used in such simulation-based training programs to successfully teach special education concepts (e.g., Parry, 1986b; Prater & Althouse, 1987; Thornburg, Baer, Ferrara, & Althouse, 1988).

Halpern (1984) discussed how expert system technology might be applied to the instruction of students with learning disabilities. Halpern noted that students with learning disabilities are often academically unsuccessful because they are unable to analyze large problems into simple, basic sub-problems. Halpern suggested that because expert system computer technology solves complex problems using variations of simple commands, the technology "has been used as a powerful research tool in investigating... theories of human thinking" (p. 155) and may have direct application to instructing students with learning disabilities.

Summary Statement

In summary, the computer technologies of computer-assisted instruction and artificial intelligence programming techniques appeared to have the potential to alleviate some of the difficulties that have restricted the implementation of strategy instruction. The technology of computer-assisted instruction, and especially the development of tutorial programs appeared to offer a means by which students could acquire skills in the rationale and steps of study strategies. The technology seemed to offer the capacity for the development of well-structured strategy instruction programs that could be used as a tool by both teachers and students. Expert system technology appeared to offer a means by which educational simulations of strategy use could be developed, allowing students to practice the metacognitive skills involved in the application of learning strategies.

Purpose of the Project

The purpose of this project was to explore the potential of applying the technologies of computer-assisted instruction and expert systems to alleviate the teacher-related difficulties that have restricted the implementation of strategy instruction. A computer-aided instructional system would be developed to provide direct instruction in the rationale and steps of study strategies, and practice in the use of metacognitive skills as strategy steps were applied to common school comprehension tasks. It was expected that the product developed would furnish teachers with a useful framework for the presentation of strategy instruction, preparing them for explaining and modeling the application of study and metacognitive strategies.

PLANNING AND DEVELOPMENT OF A PROTOTYPE PROGRAM TO TEACH STUDY STRATEGIES

Prior Planning

The validated study skills program "Metacognitive Approach to Study Strategies," by Jan and Alan Sheinker, was selected as the basis for the instructional presentations developed in this project because it provides a useful outline for instruction in study and metacognitive strategy use. The Sheinkers' curriculum is designed to teach the study strategies of skimming, summarizing, notetaking, and outlining. The curriculum is designed to be used in conjunction with content materials currently in use in classrooms, facilitating the generalized use of study strategies and critical thinking skills across content areas.

Development of a Prototype Program

Initially, computer-assisted instruction modules were designed to be used independently by students. In this "individual learning station" (ILS) approach, student were to complete modules on their own at a computer work station. These initial CAI modules were developed on the Macintosh Hypercard programming environment to teach the procedures required for the use of the study strategies of skimming, summarizing, and creating an organized set of notes from academic reading material.

There were four or five lessons developed for each strategy module. The first lesson introduced the rationale for the use of the strategy. The following lessons gradually presented individual strategy steps and the rationales for these steps. The final lessons offered students opportunities to make a limited application of the strategy to increasingly more complex reading passages.

Attempts were made to apply principles for the design of effective computer-assisted instruction (Vargas, 1986). The content of strategy instruction modules was analyzed and presented in carefully constructed sequences. Students were required to make a high rate of responses to objective comprehension questions concerning the use and rationale of strategy steps. For example, students were required to supply a missing term to complete a statement about strategy use, and were required to identify the portions of a reading passage that should be read in skimming the passage. Feedback was provided immediately following each student response. To ensure reading difficulties did not interfere with tutorial completion, instructional frames were read to students via synthesized speech software.

Evaluation Instruments

The prototype product was evaluated by two means. First, comprehension tests were developed to assess students' understanding of the rationale and steps of the three study strategies under instruction (see Appendix A). Secondly, the teacher supervising the preliminary field test was interviewed to obtain a qualitative evaluation of the usefulness of the tutorials for strategy instruction.

Product Objectives

The objectives of the product included:

1) Following training, students would demonstrate mastery by obtaining scores on the strategy comprehension tests with at least 80 percent accuracy.

2) Teachers would provide positive evaluations of the individualized tutorial programs, and indicate a desire to continue using the programs in the future.

PROTOTYPE EVALUATION AND PRODUCT REVISION

Subjects

Two ninth-grade students attending the Alternative High School program in Rock Springs, Wyoming volunteered to participate in the prototype evaluation. Both were below average readers. Student "A" earned below expected achievement level scores in the reading cluster of the Woodcock-Johnson Psycho-educational Battery, Part II (eighth-percentile by age). Student "B" earned below expected achievement level scores in the reading total of the SRA Survey of Basic Skills (24th percentile by age).

Data Collection and Procedures

Before students began each computer-assisted instruction module for study strategy instruction, they were pretested using the comprehension test developed for that module. Following pretesting, they were instructed how to use the ILS modules. They were told to read the information presented on each screen of the computer-presented instruction before advancing to the next screen, and to respond to each question presented.

If a student provided an incorrect answer to a question, the correct answer was presented, and the program branched to review the content relevant to the question. The question was then presented again. The computer required that a correct response be given for each question before allowing the student to proceed to new material.

After students had completed all lessons of a strategy instruction module, they were posttested. After all modules had been completed by the students, the field test teacher was queried to identify strengths and weaknesses of the instructional approach.

Results

As subjects were completing the lessons of the Skimming and Summarizing computer-assisted instruction tutorials, it became evident that the ILS instructional approach was not satisfactory. The final instructional module, Notetaking, was never administered.

Student A obtained a pretest score of 29 percent on the Skimming Module. He obtained a posttest score of 100 percent. Student B obtained a pretest score of 29 percent on this Module; she obtained a posttest score of 86 percent (see Table 1).

Student A obtained a pretest score of 50 percent on the Summarizing Module. He obtained a postest score of 60 percent. Student B obtained a pretest score of 90 percent on this Module; she obtained a posttest score of 70 percent (see Table 1).

TABLE 1: Prototype Evaluation Results

	Pretest:	Posttest:
Skimming		
Student A	29 percent	100 percent
Student B	29 percent	86 percent
Summarizing		
Student A	50 percent	60 percent
Student B	90 percent	70 percent

The field test teacher observed that the nature of ILS computer-based instruction is alien to fostering metacognitive skills. She noted that ILS instruction is set up in a way that there is a "correct answer," and students seek to find the answer they believe the teacher wants to hear.

The teacher commented that the ILS tutorials "look to be effective for teaching the procedures required for strategy use," but "cannot provide the process experience essential to learning to think through content." She cautioned that, as a result, "students do not generalize the use of strategies to other content."

The teacher noted a discrepancy in the learning styles of the two subjects. These subjects differed in their degree of independence, learning style, and learning speed. She observed that one student seemed to attend to the content presented by the computer, while the other seemed to "click" his way through the material. He responded to multiple-choice exercises by quickly choosing an answer, whether correct or incorrect. He tended to continue making errors until a correct answer had been provided for each lesson exercise. Subsequently, he was unable to demonstrate mastery of strategy steps on a comprehension posttest.

The field test teacher contrasted the results obtained in this evaluation with those she felt could be obtained from group-based strategy instruction. She noted that, in group-based instruction, the teacher serves as a facilitator and does not provide "the correct answer." Instead, students must be actively involved in creating their own responses and are more likely to generalize the application of strategies to new material. The teacher suggested that the observed differences in the learning styles of the two subjects would not have presented a problem in group-based instruction because group-based instruction allows students to participate "at their own level" and benefit from the models provided by stronger students.. Group-based instruction forces students to analyze and justify their responses.

In summary, the field test teacher stated,

> "While an attempt is made on the tutorials to require students to provide justifications for their responses, they are not subject to the intense self-evaluation that is prompted in the group by both teacher and peers. The group interaction is a critical component for which a computer program, however intelligent, cannot adequately substitute."

Discussion

The prototype program produced mastery-level scores on the Skimming strategy comprehension test and failed to produce mastery-level scores on the Summarizing strategy comprehension test. However, feedback provided by the field test teacher led the developers to re-think how computer technology might aid teachers in presenting strategy instruction.

As the field test teacher indicated, the tutorials taught only procedures for the use of study strategies. They failed to provide the "process experience" of "learning to think through content." The tutorials provided only limited opportunities for students to apply the strategies they had learned.

The prototype evaluation revealed that an individual learning station (ILS) approach was inappropriate for strategy instruction for at least two reasons. First, present day computer technology is not sensitive to, and cannot anticipate the kinds of responses that must be made in the application of study and metacognitive strategies. This technology can only test for understanding of comprehension within an "artificial" domain of response choices. For example, comprehension of reading passages can only be assessed by how well a student responds to objective multiple choice questions. Secondly, the technology does not serve as a useful model for teaching the application of strategies.

Students' effective use of study and metacognitive strategies rests on their ability to "construct" responses while reading. Students must be able to provide answers in their own words, and paraphrase what they have read. They must be able to argue why they have given a particular answer in response to a self-study question, and why they have created a particular key point for a summary.

The research literature supports the suggestion received from the field test teacher that strategy instruction should be more effective when conducted in a group setting. For example, reciprocal teaching (Palinscar & Brown, 1984) emphasizes interactive communication and a mutual flow of information. This instructional approach concentrates on four strategies for fostering and monitoring reading comprehension-- predicting, questioning, clarifying, and summarizing. These strategies are embedded in training sessions in which the teacher and students take turns leading a dialog concerning the text. Palinscar and Brown found that "talking about thinking" helped students to summarize relevant information and detect errors in the text. They also found that students transferred these strategies to lessons in science and social studies.

In the instructional approach of cooperative learning, students work together to complete tasks (Webb, 1982). One of the variables used to explain the positive effects of cooperative learning is the fact that when students give and receive help, they learn about strategies, metacognition, and motivation from each other (Newman, 1990).

Paris and Winograd (1990) suggested that the oral discussion that takes place during cooperative learning can help members of a group learn because it prompts debate and the restructuring of ideas. Even disagreements may help individuals seek new information, or consider old information from a new perspective. In addition, as Webb (1982) found, students in cooperative learning situations may be more motivated and less anxious than students working in other instructional settings.

Metacognitive Approach to Study Strategies (MASS, Sheinker & Sheinker, 1989) also makes use of a group setting. In this program, the classroom teacher is a facilitator who operates as a model and catalyst for student learning. Students are taught to apply study strategies to the content texts already in use in their classroom.

At the beginning of each MASS instructional session, the steps of a strategy under instruction, and the rationale for those steps are reviewed. Students are then directed to independently apply the strategy under instruction and create, for example, a set of answers to self-study questions or a set of key points. After students have applied the strategy, a group problem-solving discussion begins.

In this discussion, students cooperatively create a set of answers or key points to be listed on the classroom blackboard. Each student's daily grade depends on how well their own answers or key points correspond to those cooperatively created. As a result, students are motivated to have their own answers and key points considered. However, before a student's answer or key point can be accepted by the group, the student must provide a justification for it.

Under these conditions, a great deal of critical thinking is modeled for the class by those seeking to have an answer or key point accepted. In addition, every member of the class is motivated to be involved in the problem-solving process.

Group-based instructional approaches provide useful models of strategy application and the means by which "constructed" responses can be evaluated. However, these approaches depend heavily on teachers' background knowledge in cognitive and metacognitive strategy use and on their resources for producing instructional materials.

In view of feedback received from the field test teacher and information gained from a further review of the literature, the developers sought to revise the program. The computer would be used to provide a structure for the presentation of initial instruction in strategy use. It would also provide a guide for the application of strategies in group discussions. The developers recognized the need to place responsibility for the management of class discussions, and the evaluation of student responses with the teacher.

Product Revision

Instructional modules of the prototype program were revised to facilitate teacher-directed and group-based instruction. In the revised program, four units of instructional materials were prepared. In the first unit, students learned how to apply a skimming strategy to locate the most important information in a reading passage and answer the self-study questions. In the second unit, they learned to apply a summarizing strategy to identify the key points in a reading passage, develop a set of paraphrased key points, and modify their set to develop a written summary. In the third unit, students learned to identify important information and supporting details in a reading passage in order to develop an organized set of notes. In the final unit, students were taught methods for selecting an appropriate strategy and applying it to common school tasks.

Computer technology was used to assist instruction in two ways. In both applications, computer instructional frames were broadcast to the class via a Kodak Datashow device and overhead projector.

"Hypercard" programming technology was used in the first three units to provide a structure to assist teachers in explaining the steps and rationale of study strategies and to prompt the application of those strategies to example reading passages. Hypercard technology was used in the final unit to assist in describing four important school tasks (preparing for instruction, gathering information from instruction, completing written assignments, and studying for tests) and how the skimming, summarizing, and notetaking strategies could be used to complete those tasks.

Also, in the final unit, "expert system" programming technology was used to provide a guide for group-based discussion of the application of metacognitive strategies. A combination of procedural and artificial intelligence computer code was used to generate a variety of "scenarios" in which imaginary students responded to examples of the school task problems of preparing for instruction, gathering information from instruction, completing written assignments, and studying for tests. These scenarios were displayed to the class, and students were asked to discuss the appropriateness of the procedures followed in completing the problems. This system enabled teachers to model how metacognitive strategies might be applied to solve school tasks, and allowed students to discuss the application of those strategies.

Strategy Instruction

The first lesson of each study strategy unit began with a presentation of the rationale for the use of that strategy. Steps of the strategy were reviewed by the class. As strategy steps were introduced to students, rationales for those steps were presented.

In the early lessons of a strategy unit, the class as a group applied the steps of the strategy to an example reading passage. Example reading passages were chosen to be representative of typical classroom reading material. In later lessons, this level of prompting was faded, and students completed strategy steps independently. Following the application of each step, the rationale for the use of the step was reviewed. The lessons of each strategy unit ended with a review of the rationales for strategy steps, and class discussion of those rationales.

As recommended by the Sheinkers, responses to study problems were "brainstormed" by the group, and the group discussed how the strategy being taught helped to find those answers. For example, in the Skimming Unit, the class brainstormed the answers to reading passage questions and discussed how skimming strategy steps were useful for finding those answers.

Prompting of Student Responses

Critical oral and written responses were prompted throughout each unit of instruction. For example, the computer presentation developed for the Skimming Unit guided teachers to prompt oral discussion following the presentation of each three or four frames of instructional content (see Appendix B for a sample of instructional script).

As the steps of the Skimming strategy were applied to a reading passage, students were expected to identify steps completed, identify the portions of a reading passage being skimmed, and write answers to self-study questions on a lesson worksheet (see Appendix C for a sample lesson worksheet). Finally, students were expected to complete a written posttest in which understanding of lesson content was evaluated (see Appendix D for a sample lesson content quiz).

The student responses that resulted from this prompting allowed teachers to evaluate how well students had mastered the content taught in each lesson and how well students could apply that content. These responses enabled teachers to decide when and if lesson content should be reviewed.

In summary, the developers sought to provide a convenient means by which teachers could systematically teach study strategy steps and their rationales, model the use of a strategy, and encourage independent application.

Evaluation Instruments

The revised product was evaluated by five means. First, the ability of students to apply the skimming, summarizing, and notetaking study strategies was evaluated by asking them to correctly answer self-study questions, prepare summaries of key points, and create organized sets of notes from representative reading passages (see Appendix E for a sample evaluation instrument).

Secondly, the ability of students to correctly identify the steps of metacognitive learning strategies that should be applied in completing the school tasks of preparing for instruction, writing reports, and studying for tests was assessed (see Appendix F for a sample evaluation instrument).

Thirdly, four subtests of the SRA Survey of Basic Skills (reading vocabulary, reading comprehension, social studies, and science) were administered before and after the entire strategy instruction intervention to yield five standardized measures of academic achievement (i.e., reading vocabulary, reading comprehension, reading total, social studies, and science).

Fourth, a student satisfaction questionnaire was developed (see Appendix G). The questionnaire provided four statements on which a student could express agreement or disagreement (by providing a rating for each statement on a five point Likert-type scale where 1 = disagree, 3 = no opinion, and 5 = agree). Statements assessed whether or not students liked the tutorials, learned from the tutorials, would use the content of the tutorials in other classes, and would like to try more lessons of the type included in the tutorials.

Finally, a teacher satisfaction questionnaire was developed to obtain a qualitative evaluation of the usefulness of the computer product for strategy instruction (see Appendix H). This questionnaire asked "open-ended" questions concerning, for example, the helpfulness of the product as a teaching aid, the instructional value of the product, and how the product could be improved.

Product Objectives

The objectives of the revised product included:

1) Following training, students would achieve significantly improved scores on the instrument developed to assess study strategy application skills.

2) Following training, students would achieve significantly improved scores on the instrument developed to assess metacognitive learning strategy application skills.

3) Following training, students would achieve significantly improved scores on the five measures available from the SRA Survey of Basic Skills.

4) A majority of students would indicate satisfaction with the product (by providing an average Likert-scale rating of greater than 3.0 in response to the four statements on the student satisfaction questionnaire).

5) Teachers would indicate that the product was useful to them as an aid for strategy instruction.

MAIN FIELD TEST

Subjects

A total of 89 reading delayed junior and senior high school students volunteered to participate as subjects in the main field test. These students attended the classes of two volunteering field test teachers.

Fifty-two subjects were reading delayed students attending three sixth-grade Chapter One reading classes at the Logan Middle School in Logan, Utah. This group achieved the following mean pretest scores (in grade equivalents) on subtests of the SRA Survey of Basic Skills:

	Mean:	St. Dev.:	Range:
Reading Vocabulary	5.2	1.0	3.0-6.7
Reading Comprehension	5.3	1.8	2.4-9.8
Reading Total	5.2	1.2	3.1-7.9
Social Studies	5.2	1.3	3.0-7.8
Science	5.1	2.2	2.7-12.7

Thirty-seven subjects were reading delayed students attending three special materials classes at the Rock Springs High School in Rock Springs, Wyoming. Of the 37, 19 were identified as learning disabled and five were identified as behavior disordered or seriously emotionally disturbed. This group achieved the following mean pretest scores (in grade equivalents) on subtests of the SRA Survey of Basic Skills:

	Mean:	St. Dev.:	Range:
Reading Vocabulary	8.6	1.7	4.9-12.7
Reading Comprehension	6.5	1.8	3.5-11.0
Reading Total	7.6	1.5	5.2-11.3
Social Studies	8.4	2.4	4.3-12.7
Science	(data unavailable)		

Research Design and Procedures

Before training began, the program developers instructed the main field test teachers in how to use the computer-based strategy instruction program and when to administer the evaluation instruments.

Students were administered four subtests of the SRA Survey of Basic Skills before they began training.

A one-group pretest-posttest research design (Borg & Gall, 1983) was used to evaluate the extent to which the product met its performance objectives in each of the junior and senior high school groups. Before each unit of the study strategy curriculum students were administered the first of three versions of the strategy application test developed for that unit (pretest). The teacher used the Hypercard computer-based program to introduce and explain the steps of a study strategy and rationale for those steps, and to prompt application of the strategy, as well as to guide participation in discussion of the application. Following the computer-guided instruction, students were administered a second version of the strategy application test (posttest #1).

Subsequently, the teachers duplicated the strategy instruction approach to provide students with practice in applying the strategy to classroom content materials. This practice period lasted for approximately one week. At the conclusion of this practice, students were administered the final version of the strategy application test (posttest #2).

These procedures were followed for each of the skimming, summarizing, and notetaking strategy instruction units.

Before each lesson of the final unit, Using Skimming, Summarizing, and Notetaking, students were pretested with the metacognitive learning strategy application test. The teacher used the Hypercard computer-based program to describe four important school tasks, and how the study strategies learned in earlier units could be used to complete those tasks. The teacher used the expert system computer-based program to guide group-based discussion of the application of metacognitive strategies. Following the computer-guided discussion, students were posttested with the metacognitive strategy application test.

After students had completed all units of the study and metacognitive strategy instruction program, they were posttested, using the SRA Survey of Basic Skills.

Results

Study Strategy Application Skills

To evaluate the effectiveness of the Hypercard computer-based program in improving students' skills for applying the skimming, summarizing, and notetaking study strategies, two-tailed repeated measures t-tests were applied to make three "a priori" comparisons:

Comparison 1: between pretest scores and scores obtained following the computer-based presentation (posttest 1);

Comparison 2: between posttest 1 scores and scores obtained following class practice (posttest 2); and

Comparison 3: between pretest scores and posttest 2 scores.

Comparison 1 evaluated the effect of computer-presented instruction alone. Comparison 2 evaluated the effects of additional improvements due to class practice following the computer-presented instruction. Comparison 3 evaluated the effects of the combination of both the computer-presented instruction and the class practice that followed.

Skimming Strategy Instruction.

Teacher "I". Tests revealed that posttest 1 scores were significantly greater than pretest scores. Posttest 2 scores were statistically equivalent to posttest 1 scores. Posttest 2 scores were significantly greater than pretest scores (see Table 2).

Table 2: Skimming Strategy Instruction (Teacher "I")

		Mean:	St. Dev.:
Comparison 1	pretest	4.1	3.1
	posttest 1	6.4	3.7

($t = 4.53$; $df = 49$;
two-tailed critical value for $p < .05 = 2.01$)

Comparison 2	posttest 1	6.5	3.7
	posttest 2	6.1	4.4
	(t = 0.79; df = 47; two-tailed critical value for p < .05 = 2.01)		
Comparison 3	pretest	4.2	3.1
	posttest 2	6.2	4.5
	(t = 2.96; df = 46; two-tailed critical value for p < .05 = 2.01)		

Teacher "S". Tests revealed that posttest 1 scores were statistically equivalent to pretest scores. Posttest 2 scores were significantly greater than both posttest 1 scores and pretest scores (see Table 3).

Table 3: Skimming Strategy Instruction (Teacher "S")

		Mean:	St. Dev.:
Comparison 1	pretest	12.4	3.5
	posttest 1	12.8	3.6
	(t = 0.66; df = 32; two-tailed critical value for p < .05 = 2.04)		
Comparison 2	posttest 1	12.9	3.3
	posttest 2	14.4	2.9
	(t = 2.17; df = 26; two-tailed critical value for p < .05 = 2.04)		
Comparison 3	pretest	12.9	2.6
	posttest 2	14.5	2.7
	(t = 3.74; df = 30; two-tailed critical value for p < .05 = 2.04)		

Summarizing Strategy Instruction

Teacher "I". Tests revealed that posttest 1 scores were significantly greater than pretest scores. Posttest 2 scores were statistically equivalent to posttest 1 scores. Posttest 2 scores were significantly greater than pretest scores (see Table 4).

Table 4: Summarizing Strategy Instruction (Teacher "I")

		Mean:	St. Dev.:
Comparison 1	pretest	1.1	1.7
	posttest 1	2.0	1.6
	(t = 2.70; df = 34; two-tailed critical value for $p < .05$ = 2.03)		
Comparison 2	posttest 1	2.1	1.7
	posttest 2	1.8	1.8
	(t = 1.01; df = 32; two-tailed critical value for $p < .05$ = 2.04)		
Comparison 3	pretest	1.1	1.6
	posttest 2	1.9	1.6
	(t = 2.49; df = 36; two-tailed critical value for $p < .05$ = 2.03)		

Teacher "S". Tests revealed that posttest 1 scores were significantly greater than pretest scores. Posttest 2 scores were statistically equivalent to posttest 1 scores. Posttest 2 scores were significantly greater than pretest scores (see Table 5).

Table 5: Summarizing Strategy Instruction (Teacher "S")

		Mean:	St. Dev.:
Comparison 1	pretest	1.0	1.4
	posttest 1	5.2	2.9
	($t = 6.99$; $df = 28$; two-tailed critical value for $p < .05 = 2.05$)		
Comparison 2	posttest 1	5.3	2.8
	posttest 2	5.3	2.5
	($t = 0.00$; $df = 26$; two-tailed critical value for $p < .05 = 2.06$)		
Comparison 3	pretest	1.0	1.4
	posttest 2	5.1	2.8
	($t = 6.71$; $df = 28$; two-tailed critical value for $p < .05 = 2.05$)		

Notetaking Strategy Instruction

Teacher "I". Tests revealed no significant differences between pretest, posttest 1, and posttest 2 scores (see Table 6).

Table 6: Notetaking Strategy Instruction (Teacher "I")

		Mean:	St. Dev.:
Comparison 1	pretest	3.1	2.9
	posttest 1	3.2	2.7
	($t = 0.10$; $df = 38$; two-tailed critical value for $p < .05 = 2.03$)		
Comparison 2	posttest 1	3.3	2.7
	posttest 2	4.5	4.4
	($t = 1.70$; $df = 38$; two-tailed critical value for $p < .05 = 2.03$)		

		Mean:	St. Dev.:
Comparison 3	pretest	3.5	3.4
	posttest 2	4.5	4.4
	(t = 1.19; df = 38; two-tailed critical value for p < .05 = 2.03)		

Teacher "S". Tests revealed that posttest 1 scores were significantly greater than pretest scores, posttest 2 scores were significantly greater than posttest 1 scores, and posttest 2 scores were significantly greater than pretest scores (see Table 7).

Table 7: Notetaking Strategy Instruction (Teacher "S")

		Mean:	St. Dev.:
Comparison 1	pretest	4.9	2.6
	posttest 1	6.8	3.5
	(t = 2.55; df = 17; two-tailed critical value for p < .05 = 2.11)		
Comparison 2	posttest 1	6.8	3.5
	posttest 2	10.2	3.9
	(t = 4.08; df = 17; two-tailed critical value for p < .05 = 2.11)		
Comparison 3	pretest	5.1	2.6
	posttest 2	10.3	3.9
	(t = 6.35; df = 17; two-tailed critical value for p < .05 = 2.11)		

Summary of Strategy Application Results

In summary, comparison 1 showed that computer-presented instruction alone produced significant increases in skimming and summarizing application scores for students of teacher "I", and significant increases in summarizing and notetaking application scores for students of teacher "S". Comparison 2 showed that additional class practice failed to produce significant increases in any of the strategy application scores for students of teacher "I", but produced significant increases in skimming and notetaking application scores for students of teacher "S". Finally, Comparison 3 showed that the combination of both computer-presented instruction and class practice produced significant increases in skimming and summarizing application scores for students of teacher "I", and significant increases in all three strategy application scores for students of teacher "S" (see Table 8).

Table 8: Study Strategy Application Scores

Significant "a priori" Comparison Findings

	Comparison 1 (pretest to posttest 1)	Comparison 2 (posttest 1 to posttest 2)	Comparison 3 (pretest to posttest 2)
Skimming			
Teacher "I"	significant		significant
Teacher "S"		significant	significant
Summarizing			
Teacher "I"	significant		significant
Teacher "S"	significant		significant
Notetaking			
Teacher "I"			
Teacher "S"	significant	significant	significant

Metacognitive Learning Strategy Application Skills

To evaluate the effectiveness of the expert system-based guide for group discussion of the application of metacognitive learning strategies in completing school tasks (preparing for instruction, writing reports, and studying for tests), two-tailed repeated measures t-tests were applied to compare students' pretest and posttest scores.

Preparing for Instruction

Tests revealed that the posttest scores of students in the classes of Teacher "I" were significantly greater than their pretest scores. The posttest scores of students in the classes of Teacher "S" were also significantly greater than their pretest scores (see Table 8).

Table 8: Metacognitive Strategy Instruction: Preparing for Instruction

		Mean:	St. Dev.:
Teacher "I"	pretest	15.3	2.8
	posttest	16.3	3.0
	($t = 2.15$; $df = 38$; two-tailed critical value for $p < .05 = 2.02$)		
Teacher "S"	pretest	14.8	3.9
	posttest	16.9	2.8
	($t = 3.29$; $df = 19$; two-tailed critical value for $p < .05 = 2.09$)		

Writing Reports

Tests revealed that the posttest scores of students in the classes of Teacher "I" were significantly greater than their pretest scores. The posttest scores of students in the classes of Teacher "S" were also significantly greater than their pretest scores (see Table 9).

Table 9: Metacognitive Strategy Instruction:

Writing Reports

		Mean:	St. Dev.:
Teacher "I"	pretest	10.4	2.4
	posttest	12.0	1.9
	(t = 4.90; df = 35; two-tailed critical value for p < .05 = 2.03)		
Teacher "S"	pretest	10.3	2.1
	posttest	13.1	1.9
	(t = 4.53; df = 15; two-tailed critical value for p < .05 = 2.13)		

Studying for Tests

Tests revealed that the posttest scores of students in the classes of Teacher "I" were not statistically different from their pretest scores. However, the posttest scores of students in the classes of Teacher "S" were significantly greater than their pretest scores (see Table 10).

Summary of Metacognitive Strategy Application Results

In summary, tests revealed that the "Preparing for Instruction" guide produced significant increases in application scores for students of both teacher "I" and teacher "S". The "Writing Reports" guide produced significant increases in application scores for students of both teacher "I" and teacher "S". The "Studying for Tests" guide failed to produce significant increases in application scores for students of teacher "I", but produced significant increases in application scores for students of teacher "S".

Table 10: Metacognitive Strategy Instruction:

Studying for Tests

		Mean:	St. Dev.:
Teacher "I"	pretest	13.2	2.6
	posttest	13.7	3.9
	($t = 0.94$; $df = 26$; two-tailed critical value for $p < .05 = 2.06$)		
Teacher "S"	pretest	12.9	2.1
	posttest	14.4	2.5
	($t = 2.44$; $df = 18$; two-tailed critical value for $p < .05 = 2.10$)		

Standardized Test Results

To evaluate improvements in academic achievement, repeated measures t-tests were applied to make comparisons between the five sets of pretest and posttest scores available from the SRA Survey of Basic Skills (reading vocabulary, reading comprehension, reading total, social studies, and science).

Reading Vocabulary

Tests revealed that the reading vocabulary posttest scores (reported in grade equivalents) of students in both the classes of Teacher "I" and Teacher "S" were not significantly different from their pretest scores (see Table 11).

Table 11: Standardized Test Results:

Reading Vocabulary

		Mean:	St. Dev.:
Teacher "I"	pretest	5.2	1.0
	posttest	5.5	1.3
	(t = 1.88; df = 37; two-tailed critical value for p < .05 = 2.02)		
Teacher "S"	pretest	8.5	1.7
	posttest	8.8	2.1
	(t = 0.80; df = 29; two-tailed critical value for p < .05 = 2.05)		

Reading Comprehension

Tests revealed that the reading comprehension posttest scores (reported in grade equivalents) of students in both the classes of Teacher "I" and Teacher "S" were not significantly different from their pretest scores (see Table 12).

Table 12: Standardized Test Results:

Reading Comprehension

		Mean:	St. Dev.:
Teacher "I"	pretest	5.1	1.6
	posttest	4.7	1.7
	(t = 1.35; df = 38; two-tailed critical value for p < .05 = 2.02)		
Teacher "S"	pretest	6.2	1.7
	posttest	6.7	2.2
	(t = 1.09; df = 28; two-tailed critical value for p < .05 = 2.05)		

Reading Total

Tests revealed that the reading total posttest scores (reported in grade equivalents) of students in the classes of Teacher "I" were not significantly different from their pretest scores. However, the posttest scores of student in the classes of Teacher "S" were significantly greater than their pretest scores (see Table 13).

Table 13: Standardized Test Results:

Reading Total

		Mean:	St. Dev.:
Teacher "I"	pretest	5.0	1.1
	posttest	5.1	1.3
	($t = 1.01$; $df = 32$; two-tailed critical value for $p < .05 = 2.04$)		
Teacher "S"	pretest	7.4	1.4
	posttest	7.8	1.9
	($t = 2.14$; $df = 28$; two-tailed critical value for $p < .05 = 2.05$)		

Social Studies

Tests revealed that the social studies posttest scores (reported in grade equivalents) of students in both the classes of Teacher "I" and Teacher "S" were not significantly different from their pretest scores (see Table 14).

Summary of Standardized Test Results

In summary, tests revealed that the overall revised strategy instruction program failed to produce significant increases in any subtest score for students of teacher "I", and produced significant increases only in the reading total score for students of teacher "S".

Table 14: Standardized Test Results:

Social Studies

		Mean:	St. Dev.:
Teacher "I"	pretest	5.2	1.2
	posttest	5.2	2.0
	(t = 0.10; df = 35; two-tailed critical value for p < .05 = 2.03)		
Teacher "S"	pretest	8.3	2.4
	posttest	8.2	2.2
	(t = 0.24; df = 28; two-tailed critical value for p < .05 = 2.05)		

Science

Tests revealed that the science posttest scores (reported in grade equivalents) of students in the classes of Teacher "I" were not significantly different from their pretest scores (see Table 15). Posttest and pretest scores from the students in the classes of Teacher "S" were not available.

Table 15: Standardized Test Results:

Science

		Mean:	St. Dev.:
Teacher "I"	pretest	5.0	1.9
	posttest	5.5	2.5
	(t = 1.24; df = 33; two-tailed critical value for p < .05 = 2.04)		

Student Satisfaction

Forty-nine student satisfaction questionnaires were returned from the students in the classes of teacher "I"; Thirty-four were returned from the students in the classes of teacher "S". The ratings provided by each student were averaged to produce a mean satisfaction score. Satisfaction was defined as a mean score of greater than 3.0 on the five-point Likert-type scale. Forty-four (90 percent) of the 49 mean scores computed for the students in the classes of teacher "I" indicated satisfaction with the computer-based program. Eight (24 percent) of the 34 mean scores computed for the students in the classes of teacher "S" indicated satisfaction.

Teacher Satisfaction

The Teacher Satisfaction Questionnaire asked the field test teachers to respond to a number of open-ended questions concerning difficulties encountered, appropriateness of content, instructional value of the product, and suggested instructional applications.

Both teachers experienced minor technical difficulties with the equipment. Teacher "I" reported that she had difficulty starting the program on two occasions. Teacher "S" found it difficult at first to use the Macintosh computer because she had not used it before. However, she stated "Once I became more comfortable with the MAC it was not a problem." She found that students using the computer to "make up lessons" were able to utilize the program with very little assistance.

Teacher "I" reported the content of the tutorials to be "very" appropriate. However, she found the reading level to be slightly advanced for 6th-grade at-risk students, and frequently paraphrased for them. She indicated that students liked the program, and stated, "Most students reported that they learned new skills and used them occasionally in content classes."

Teacher "S" pointed out that the tutorial examples relied heavily on science reading examples, whereas she was using the computer-based program to teach strategy use in a social studies class. She stated, "I experienced a lot of difficulty with students over the content used to instruct the strategies. Many students didn't like taking so much time out of their content area to learn study strategies primarily taught through another subject matter. The tutorials would have been much more successful if they had been more directly related to the class subject matter."

Teacher "S" indicated the reading level was appropriate for the classes she taught. However, she stated, "readability was complicated because many of the students were unfamiliar with the content vocabulary and there really wasn't enough time to develop background knowledge that would have added reading comprehension."

When asked how the tutorials were helpful, teacher "I" responded, "they saved time because I wasn't required to put examples on the board; I could return to review concepts that were not firm. The program gave me a consistent guide for presenting information across my classes."

Teacher "S" stated, "The tutorials were great for introducing the strategies but did not provide enough different instructional opportunities to teach to mastery. I felt very rushed in the timelines set up and feel this hurt the effectiveness of the tutorials. I needed more class practice activities and instructional time prior to taking the quiz or having the student take the second passage exam."

Teacher "I" concluded that the product was useful because it provided ready made training materials for the instruction of study skills. Teacher "S" said, "This type of tutorial would be excellent in an English curriculum that was directed towards study strategies, in a remedial reading program at the secondary level, in an elementary curriculum or resource room program. The tutorials are very teacher friendly and would be an excellent way for a teacher who is not familiar with the strategies to instruct them. Having everything prepared makes them easy to utilize in the classroom."

CONCLUSIONS AND IMPLICATIONS

Conclusions

The revised training program was largely successful in meeting the student learning objectives established for it. "Hypercard" computer-presented instruction alone produced significant increases in strategy application scores in two of three strategies for each teacher. The expert system-based discussion guides produced significant increases in five of six measures of metacognitive strategy knowledge. However, with one exception, the program did not produce significant increases in standardized test scores.

Applications of computer technology in the revised product could be considered successful in addressing many of the teacher-related difficulties that have been identified as restricting the implementation of strategy instruction programs in the past. The product provided a vehicle for teachers to learn study and metacognitive strategies as they initially presented strategies to students. It also reduced a demand on teachers' time required for the initial preparation of structured presentations by supplying necessary examples and guides for instruction.

In the prototype program, students had been asked to independently use a computer to learn study strategy procedures. However, the learning environment created in individualized computer-based learning programs can be artificial, as Hativa (1988) found, and may actually introduce new learning problems for low-achieving students. Students may have difficulty "adapting" to the environment.

On the other hand, participation in group problem-solving may assist low-achieving students to learn in a number of ways. Students are interacting with actual classroom materials, and can follow along more easily because they can see how the teacher and stronger students apply strategy skills. This use of the group process is supported by previous work. Two good examples are Palinscar and Browns' (1984) Reciprocal Instruction and Webb's (1982) Cooperative Learning. The training product was revised to utilize the resources available in a group problem-solving environment.

Group problem-solving allows the evaluation of "constructed" student responses by appropriate evaluation sources-- the teacher and other students. Computer technology presently cannot evaluate the types of responses that students need to make to demonstrate they can apply study and metacognitive strategies. It can, however, prompt group discussions of strategy applications at appropriate times. In the revised training product, the computer was no longer used to evaluate student responses, but was used to enhance the group's role in evaluation by prompting discussions.

Implications

Both main field test teachers suggested the revised training program was an "excellent" way to introduce study strategies to students and would be useful to new teachers. They recommended the program be used for initial strategy instruction, student review, and bringing incoming students "up to speed" with the rest of the class. It is likely that using the program reduces some teacher training demands because of the structure it provides for instruction.

It should be noted that the teacher more experienced in group-based instruction of study strategies, teacher "S", emphasized the need to provide substantial amounts of practice in applying study strategies to classroom materials. This teacher stated that she felt constrained by the artificial timelines established for the research study.

In addition, teacher "S" emphasized the need to make the content material used for strategy instruction relevant to the classes in which the program is being used. Few of the students in the classes of teacher "S" expressed satisfaction with the training program because, as teacher "S" explained, her students didn't like learning strategies in a subject matter unrelated to the class they were in. As teacher "S" stated, "The students had difficulty seeing beyond the science content to realize the 'process' was the real content."

In reviewing the results of the present study, the developers considered the possibility of developing a "content-free" computer-based shell to guide discussion during study strategy instruction. Of course, such a shell could not provide examples of content application.

The product developed was considered to be a means by which teachers could systematically initiate instruction in several important study strategies. It assists this initial instruction because it provides examples and a guide for group-based discussion.

In future implementations of the product, the developers would urge users to ensure the content examples used in the program were relevant to the content being taught in the class in which the program is to be used. The developers would also emphasize the need for teachers to provide additional strategy application practice beyond that prompted in the computer-based program.

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Appendix A

Sample Prototype Comprehension Test

Name:________________________

SUMMARIZING PRE/POSTTEST

1. Find the best words to complete the following statement:

When we summarize, we read for the purpose of finding the most important information in a reading passage, and ________ that information into a brief paragraph, or summary.

1) compare
2) condense

2. What are key points? (Two of the following are correct)

A) statements of details.
B) statements of the most important information.
C) statements of facts.
D) statements that can be used to form a summary.

3. Why do we skim a passage before summarizing?

A) Because it helps us to locate facts contained in the reading passage.
B) Because it helps us to locate details contained in the reading passage.
C) Because it helps us to locate information contained in the reading passage.
D) Because it helps us to locate the most important information contained in the reading passage.

4. Which of the following words best completes the sentence:

________ ________ can give us a good idea of what the author thinks is most important.

Reading slowly
Self-study questions

5. Find the word that best completes the following sentence:

If you think that the first sentence in the paragraph contains the key point, look at the other sentences in the paragraph as well. If the first sentence contained a key point, it will usually be ________ by the other sentences which will give details about the key point.

supported
replaced

6. Find the best word to complete the following sentences:

When we make up a list of key points from a reading passage, sometimes the list contains points that should not be considered key points. They are likely to be facts, or details that ________ key points.

support
are

7. Read the following paragraph and underline the sentence that contains a key point:

The interview method is used to see what an individual's personality is like. A rating scale is also used to judge personalities. A personality inventory or questionaire also gives information about people and the way they act toward others. Personality can be measured in several different ways.

8. The following is a key point from the reading passage.

"Forecasting weather is a very helpful service".

With which of the following key points may this point be combined?

A) A weather expert can usually tell what weather conditions will follow in the next day or two.
B) Weather warnings often save crops.
C) Weather warnings may even save lives.
D) Thousands of people plan their trips and even their daily clothing according to the reports of the weather experts.
E) Forecasting the weather is one of the services the United States government provides for its citizens.

9. Read the following paragraph, and create a key point statement:

Passage title: "Muscles"

All body movement from blinking an eyelid to kicking a ball requires the use of muscles. Digestion, circulation of blood, and excretion of wastes also depend on the action of muscles. Muscle is tissue that moves the parts of your body. The more than 400 muscles of the human body make up about a third of a person's body weight.

Self-study question: How do muscles help you to live?

Your key point:

Appendix B

Sample of Instructional Script

Skimming Strategy: What is Skimming? Quit

Skimming Strategy:

What is Skimming?

Press the forward arrow to begin Lesson 1.

Skimming Strategy: What is Skimming? Quit

Welcome to Skimming!

In the Skimming Strategy, you will learn about skimming: a way to read material FAST to LOCATE IMPORTANT INFORMATION.

Skimming Strategy: What is Skimming? Quit

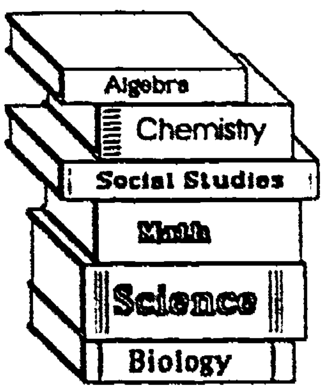
In school, you have many things to read.

Skimming Strategy: What is Skimming? Quit

In school, you have many things to read.

Skimming Strategy: What is Skimming? Quit

Because you have so much to read, you need a way of covering reading material FAST.



Skimming Strategy: What is Skimming? Quit

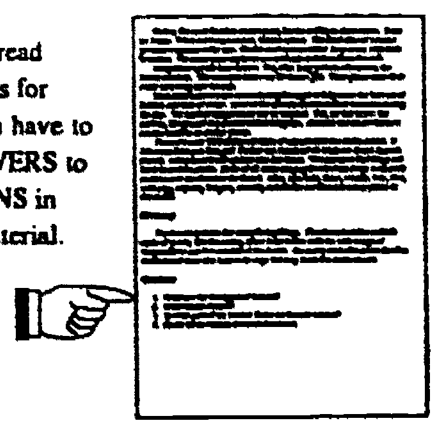
Skimming helps you cover your reading material FASTER!

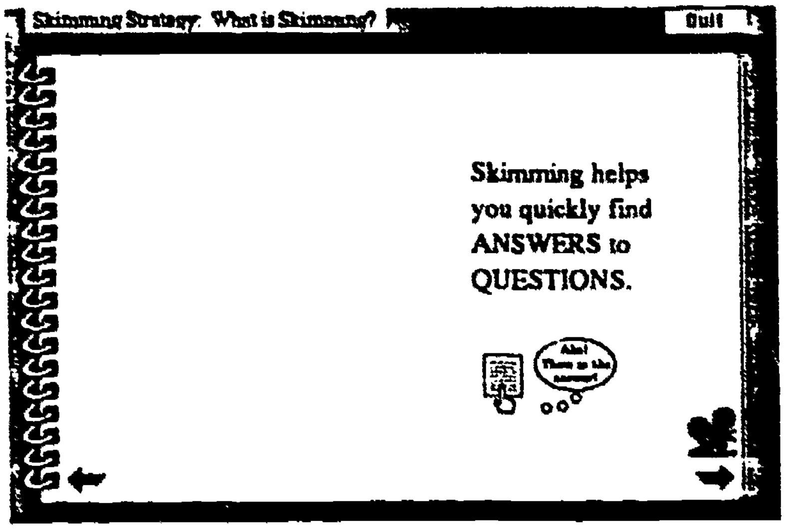
Skimming Strategy: What is Skimming? Quit

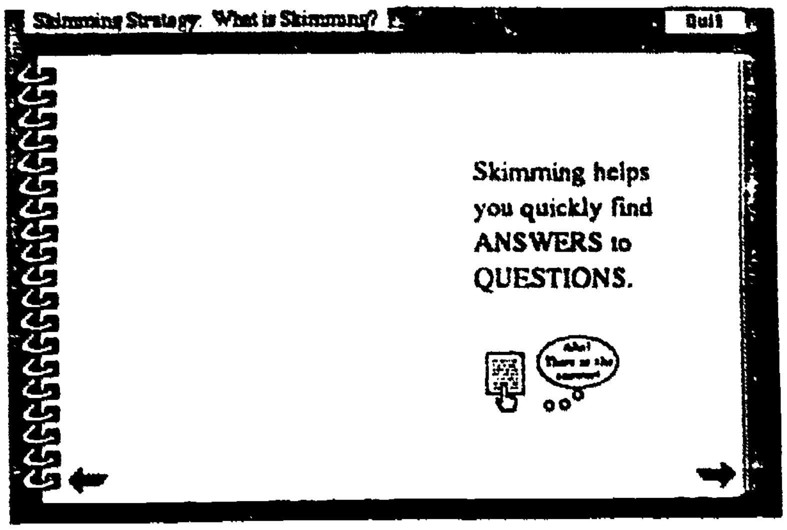
Skimming helps you cover your reading material FASTER!

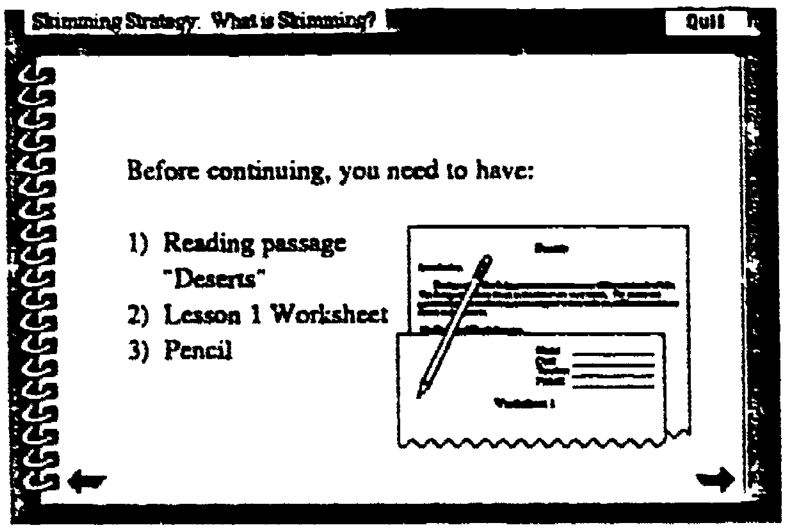
Skimming Strategy: What is Skimming? Quit

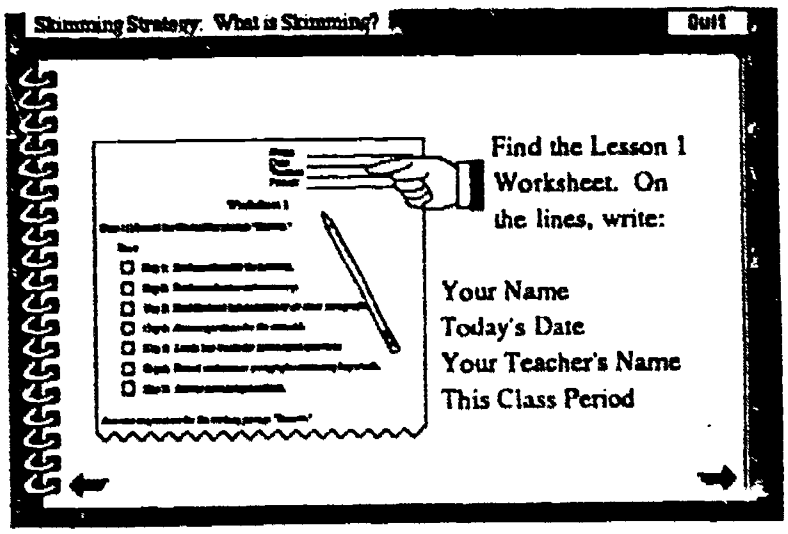
When you read assignments for school, you have to find ANSWERS to QUESTIONS in reading material.

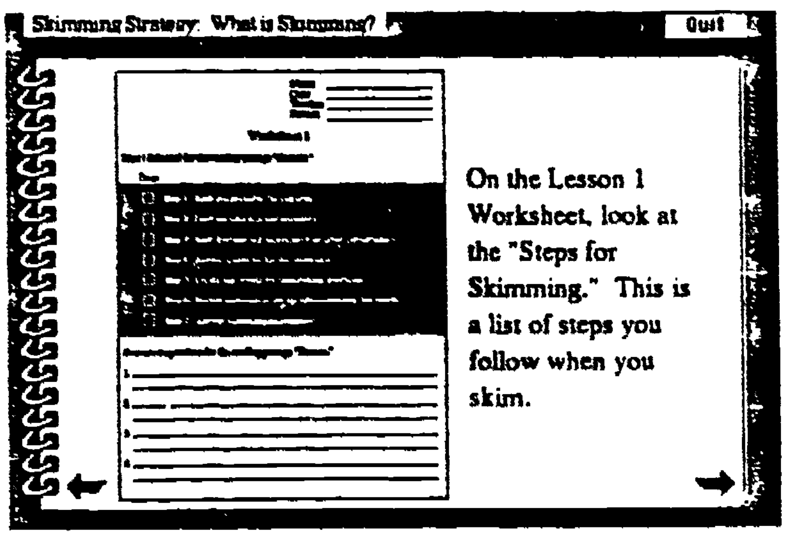


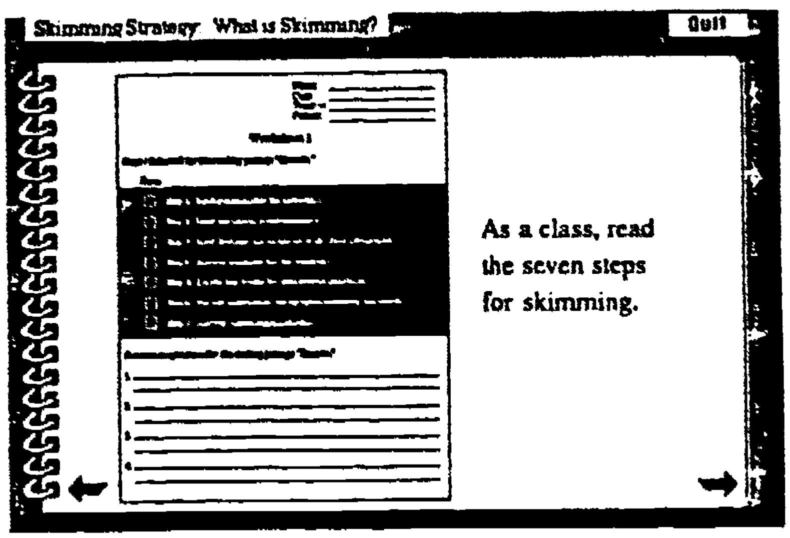

Skimming Strategy: What is Skimming?
Quit
Skimming helps you quickly find ANSWERS to QUESTIONS.

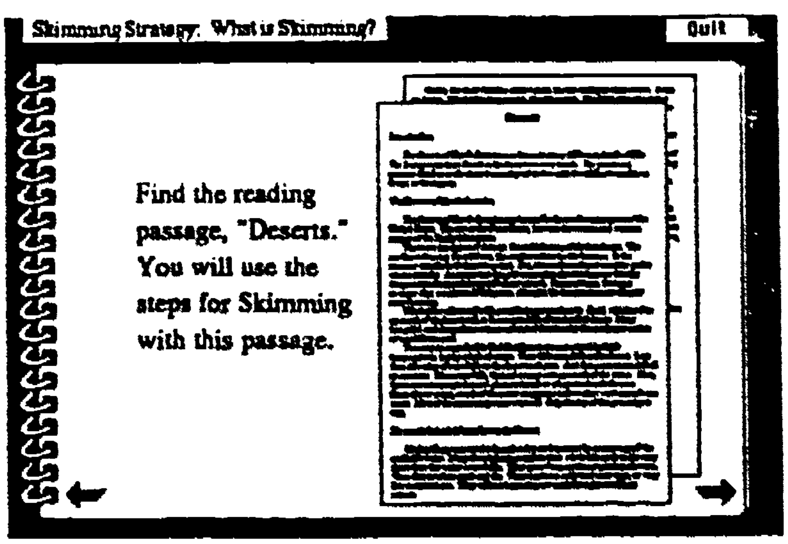

Skimming Strategy: What is Skimming?
Quit
Skimming helps you quickly find ANSWERS to QUESTIONS.

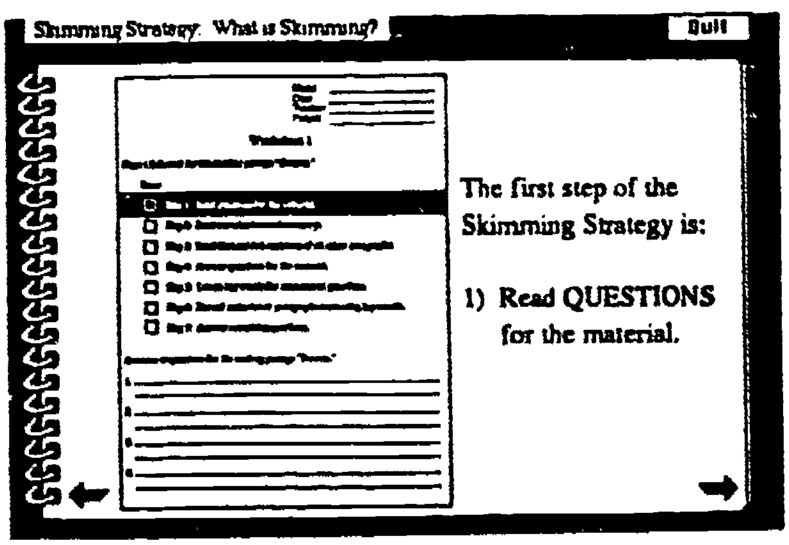

Skimming Strategy: What is Skimming?
Quit
Before continuing, you need to have:
1) Reading passage "Deserts"
2) Lesson 1 Worksheet
3) Pencil

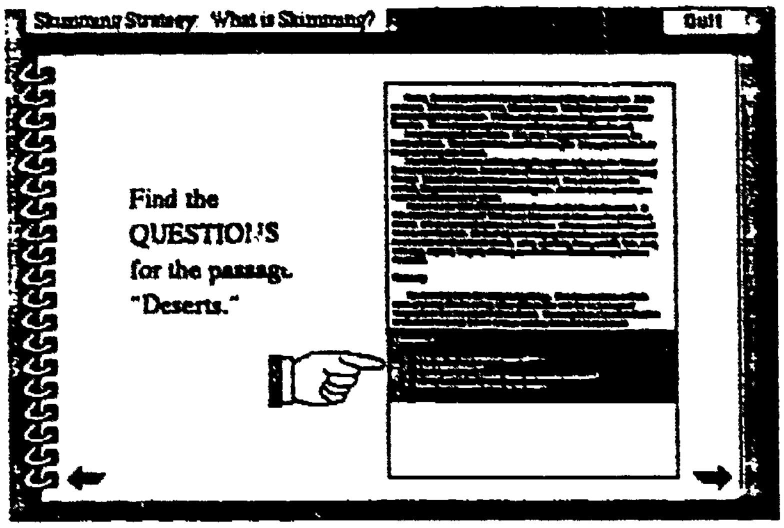

Skimming Strategy: What is Skimming?
Quit
Find the Lesson 1 Worksheet. On the lines, write:
Your Name
Today's Date
Your Teacher's Name
This Class Period

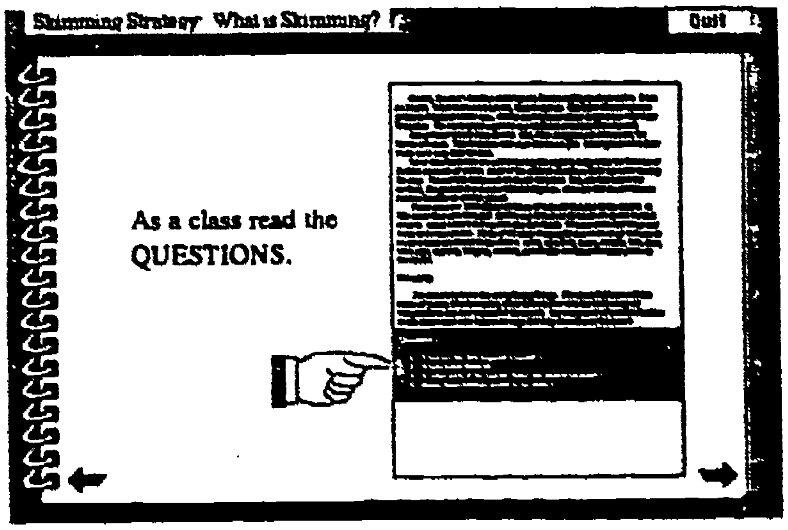

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, look at the "Steps for Skimming." This is a list of steps you follow when you skim.

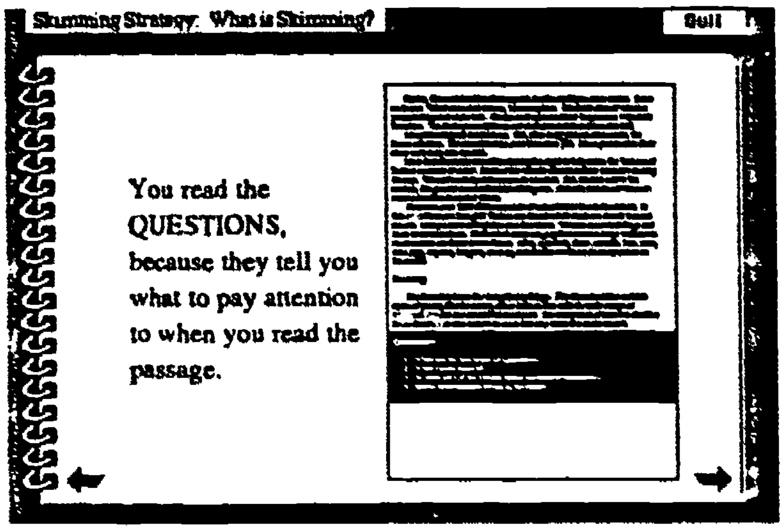

Skimming Strategy: What is Skimming?
Quit
As a class, read the seven steps for skimming.

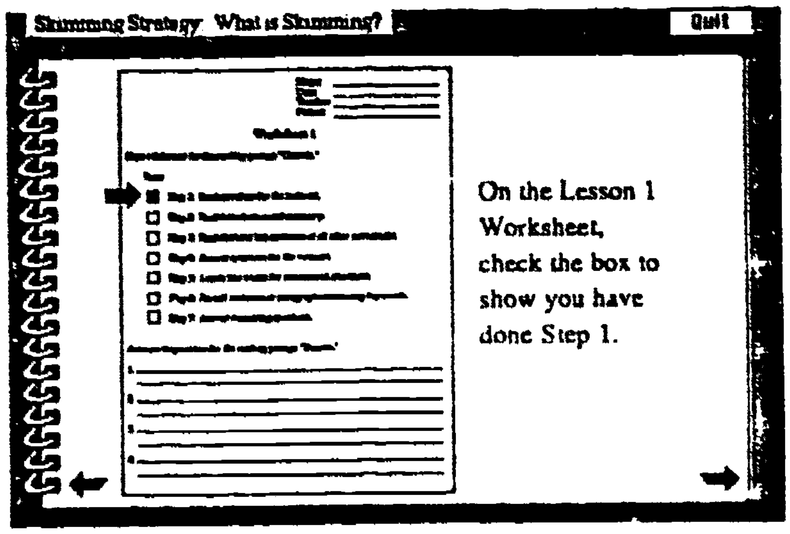

Skimming Strategy: What is Skimming?
Quit
Find the reading passage, "Deserts." You will use the steps for Skimming with this passage.

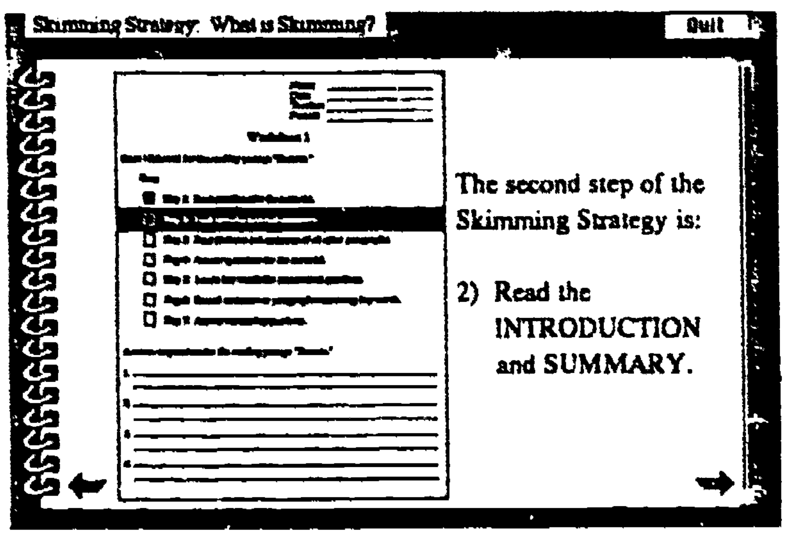

Skimming Strategy: What is Skimming?
Quit
The first step of the Skimming Strategy is:
1) Read QUESTIONS for the material.

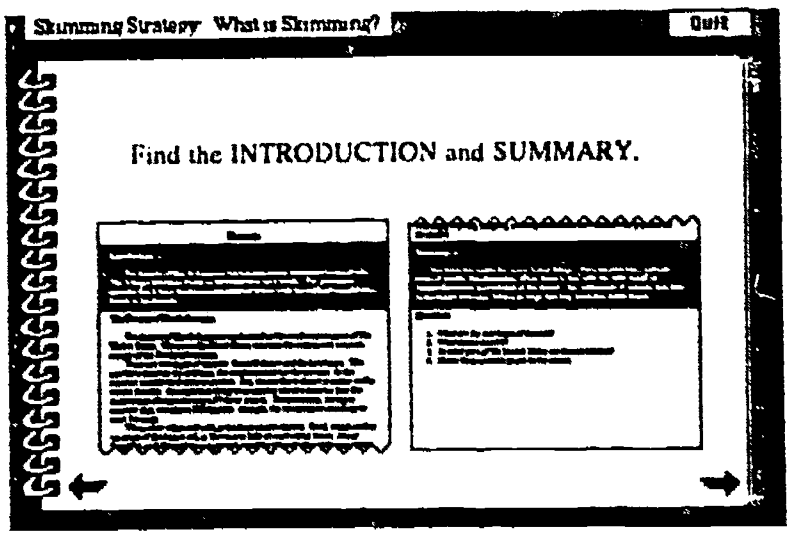

Skimming Strategy: What is Skimming?
Quit
Find the QUESTIONS for the passage "Deserts."

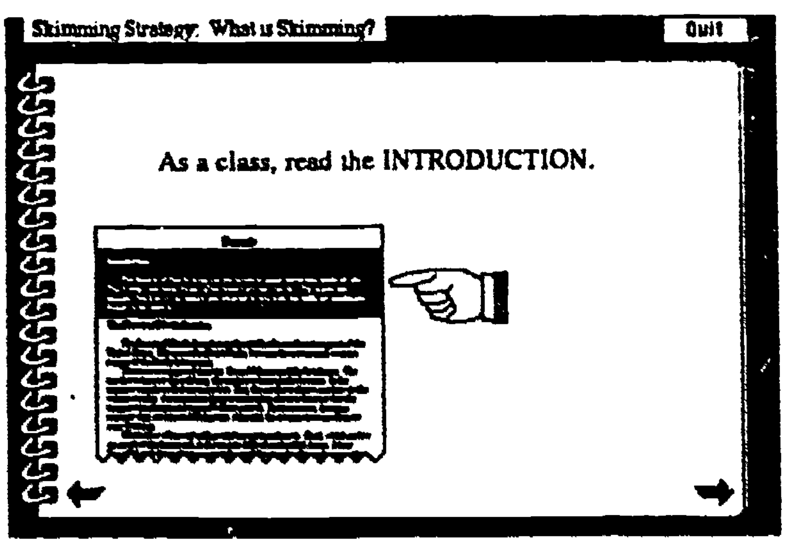

Skimming Strategy: What is Skimming?
Quit
As a class read the QUESTIONS.

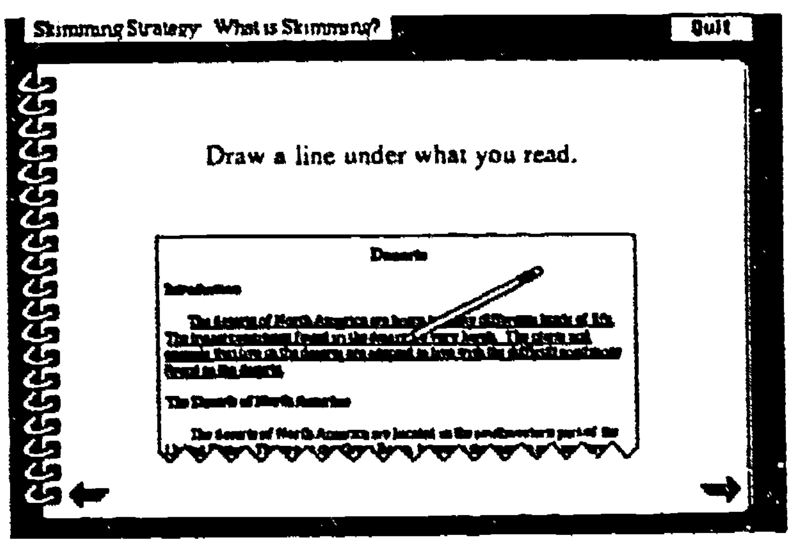

Skimming Strategy: What is Skimming?
Quit
You read the QUESTIONS, because they tell you what to pay attention to when you read the passage.

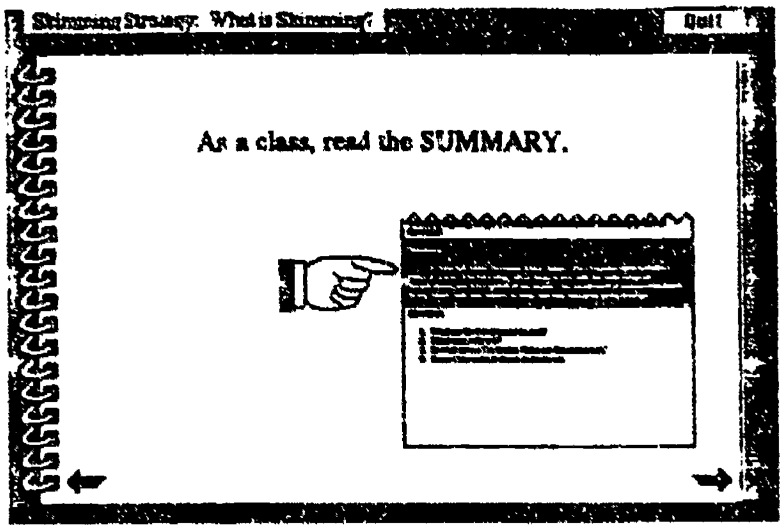

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, check the box to show you have done Step 1.

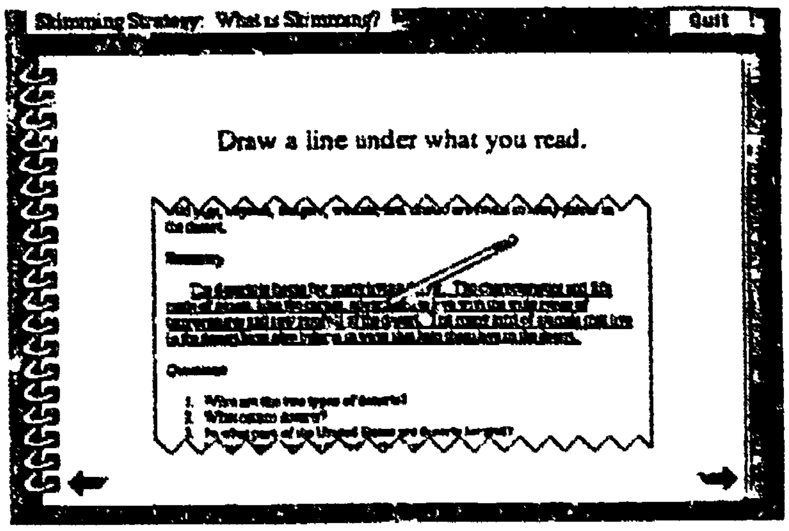

Skimming Strategy: What is Skimming?
Quit
The second step of the Skimming Strategy is:
2) Read the INTRODUCTION and SUMMARY.

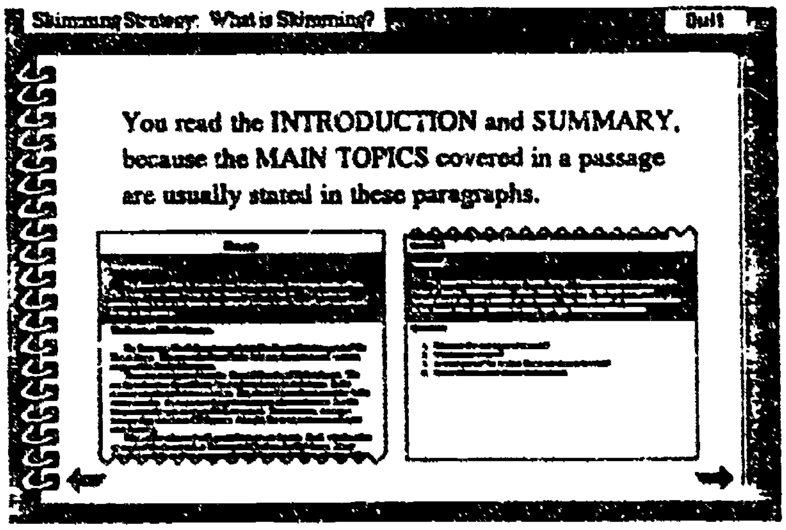

Skimming Strategy: What is Skimming?
Quit
Find the INTRODUCTION and SUMMARY.

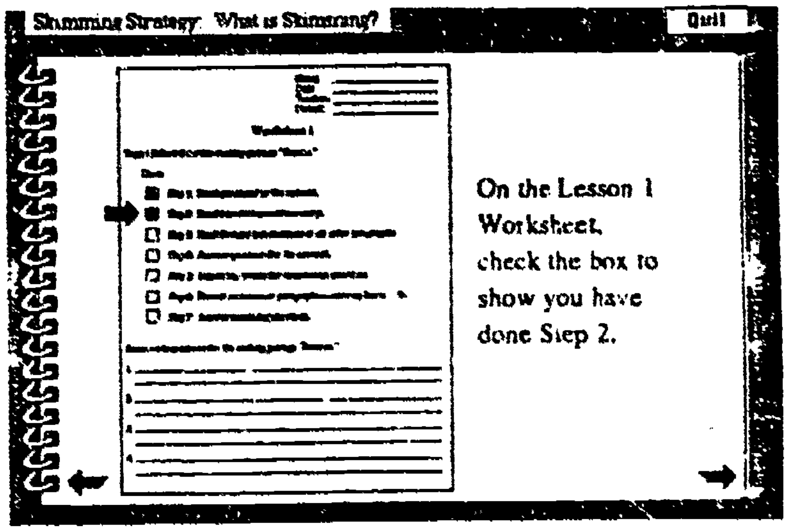

Skimming Strategy: What is Skimming?
Quit
As a class, read the INTRODUCTION.

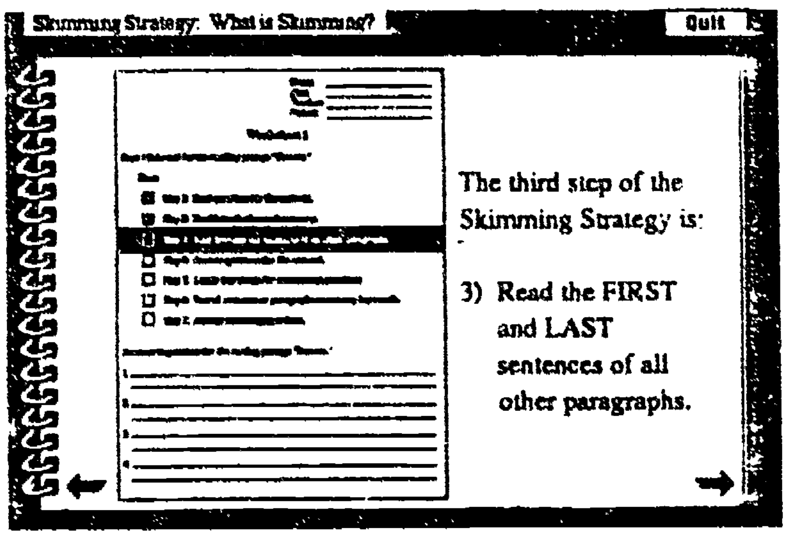

Skimming Strategy: What is Skimming?
Quit
Draw a line under what you read.
Deserts

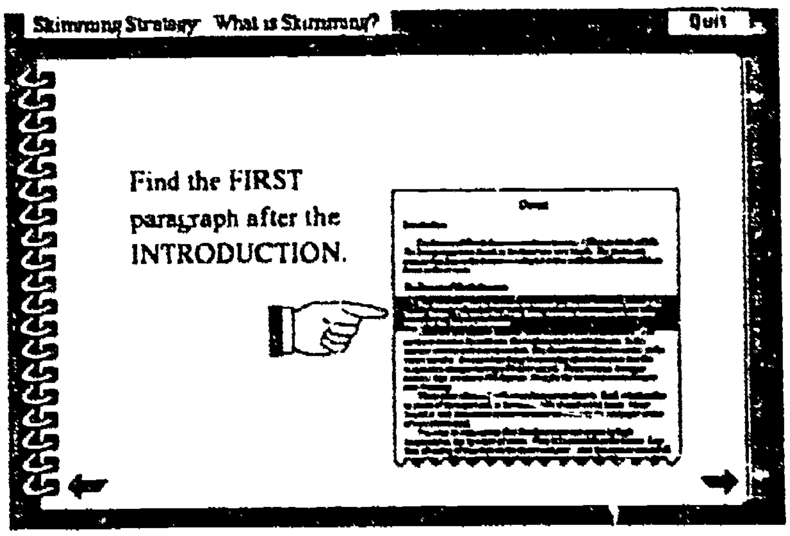

Skimming Strategy: What is Skimming?
Quit
As a class, read the SUMMARY.

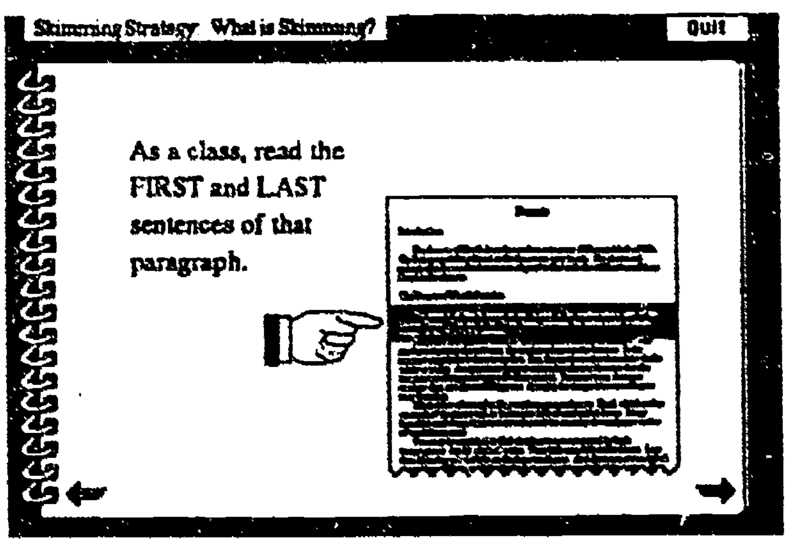

Skimming Strategy: What is Skimming?
Quit
Draw a line under what you read.

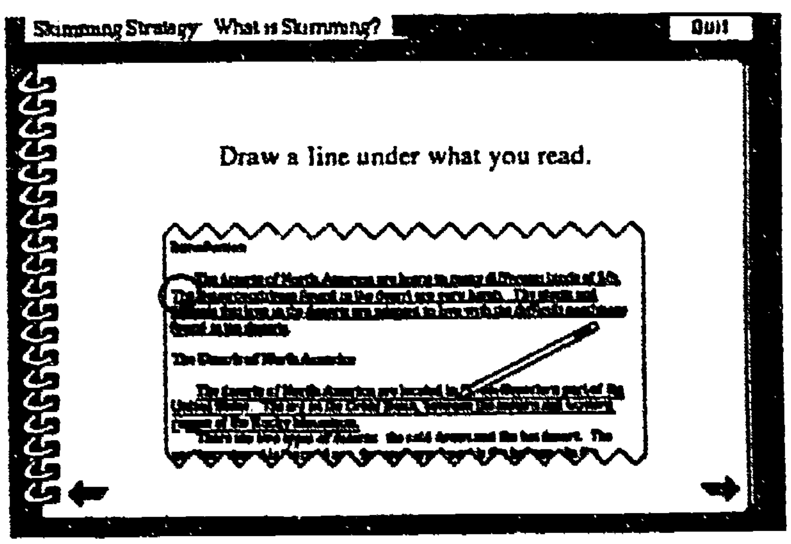

Skimming Strategy: What is Skimming?
Quit
You read the INTRODUCTION and SUMMARY, because the MAIN TOPICS covered in a passage are usually stated in these paragraphs.

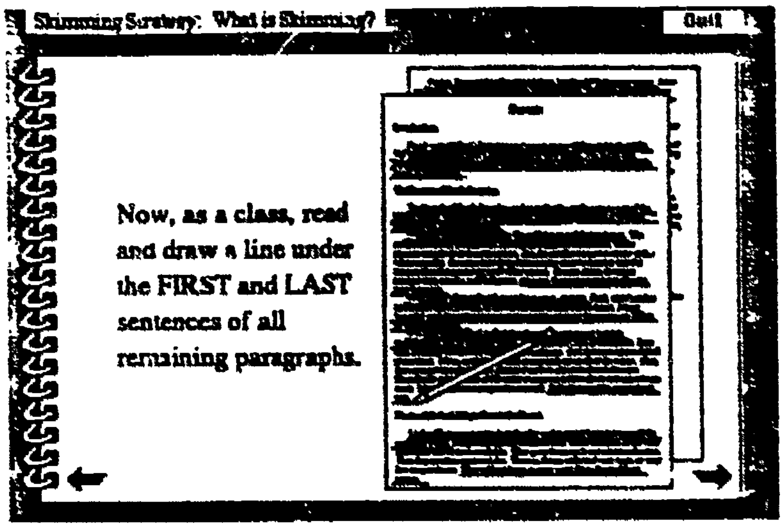

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, check the box to show you have done Step 2.

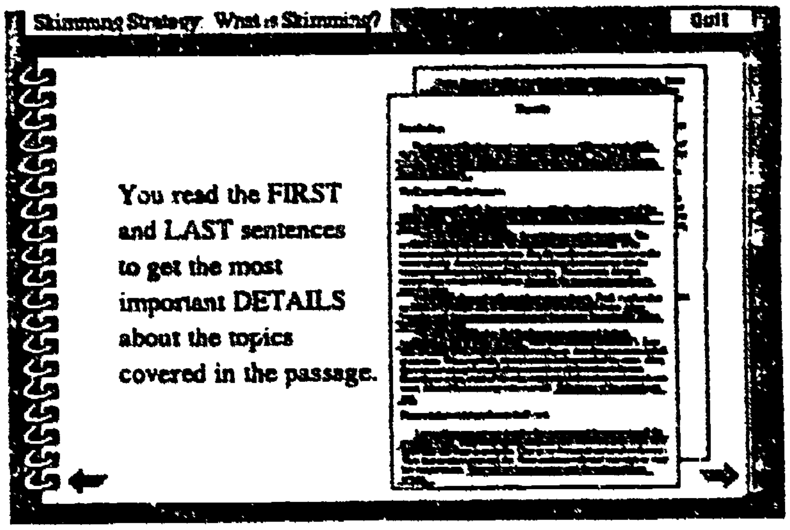

Skimming Strategy: What is Skimming?
Quit
The third step of the Skimming Strategy is:
3) Read the FIRST and LAST sentences of all other paragraphs.

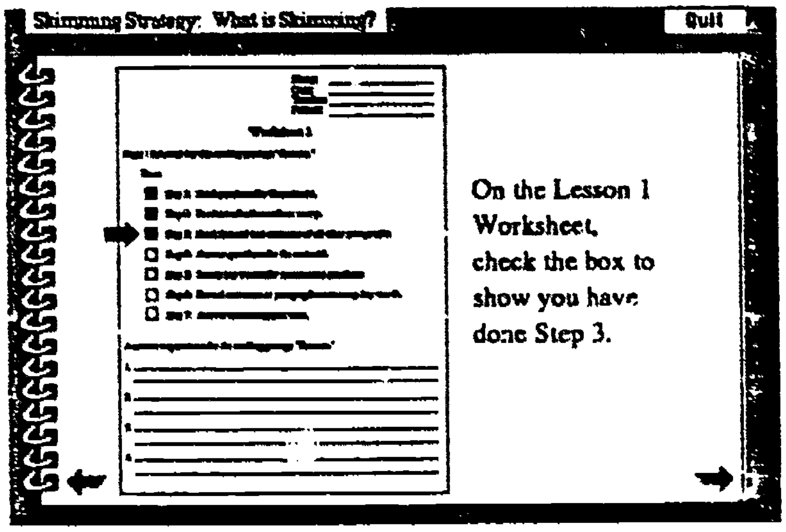

Skimming Strategy: What is Skimming?
Quit
Find the FIRST paragraph after the INTRODUCTION.

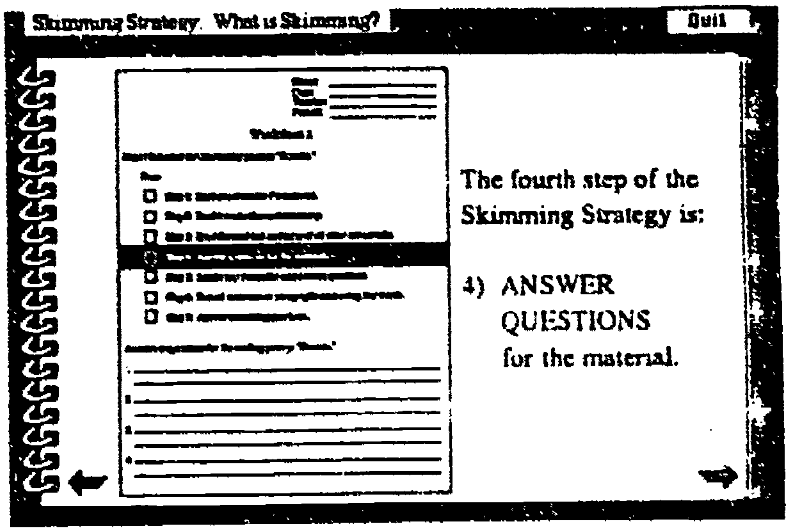

Skimming Strategy: What is Skimming?
Quit
As a class, read the FIRST and LAST sentences of that paragraph.

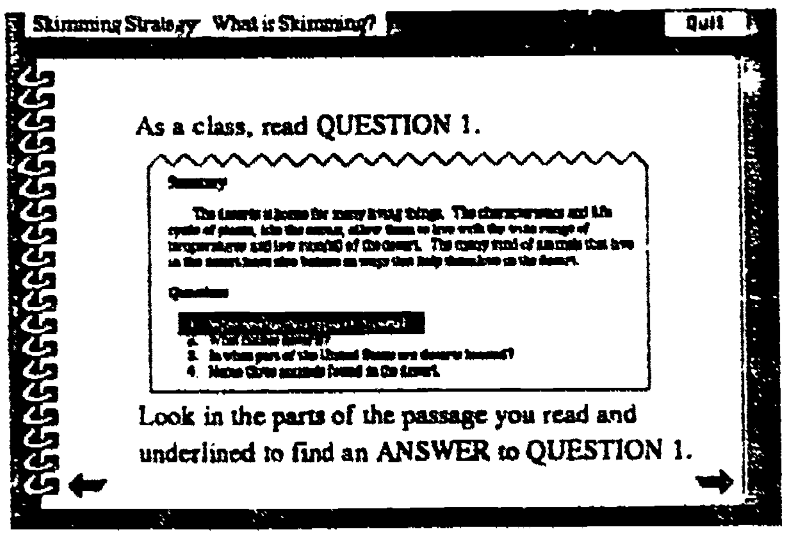

Skimming Strategy: What is Skimming?
Quit
Draw a line under what you read.

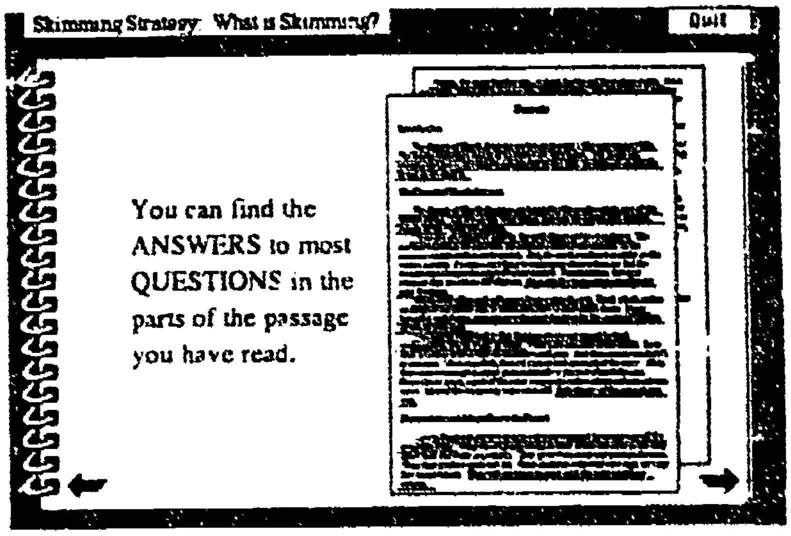

Skimming Strategy: What is Skimming?
Quit
Now, as a class, read and draw a line under the FIRST and LAST sentences of all remaining paragraphs.

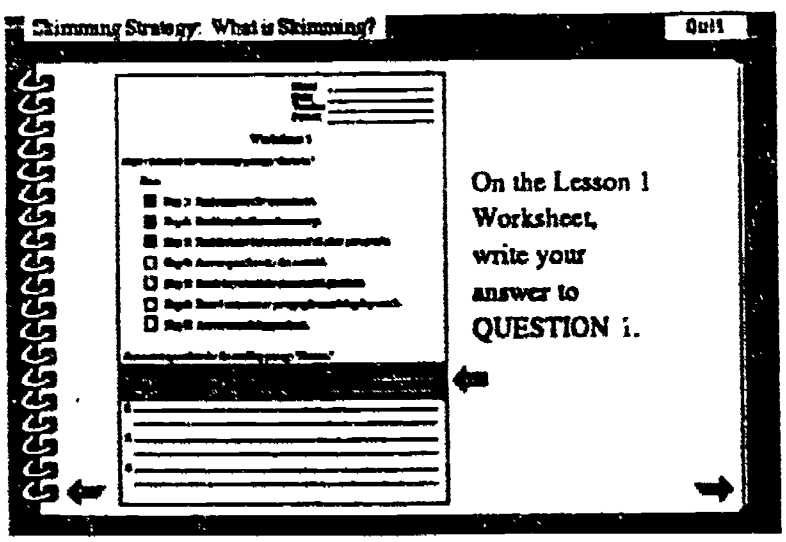

Skimming Strategy: What is Skimming?
Quit
You read the FIRST and LAST sentences to get the most important DETAILS about the topics covered in the passage.

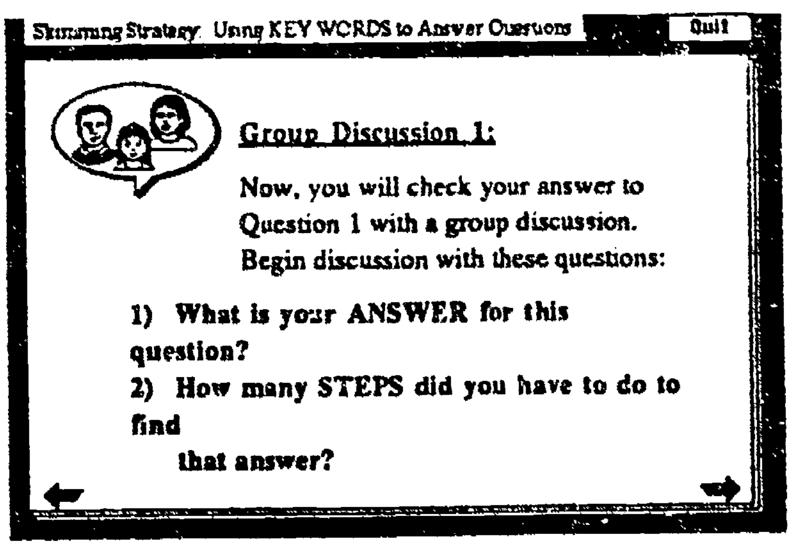

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, check the box to show you have done Step 3.

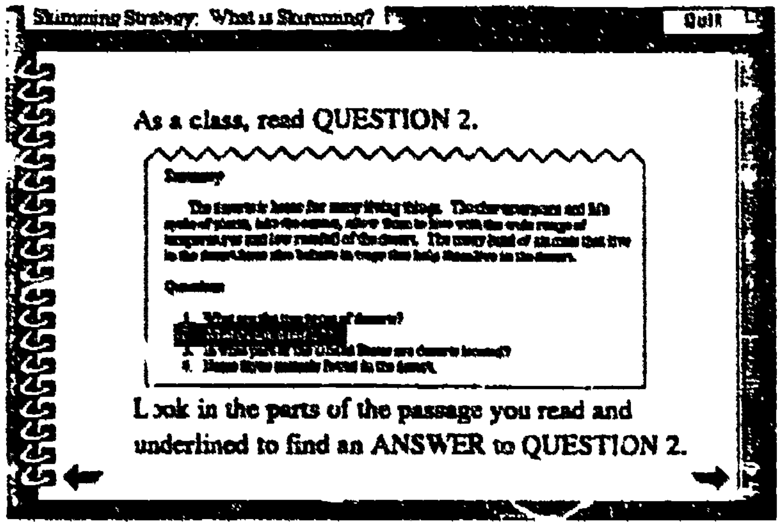

Skimming Strategy: What is Skimming?
Quit
The fourth step of the Skimming Strategy is:
4) ANSWER QUESTIONS for the material.

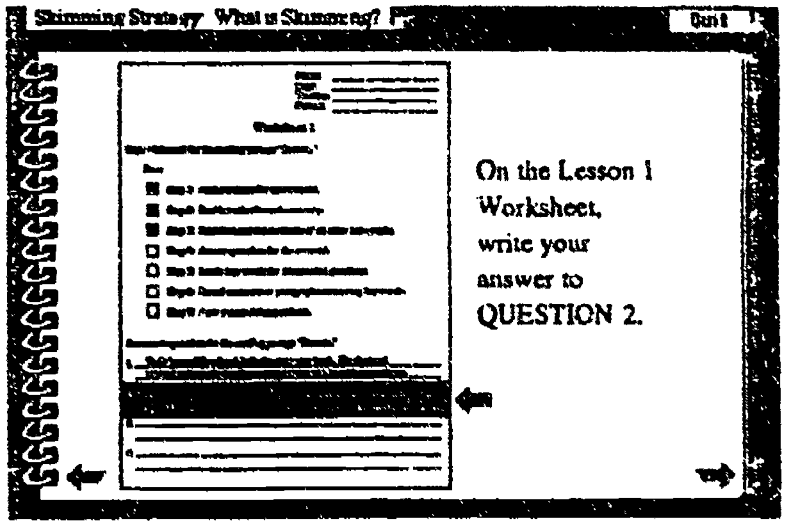

Skimming Strategy: What is Skimming?
Quit
As a class, read QUESTION 1.
Look in the parts of the passage you read and underlined to find an ANSWER to QUESTION 1.

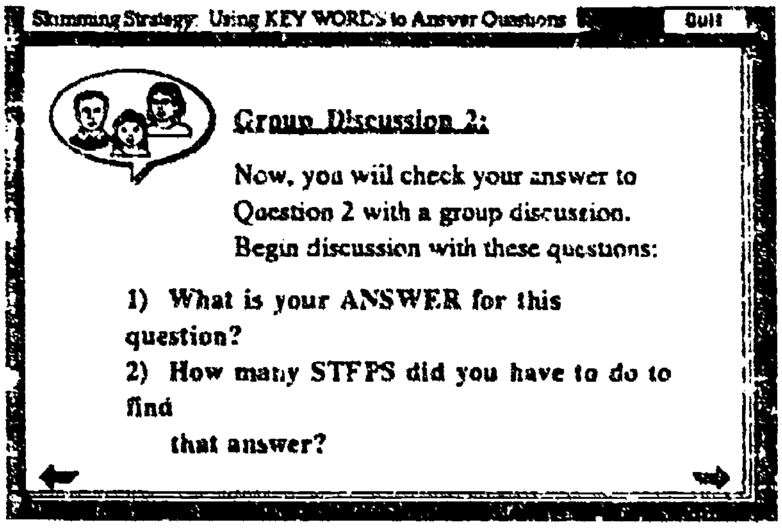

Skimming Strategy: What is Skimming?
Quit
You can find the ANSWERS to most QUESTIONS in the parts of the passage you have read.

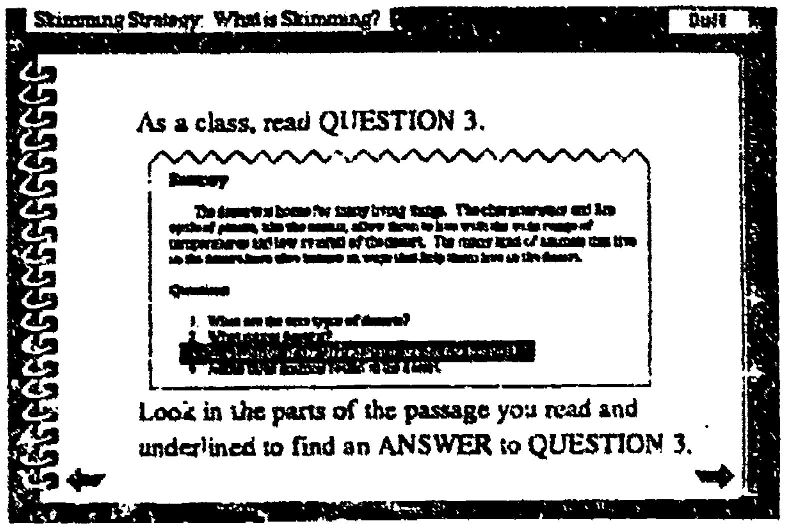

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, write your answer to QUESTION 1.

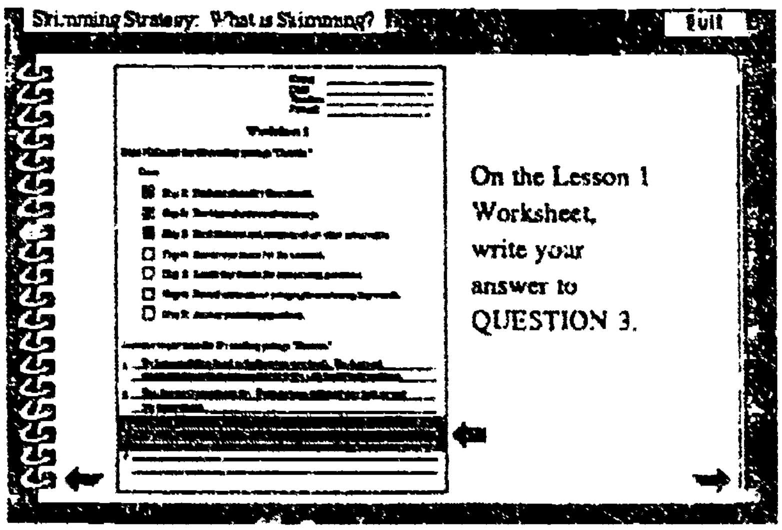

Skimming Strategy: Using KEY WORDS to Answer Questions
Quit
Group Discussion 1:
Now, you will check your answer to Question 1 with a group discussion. Begin discussion with these questions:
1) What is your ANSWER for this question?
2) How many STEPS did you have to do to find that answer?

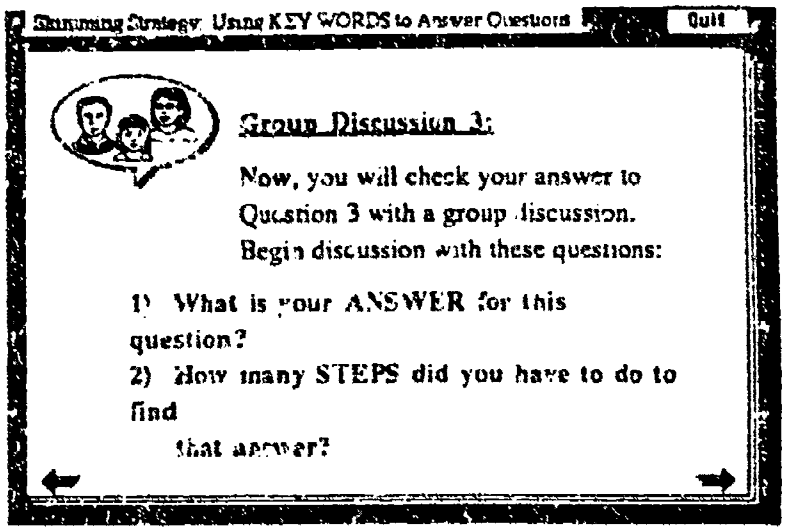

Skimming Strategy: What is Skimming?
Quit
As a class, read QUESTION 2.
Summary
Questions
Look in the parts of the passage you read and underlined to find an ANSWER to QUESTION 2.

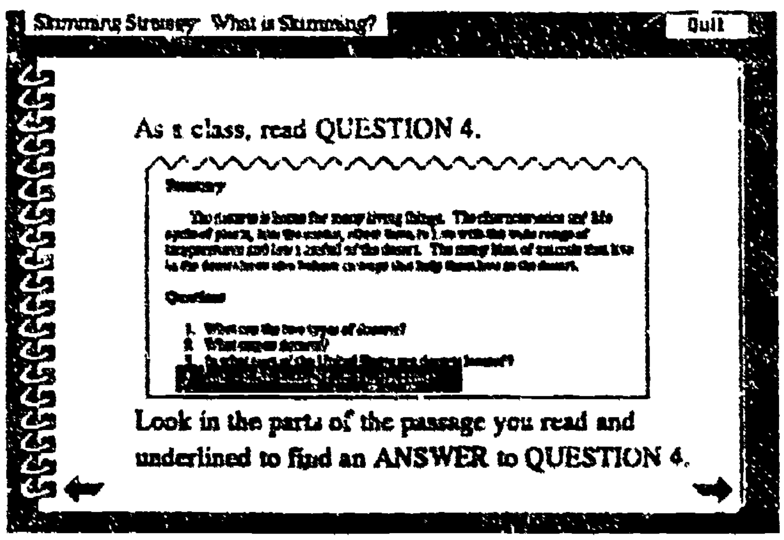

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, write your answer to QUESTION 2.

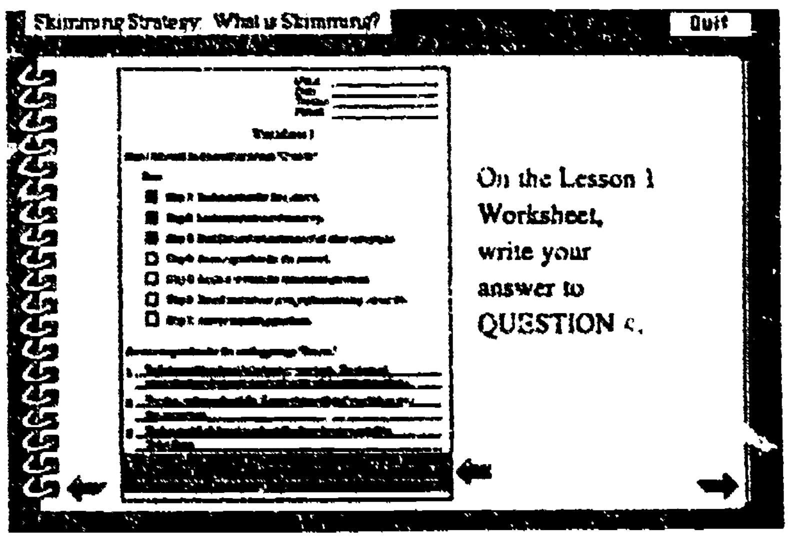

Skimming Strategy: Using KEY WORDS to Answer Questions
Quit
Group Discussion 2:
Now, you will check your answer to Question 2 with a group discussion. Begin discussion with these questions:
1) What is your ANSWER for this question?
2) How many STEPS did you have to do to find
that answer?

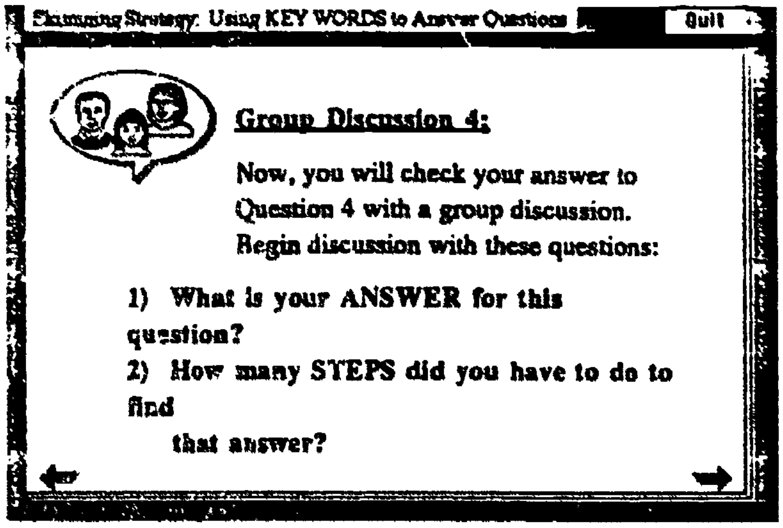

Skimming Strategy: What is Skimming?
Quit
As a class, read QUESTION 3.
Summary
Questions
Look in the parts of the passage you read and underlined to find an ANSWER to QUESTION 3.

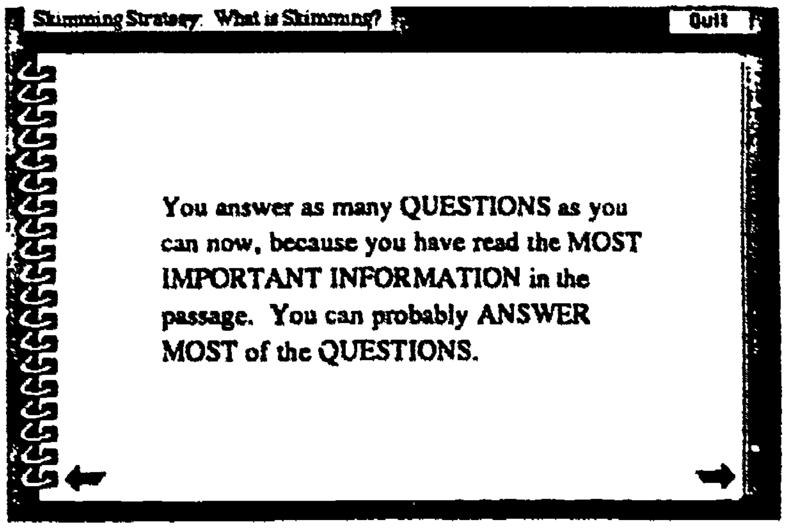

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, write your answer to QUESTION 3.

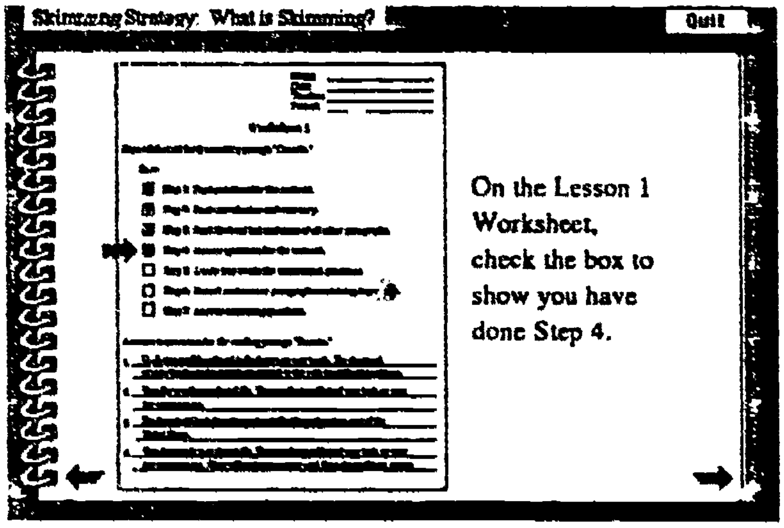

Skimming Strategy: Using KEY WORDS to Answer Questions
Quit
Group Discussion 3:
Now, you will check your answer to Question 3 with a group discussion. Begin discussion with these questions:
1) What is your ANSWER for this question?
2) How many STEPS did you have to do to find
that answer?

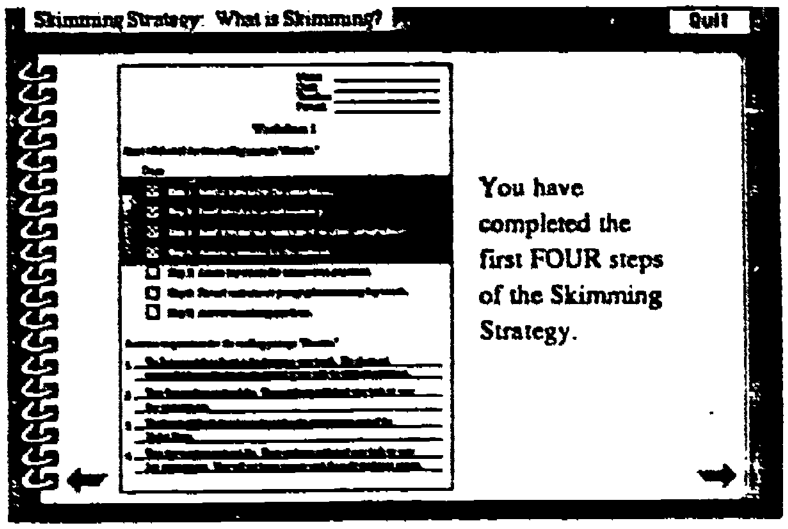

Skimming Strategy: What is Skimming?
Quit
As a class, read QUESTION 4.
Summary
Questions
Look in the parts of the passage you read and underlined to find an ANSWER to QUESTION 4.

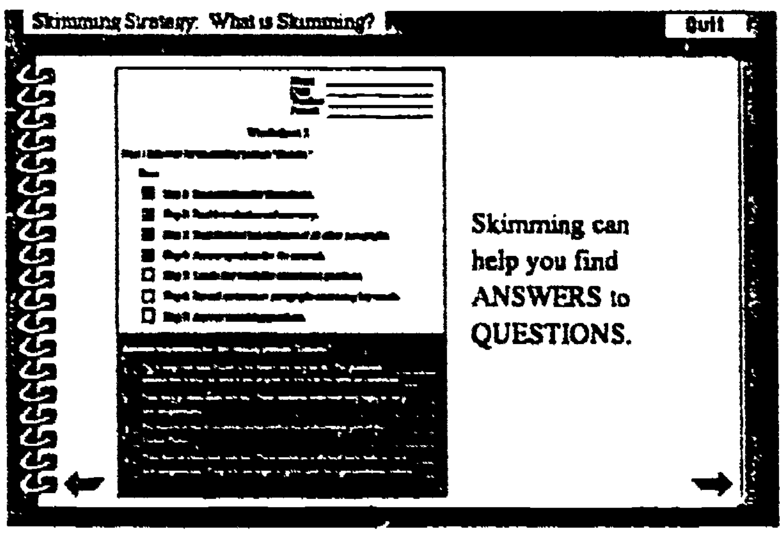

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, write your answer to QUESTION 4.

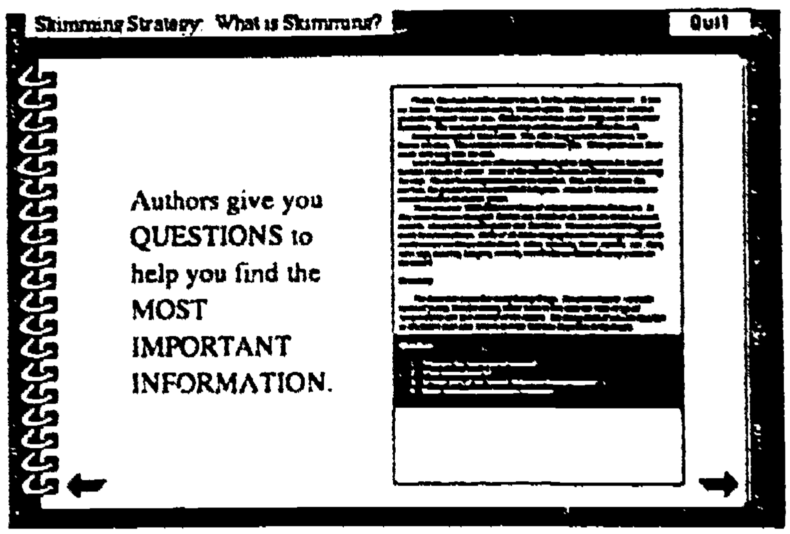

Skimming Strategy: Using KEY WORDS to Answer Questions
Quit
Group Discussion 4:
Now, you will check your answer to Question 4 with a group discussion. Begin discussion with these questions:
1) What is your ANSWER for this question?
2) How many STEPS did you have to do to find
that answer?

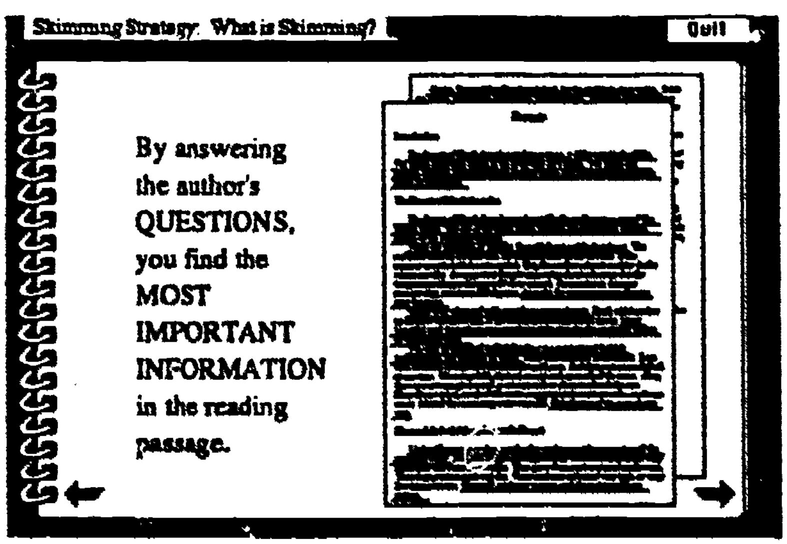

Skimming Strategy: What is Skimming?
Quit
You answer as many QUESTIONS as you can now, because you have read the MOST IMPORTANT INFORMATION in the passage. You can probably ANSWER MOST of the QUESTIONS.

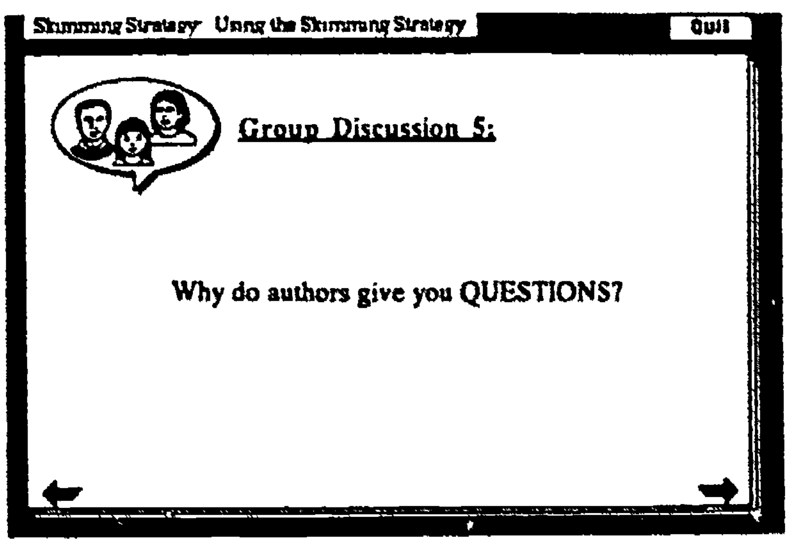

Skimming Strategy: What is Skimming?
Quit
On the Lesson 1 Worksheet, check the box to show you have done Step 4.


Skimming Strategy: What is Skimming?
Quit
You have completed the first FOUR steps of the Skimming Strategy.


Skimming Strategy: What is Skimming?
Quit
Skimming can help you find ANSWERS to QUESTIONS.


Skimming Strategy: What is Skimming?
Quit
Authors give you QUESTIONS to help you find the MOST IMPORTANT INFORMATION.


Skimming Strategy: What is Skimming?
Quit
By answering the author's QUESTIONS, you find the MOST IMPORTANT INFORMATION in the reading passage.


Skimming Strategy: Using the Skimming Strategy
Quit
Group Discussion 5:
Why do authors give you QUESTIONS?

Skimming Strategy: Using the Skimming Strategy Quit

GROUP

Discussion Answer 5:

A good answer is:

Authors give you QUESTIONS to help you find IMPORTANT INFORMATION.

Skimming Strategy: What is Skimming? Quit

Look at the passage "Deserts." You read ONLY the parts that are underlined. You DID NOT have to read the whole passage.

Skimming Strategy: What is Skimming? Quit

Because you DID NOT have to read the whole passage, you covered the material FASTER.

Skimming Strategy: What is Skimming? Quit

The Skimming Strategy helped you:

- cover reading material FASTER.
- find ANSWERS to QUESTIONS.

Skimming Strategy: Using the Skimming Strategy Quit

Group Discussion 6:

How can skimming help you?

Skimming Strategy: Using the Skimming Strategy Quit

GROUP

Discussion Answer 6:

A good answer is:

Skimming can help you:

- cover reading material FASTER and
- find ANSWERS to QUESTIONS.

Skimming Strategy: What is Skimming? Quit

Congratulations! You have finished the first lesson in the Skimming Strategy: What is Skimming?

In the next lesson, you will learn more about HOW to use the Skimming Strategy.

Give the Lesson 1 Quiz now.

QUIT

Skimming Strategy: What is Skimming? Quit

Skimming Strategy: Quit

Click on the button of your choice. Please read button operations carefully.

Cancel	Return to the previous screen
Menu	Return to Lesson Menu
Quit	Quit Hypercard

Appendix C

Sample Lesson Worksheet

Steps for Skimming

Skimming involves reading through material rapidly to locate information.

Step 1: Read questions for the material.

Step 2: Read introduction and summary.

Step 3: Read first and last sentences of all other paragraphs.

Step 4: Answer questions for the material.

Step 5: Locate key words for unanswered questions.

Step 6: Reread sentences or paragraphs containing key words.

Step 7: Answer remaining questions.

Deserts

Introduction

The deserts of North America are home to many differents kinds of life. The living conditions found in the desert are very harsh. The plants and animals that live in the deserts are adapted to live with the difficult conditions found in the deserts.

The Deserts of North America

The deserts of North America are located in the southwestern part of the United States. The are in the Great Basin, between the eastern and western ranges of the Rocky Mountains.

There are two types of deserts: the cold desert and the hot desert. The northern desert is the cold one, the southern desert is the hot one. In the summer months both deserts are hot. But, the northern desert is colder in the winter months. An important thing to remember about a desert is that the temperatire changes durong a 24-hour period. Temperatures, during a summer day, are above 100 degrees. At night, the temperature can drop to near freezing.

Winds blow often and with great force across deserts. Sand, which makes up much of the desert soil, is blown into hills of sand called dunes. Many beautiful rock formations are carved out of the stone by the sandpaper action of windblown sand.

You may be surprised to find that deserts are not caused by high temperatures, but by a lack of water. Very little rain falls in the desert. Less than 10 inches of rain falls on the desert each year. And that amount can fall all at one time. When rain falls, the land cannot soak up much of the water. Also, there are not enough decayed plant materials or plants to absorb the rain. Since the air is hot, much of the water evaporates before plants and animals can use it. Most of the remaining water runs off. Only the top of the ground gets wet.

Plant and Animal Adaptations to the Desert

Living things can survive in such a dry environment by conserving all the available water. Many desert plants complete their whole life cycle in the very short time that water is available. They grow from seeds and produce flowers. Then they produce seeds and die. These seeds can withstand very high, or very low temperatures. They will not begin to grow until the right conditions return.

Name: ______________________
Date: ______________________
Teacher: ______________________
Period: ______________________

Worksheet 1

Steps I followed for the reading passage "Deserts."

Done		
☐	**Step 1:**	Read questions for the material.
☐	**Step 2:**	Read introduction and summary.
☐	**Step 3:**	Read first and last sentences of all other paragraphs.
☐	**Step 4:**	Answer questions for the material.
☐	**Step 5:**	Locate key words for unanswered questions.
☐	**Step 6:**	Reread sentences or paragraphs containing key words.
☐	**Step 7:**	Answer remaining questions.

Answers to questions for the reading passage "Deserts."

1. ____
____

2. ____
____

3. ____
____

4. ____
____

Appendix D

Sample Lesson Content Quiz

Name: ____________________
Date: ____________________
Teacher: ____________________
Period: ____________________

Lesson 1 Quiz

1. Why do authors give you questions?

2. How can skimming help you?

Start time: ________

Finish time: ________

Name: ________________
Date: ________________
Teacher: ________________
Period: ________________

Skimming Posttest

1. How can skimming help you?

2. Why do authors give you questions?

3. Why can you answer most questions with the first four steps of the skimming strategy?

4. How are key words used in the skimming strategy?

5. Why do authors highlight words?

Appendix E

Sample Strategy Application Test

Start Time: __________

Finish Time: __________

Name: KEY
Teacher: __________
Period: __________
Date: __________

Weather

The Atmosphere

1 Earth is surrounded by a blanket of gases about 900 km thick. This is Earth's **atmosphere**. The atmosphere 2 helps to hold in Earth's heat. In addition, it protects Earth's surface from harmful rays of the sun. The atmosphere is difficult to detect on a clear day. You don't sense its presence unless the wind is blowing.

The gases of the atmosphere push down on Earth's surface with great force. Force applied on a given area of surface is called *pressure*. The force exerted by the 3 atmosphere on a given area of Earth's surface is called **atmospheric pressure**, or air pressure. Atmospheric pressure at Earth's surface is sometimes referred to as *one atmosphere* of pressure.

You notice differences in air pressure when it changes rapidly. Think of what happens when you are on a fast-moving elevator. The plugged-up feeling in your ears is caused by a change in air pressure. Air pressure decreases as height above Earth's surface increases. The low pressure at high altitudes makes it necessary for airplanes to have pressurized cabins.

Atmospheric pressure is measured with an instrument called a **barometer**. In the 1600's, Otto von Guericke made a giant barometer to demonstrate air pressure. He attached a 10-m pipe almost full of water to the side of his house. The bottom of the pipe was in a tub of water. When air pressure increased on the water in the tub, the water rose in the pipe. When the pressure decreased, the level in the pipe dropped. Von Guericke tried to predict weather as the water-level rose and fell.

Scientists have found that the atmosphere consists of several layers. The layers differ in such physical properties as pressure and types of gases. The most significant characteristic of each layer, however, is its pattern of temperatures.

The layer of the atmosphere closest to Earth is called the **troposphere**. It contains about 90% of the total mass of the atmosphere. The troposphere is about 16 km thick at the equator. It thins toward the poles. The temperature of the troposphere is highest at Earth's surface. It decreases gradually with height. The lowest temperature in the troposphere is found at its upper boundary--the *tropopause*.

Almost all of Earth's weather occurs in the 4
troposphere. For this reason, it is the part of the atmosphere that has the most noticeable effect on our daily lives.

The layer above the troposphere is called the **stratosphere**. The stratosphere begins about 16 km above the Earth's surface. It is about 32 km thick. In this layer there is a steady increase in temperature due to the absorption of high-energy ultraviolet rays from the sun. (Ultraviolet rays are invisible rays with higher energy than visible light.) You may have heard of the **ozone** layer. This is the part of the stratosphere where absorption of ultraviolet rays occurs. The ozone layer is a broad band of gas that extends through most of the stratosphere. A molecule of oxygen is made up of two atoms of oxygen. When oxygen molecules are hit by ultraviolet rays, they break apart into separate oxygen atoms. Some of these atoms then combine with other oxygen molecules, forming ozone, which has three atoms of oxygen.

Scientists worry that the **ozone layer** can be destroyed by some of the gases used in spray cans. Some of these gases react with ozone. This reduces the amount of ozone in the ozone layer, allowing more ultraviolet
rays to reach Earth's surface. Ultraviolet rays can be 5
harmful to living things. For example, people who are exposed to large amounts of ultraviolet rays are more likely to get skin cancer. This is one reason people are cautioned to limit exposure to the sun, or to use special lotions that block out ultraviolet rays.

The upper boundary of the stratosphere is called the *stratopause*. Beyond this the temperature decreases again. The layer above the stratosphere is called the mesosphere. In the *mesosphere* the temperature decreases to -100 degrees C. The *thermosphere* lies above the mesosphere. Here the temperature increases to several thousand degrees. Ultraviolet rays from the sun bombard the gases in the thermosphere. This ionizes (charges) them. These ionized gases form a layer within the thermosphere called the **ionosphere**. The ionosphere has electrical properties, and because of these, the ionosphere is used to relay radio communications around the world. Radio waves can be reflected off parts of the ionosphere. This allows them to travel farther around Earth.

The outermost part of Earth's atmosphere extends from about 480 km out to 960 km. This part is called the *exosphere*. There is no real boundary between the exosphere and outer space. The gas particles just get farther and farther apart. Some may be kilometers apart.

The composition of the atmosphere varies. The two lower levels (the troposphere and stratosphere) contain the mixture of gases that we call *air*. The most abundant 6 gases in air (by volume) are nitrogen (78%), oxygen (21%), argon (0.9%), and carbon dioxide (.03%). there are a number of other gases, including water vapor, in air. These gases, however, make up less than 0.1% of the air.

Air contains many solid particles also. Dust-sized bits of matter from industry and volcanic eruptions are examples. In addition, the ocean adds salt particles to the air as water evaporates from ocean spray. Substances that enter the atmosphere may travel far from their sources. They may eventually affect the weather.

Wind

Wind is air in motion. You have probably observed how changeable wind can be. Sometimes there is hardly any wind. At other times, it is difficult to move against it. Wind is something you can't see, but you can see its' work.

The major cause of wind is the unequal heating of 7 Earth. Energy from the sun is not received equally all over Earth's surface. The greatest amount of energy is received where the sun's rays striking the surface are *vertical*, that is, at right angles to the surface. A vertical ray delivers more energy per square meter of surface than does a slanting ray. As a result, areas receiving vertical rays are warmer. Because Earth's surface is curved, some places receive vertical rays while other places receive slanting rays.

Other factors also affect how much of the sun's energy is received by Earth. As the sun's energy nears Earth, it is affected by the atmosphere. Some energy is reflected back by clouds. Some is absorbed in the stratosphere or by water vapor in the troposphere. And some is scattered by dust particles in the air. A little less (8) than half of the sun's energy that reaches the atmosphere arrives at Earth's surface.

Some heat is added to the atmosphere by the ground. Energy from the sun comes to the surface of Earth in short, high-energy waves. These are absorbed by the ground. Earth, in turn, radiates long, low-energy waves back to the atmosphere. In this way, the ground adds a small amount of energy to the atmosphere. The long-wave energy radiated by Earth is absorbed by carbon dioxide in the atmosphere. The "trapped" energy causes the atmosphere to become warmer. This is called the greenhouse effect, because greenhouses work on the same principle. The greenhouse effect keeps Earth, warmer (9) than it would be without an atmosphere.

As a result of unequal heating, air is warmer in some places than in others. Warm air expands, becomes less dense, and rises. Cooler air then flows in to replace the warm air. The result is wind. The warmer air cools as it rises, becomes denser, and sinks again. This motion of air is called a *convection current* or *cell*. The principle of convection is used in some heating systems in homes.

A common example of local air convection cell occurs along the seashore. Land heats up faster in the daytime than water does. During the day, warmer air (10) over the land rises and flows toward the water. Cooler air from over the water flows in to replace the warm air. The result is a cool onshore breeze, or *sea breeze*. At night, the reverse takes place. Land cools more rapidly than water. The warmer air over the water rises and moves toward the land. Cooler air from the land flows in to replace the warm air. The result is an offshore breeze, or *land breeze*.

Wind Patterns

If Earth were not rotating, air heated at the equator would rise, spread toward each pole, and sink as it cooled. Cool air would then move along the surface toward the equator. The winds at the surface would always be from the north or south. However, Earth's rapid rotation from west to east affects air currents. Earth's rotation causes air to be deflected in a clockwise direction in the Northern Hemisphere and in a counter-clockwise direction in the Southern Hemisphere. This change in the 11
path of movement caused by Earth's rotation is called the **Coriolis effect.**

In the region between 30 degrees N and 30 degrees S the surface winds are mostly from the east. These are the *trade winds*, or tropical easterlies. Between 30 degrees N and 60 degrees N and 30 degrees S and 60 degrees S, the surface winds are from the west, the so-called *prevailing westerlies*. Finally, between 60 degrees N and 90 degrees N and 60 degrees S and 90 degrees S, the winds are from the east - *polar easterlies*. This is the global pattern of winds on Earth. Notice that winds are named according 12
to the direction *from which* they blow.

Warm air rises because it is less dense than cool air. Cooler air, being more dense, exerts a higher pressure than warm air. Thus, when cool air flows in to replace rising warm air, the air flow is from a region of higher pressure to a region of lower pressure. Regions of high and low pressure, caused by unequal heating of the atmosphere, determine which way the wind will blow.

Wind blowing outward from a high pressure area in the Northern Hemisphere is deflected by the Earth's rotation. The wind moves clockwise. Wind blowing inward around a low pressure area in the Northern Hemisphere is deflected in a counterclockwise direction. (In the Southern Hemisphere, these directions are reversed.) The greater the difference in pressure and the closer these systems are together, the faster the winds will blow.

High above Earth's surface are upper-level winds 13
called **jet streams.** These are about 10 km above Earth's surface in the middle latitudes. The jet streams are caused by extreme differences in pressure at this level of the

atmosphere. The major jet streams in the Northern Hemisphere blow from west to east.

High level winds in the atmosphere are not slowed down by contact with Earth's surface. The air is less dense at this altitude, so winds can reach very high speeds--as great as 400 to 500 km/h.

By observing the path of a jet stream, *meteorologists* (14) (scientists who study the weather) can predict the paths of highs and lows on the surface. High pressure areas, or *highs*, on the ground are usually under highs at upper levels. Low pressure areas, or *lows*, on the ground are under lows in a jet stream. Pressure systems on Earth's surface behave like shadows of the jet streams above them.

Clouds and Precipitation (15)

Clouds form when warm, moist air rises. As it rises, the warm air expands and cools. As air cools it loses its ability to hold water vapor. As warm, moist air rises and cools, it reaches a temperature called the **dew point**. At this point the water vapor it is holding starts to *condense*, or change to liquid water. Water condenses on a solid surface. (You may have seen this happen on the outside of a glass of cold water.) Water in the atmosphere condenses on dust of salt particles. These are called **condensation nuclei**. Clouds are made of billions of water droplets that have condensed out of the air.

There are many different kinds of clouds, but they are classified into three main types. **Stratus clouds** are (16) layered clouds that usually cover the whole sky. **Cumulus clouds** are billowy clouds that look like huge heaps of cotton. **Cirrus clouds** are high, thin, wispy clouds.

Once you know the three main cloud types, a few other terms are all you need to help you name clouds. For example, *nimbus*, which is Latin for "rain," can be added to cloud names. *Cumulonimbus clouds*, also called (17) *thunderheads*, are huge, towering clouds that form when a cumulus cloud expands into a vertical rain cloud. Cumulonimbus clouds bring winds, lightning, showers, and sometimes hail. *Nimbostratus clouds* are sheetlike clouds that usually bring rain. The prefix *alto* is often used to identify clouds of intermediate height. *Altostratus* and *altocumulus* are "middle-level" clouds. The term is used to describe stratus clouds at ground level is *fog*.

Cloud droplets are very tiny. It takes a million cloud droplets to make one raindrop! When enough cloud droplets accumulate, a drop becomes heavy enough to fall as *precipitation*.

The kind of precipitation that falls depends on four major factors: the type of cloud from which it falls, the temperature of the cloud, the temperature of the air through which it falls, and the temperature of the ground.

Rain is probably the most common form of precipitation. It can fall from any cumulonimbus or nimbostratus cloud. *Sleet* is rain that has fallen through a cold layer of air and is frozen by the time it hits the ground. Sleet usually originates in high stratus clouds. *Drizzle* is the slow fall of very tiny drops of water. They sometimes stay suspended in the air as a mist. Drizzle forms in low-lying stratus clouds. If the temperature of the ground is below freezing, the drizzle freezes as it hits the ground.

20 18

If the clouds are high and cold enough, the water freezes in the cloud and starts out as *snow*. If it melts on the way down, it lands as rain. If the temperatures are low enough all the way down, the precipitation remains snow.

Hail is another form of frozen precipitation. It usually accompanies thunderstorms and comes from cumulonimbus clouds. If the clouds are piled up extremely high, the winds inside the cloud form strong convection cells. In these cells, raindrops are lifted to heights where it is so cold they freeze into hailstones. Hailstones can be tossed up and down within the cloud many times. They pick up layers of ice as they move. When they get heavy enough, they fall. The largest recorded hailstone was 19 cm in diameter, about the size of a volleyball. A hailstorm can do a tremendous amount of damage in a few minutes. Hailstorms often flatten growing crops such as grain. 19

The amount of precipitation varies around the world. Some places, such as the Atacama Desert in Chile, have never recorded any rainfall. In contrast, Mt. Waialeale in Hawaii receives about 1200 cm each year!

Questions

1. What is the atmosphere?
2. Name two ways the atmosphere effects Earth?
3. What is atmospheric pressure?
4. In what layer of the atmosphere does weather occur?
5. How could a change in the ozone layer affect life on Earth?
6. What is the most abundant gas in the air?
7. What is the major cause of wind?
8. About how much of the sun's energy that reaches Earth's atmosphere actually arrives at Earth's surface?
9. What does the greenhouse effect do to the temperature of Earth?
10. Describe the cause of a seabreeze.
11. What is the name for the change in the path of movement of air caused by Earth's rotation?
12. How are winds named?
13. What are jet streams?
14. How does knowing the path of a jet stream help weather prediction?
15. What causes a cloud to form?
16. What are the three main types of clouds?
17. What is another name for a cumulonimbus cloud?
18. What is the difference between sleet and snow?
19. What kind of cloud produces hail?
20. What kind of cloud produces drizzle?

Name: __________
Teacher: __________
Period: __________
Date: __________

Answer Sheet for Weather

1. __________

2. __________

3. __________

4. __________

5. __________

6. __________

7. __________

8. __________

9. __________

10. __________

11. ____

12. ____

13. ____

14. ____

15. ____

16. ____

17. ____

18. ____

19. ____

20. ____

Theme #6

Skimming Answers: Weather

1. **What is the atmosphere?**

   A blanket of gases around Earth.

2. **Name two ways the atmosphere effects Earth?**

   Holds in heat.

   Protect's Earth's surface from harmful rays.

3. **What is atmospheric pressure?**

   The force exerted by the atmosphere on a given area of Earth's surface.

4. **In what layer of the atmosphere does weather occur?**

   In the troposphere.

5. **How could a change in the ozone layer affect life on Earth?**

   Any one of the following:

   1. By allowing more ultraviolet light to reach Earth's surface.
   2. Ultraviolet light can be harmful to living things.
   3. Can cause skin cancer.

6. **What is the most abundant gas in the air?**

   Nitrogen.

7. **What is the major cause of wind?**

   Unequal heating of Earth's surface.

8. **About how much of the sun's energy that reaches Earth's atmosphere actually arrives at Earth's surface?**

   A little less than half.

9. **What does the greenhouse effect do to the temperature of Earth?**

Keeps Earth warmer.

10. **Describe the cause of a seabreeze.**

Primary answer: Land heats up faster than water.

OK if further explanation included: Air rises over the land and goes toward the water. Cooler air flows in from over the water to replace the warm air.

11. **What is the name for the change in the path of movement of air caused by Earth's rotation?**

Coriolis effect.

12. **How are winds named?**

According to the direction from which they blow.

13. **What are jet streams?**

Upper level winds.

14. **How does knowing the path of a jet stream help weather prediction?**

By knowing the path of the jet stream, scientists can predict the paths of highs and lows on the surface.

15. **What causes a cloud to form?**

Clouds form when warm, moist air rises.

16. **What are the three main types of clouds?**

Stratus, cumulus, cirrus.

17. **What is another name for a cumulonimbus cloud?**

Thunderheads.

18. What is the difference between sleet and snow?

Sleet is rain that has fallen through a cold layer of air and is frozen by the time it hits the ground. Snow happens when water freezes in the clouds. Also: Snow starts in the clouds.

19. What kind of cloud produces hail?

Cumulonimbus.

20. What kind of cloud produces drizzle?

Drizzle comes from low-lying stratus clouds.

Comes from stratus clouds.

Comes from low-lying clouds.

Appendix F

Sample Test of Metacognitive Knowledge

Name: ______________________________ Date: ____________

Teacher: ____________________________ Period: ______

Preparing for Instruction: Pretest Posttest

Study the following examples, and try to determine if each student has done everything he or she should have to properly prepare for instruction.

If a student has done everything he or she should have, circle the word "complete". If a student has not done everything he or she should have to prepare, or has done something incorrectly, circle the numbers of the activities which he or she has missed or has done incorrectly.

The four activities that should be done to prepare for class are:

1. Find out what material will be covered in class by looking at a class assignment calendar or schedule or by asking the teacher.
2. Skim to answer the questions.
3. List the key points.
4. Make up a list of questions for any material that seems unclear.

Example

****

This is how Jeff prepared for class the next day:

Jeff looked on his class assignment calendar to determine what materials to study. After skimming the materials, Jeff answered many of the questions. He then listed the key points he found in the materials. Jeff didn't have time to list his questions about the material.

What is missing? 1 2 3 4 complete

****

Exercises

****

1. This is how Ann prepared for class the next day:

Ann ask the teacher what materials to prepare for the next day. After skimming the materials, Ann answered many of the questions. Using the things she'd practiced when she learned how to summarize, Ann listed the key points of the material. She carefully listed a question about every part of the material she didn't understand.

What is missing? 1 2 3 4 complete

****

****
2. This is how Ann prepared for class the next day:

Ann wasn't sure what materials to prepare, so Ann looked at the class schedule. Ann used parts of the skimming strategy to preview the material, but didn't try to answer the questions. Ann thought about what the main ideas might be for the material but never made a list. Ann thought about things she didn't understand in the material but never made a list of questions.

What is missing? 1 2 3 4 complete
****

****
3. This is how Tom prepared for class the next day:

Because Tom didn't get along well with his teacher, Tom guessed about what materials he needed to prepare instead of asking the teacher. Tom copied the answers to the questions from a friend. Tom thought about what the main ideas might be for the material but never made a list. He carefully listed a question about every part of the material he didn't understand.

What is missing? 1 2 3 4 complete
****

****
4. This is how Bob prepared for class the next day:

Since he'd lost his class calendar, Bob ask a friend, who had his calendar, what materials to study. Bob read the materials. Bob thought about what the main ideas might be for the material but never made a list. He then listed the questions he had about the material.

What is missing? 1 2 3 4 complete
****

****
5. This is how Ann prepared for class the next day:

None of Ann's friends were sure what to study, so together they decided what to study. Ann answered many of the questions after skimming the material. Ann listed all of the key points she could. Ann thought about things she didn't understand in the material but never made a list of questions.

What is missing? 1 2 3 4 complete
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Appendix G

Student Satisfaction Questionnaire

Student Evaluation of Strategy Tutorials

Read the following statements. Circle the number to show how much you agree with them.

1. I liked the computer tutorials.

Disagree 1 ——— 2 ——— 3 ——— 4 ——— 5 **Agree**

2. I learned from the computer tutorials.

Disagree 1 ——— 2 ——— 3 ——— 4 ——— 5 **Agree**

3. I think I will use what I learned from the computer tutorials in my other classes.

Disagree 1 ——— 2 ——— 3 ——— 4 ——— 5 **Agree**

4. I would like to try more lessons like the ones I have just completed.

Disagree 1 ——— 2 ——— 3 ——— 4 ——— 5 **Agree**

Write a few sentences for each of the following:

5. The things I like most about the computer tutorials were:

6. The things that I would like to see changed were:

Appendix H

Teacher Satisfaction Questionnaire

Teacher Evaluation of Strategy Tutorials

Please consider and respond to the following questions. We will use your responses as a basis for revision of the products.

1. How did you arrange your schedule to use the computer tutorials?

2. Did you have difficulties operating the equipment? What difficulties did peer tutors have?

3. How helpful were the tutorials? How would you change them to make them more helpful?

   Please consider:

   Content appropriate?

   Appropriate reading level

   Instruction/explanation: good/bad? too much/not enough?

   Examples used: good/bad? too many/not enough?

   Questions used: good/bad? too many/not enough?

For the next two questions, a printed copy of the screens is enclosed. Please circle any screens that presented difficulty for students.

4. Which sections did you like the best? Why?

5. Which sections need improvement? Why?

6. In what way did the tutorials help in your presentation?

7. How did the students like the tutorials? Were they motivated to complete the lessons? Why, or why not?

8. If this product was available for sale, would you buy it? Why, or why not?

9. In general, were these tutorials helpful to you as a teacher? Do you see a place for them? Where and for whom?