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The effect of trial repetition and explanatory feedback in computer-assisted instruction on the science and computer attitudes and performance of less successful students in secondary science

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THE EFFECT OF TRIAL REPETITION AND EXPLANATORY FEEDBACK IN COMPUTER-ASSISTED INSTRUCTION ON THE SCIENCE AND COMPUTER ATTITUDES AND PERFORMANCE OF LESS SUCCESSFUL STUDENTS IN SECONDARY SCIENCE

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The Effect of Trial Repetition and Explanatory Feedback in Computer-Assisted Instruction on the Science and Computer Attitudes and Performance of Less Successful Students in Secondary Science

by

Bonnie Jean Myers

ABSTRACT

This study examined the effect of trial repetition and explanatory feedback in computer-assisted instruction (CAI) on the achievement, retention, and science and computer attitudes of less successful students in secondary science. The CAI programs were tutorial in nature and the curriculum content was taken from the life science area. Programs were designed based on the ID model proposed by Gagne, Wager, and Rojas using the Apple SuperPILOT authoring system.

The 184 subjects in the study were enrolled in non-Regents level science classes in a small rural high school. Subjects were randomly assigned to one of four treatment groups for CAI intervention. All groups received regular feedback in the form of positive reinforcement and knowledge of correct results. These were the feedback conditions for the control group (Group 1). Students in Group 2 also received trial repetition, which allowed students to "try again" if the original answer was incorrect. Students in Group 3 received explanatory feedback, which explained why the student's answers were correct or incorrect. Subjects in Group 4 received both trial repetition and explanatory feedback.

All students involved in the study were pretested using a 30-item researcher-designed science content test and computer and science attitude scales. After three CAI instruction sessions, students were given an achievement posttest that was similar to the pretest. Nine days later they were given a second posttest to measure retention.

Three MANOVAs were performed for achievement, retention, computer attitude, and science attitude by treatment group, sex, and ability level. Data was examined for significance of main effects and interactions. No significant difference was found between the achievement, science and computer attitudes, or retention of students in the four treatment groups. Significant interactions were found between group, sex, and ability level for both computer attitude ($p = .016$) and science attitude ($p = .028$).

In summary, trial repetition and explanatory feedback were not found to be significant in facilitating achievement and retention or in promoting positive science or computer attitudes of less successful students in secondary science.

DEDICATION

For Richard and Scott

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This has been the most arduous endeavor that I have yet undertaken in my professional career. Of course, it would never have reached fruition without the assistance and guidance of some of the most dedicated and knowledgeable professionals I have ever met. Dr. Ted Bredderman, Dr. Robert Bangert-Drowns, and Dr. Vick Kouba served on my committee. Without them, this piece of research would never have been and I am deeply grateful for the encouragement and advice they have given me. They have each made a unique and important contribution to the continually evolving process that resulted in the final end-product. I especially want to thank Dr. Bredderman for acting as the chair of my committee, Dr. Bangert-Drowns for giving me a new purpose and direction when I reached a standstill, and Dr. Kouba for the marvelous year I spent working with her during my residency.

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CHAPTER I

Introduction

Behaviorism has fallen on hard times due to the rise of cognitive psychology as the dominant paradigm for learning theory in the 1970s (Sprague, 1981; Gagne, 1982; Wittrock & Lumsdaine, 1977). Instructional design has been particularly affected by this shift in educational learning theory since certain aspects of instructional design have emerged from past behavioristic research. Feedback is one remnant from behavioral learning theory. In the 1960s, operant psychologists supported the principle of immediate feedback following a correct stimulus-response bond as a means of positive reinforcement (Cohen, 1985). Subsequent research has focused on a comparison of the reinforcing function of feedback to its function of providing information for correction of learners' errors (Anderson, Kulhavy, & Andre, 1972; Bardwell, 1981; Roper, 1977). Results of research from both cognitive learning theory and instructional design theory indicate that feedback, in a cognitive context, must do much more than provide knowledge of results. Further clarification of how feedback functions in computer-assisted instruction is necessary in order to design software that maximizes the ability of the computer to provide learner feedback (Roper, 1977).

Background of the Problem

At the end of the 1970s the National Science Foundation (NSF) initiated three national studies on the status of pre-college education in the United States (Panel on School Science, 1979). Results of these studies were alarming, revealing a national decline in the quality of mathematics and science education. State legislators and other groups concerned with the quality of education in the United States responded by increasing demands for generalized educational accountability (National Science Teachers Association, 1985).

In June of 1979, the Panel on School Science of the National Research Council issued *The State of School Science: A Review of the Teaching of Mathematics, Science and Social Studies in American Schools, and Recommendations for Improvements*. Part of the Panel's review was devoted to reacting to a national move toward increasing educational accountability in the United States. According to the Panel's review 10 years ago, 75 % of the states had already adopted some form of minimum competency legislation in basic skill areas. Science is one of these basic skill areas and New York State is one state that has moved in this direction. The instructional problems facing educators in New York State are similar to those of educators in other states that are presently administering or are planning to administer a science competency examination.

In April of 1984, the New York State Board of Regents published a document that reflected two and one-half years of planning for improvement of education in New York State (The State Education Department, 1984). This document outlined the steps to be taken to achieve the stated RAP goals in New York State. An important repercussion of the Regents Action Plan was the implementation of a new Regents Competency Test (RCT) in science, which was first administered in June of 1988. Only those students who did not take and pass a science Regents examination had to take the new science RCT to be eligible for a high school diploma. This group of students, comprised of those assigned to non-Regents science courses (primarily in grades 9 and 10) or those who failed a Regents examination in science, has traditionally been less successful in science than their peers.

All students who failed the RCT must be provided with appropriate remedial instruction (Reynolds, 1986). Such remediation is difficult to administer due to the design of the science program upon which the RCT is based. The RCT covers science content that is contained in ten separate syllabus blocks taught in grades 7-9. Schools have the option of designing their own 7th, 8th, and 9th grade science programs to teach the content and science skills in the blocks. The syllabus blocks may be presented in any order in grades

7-9. Thus, there may be tremendous variability in the content and the skills of the science programs offered from one school district to another. To ensure success of students on the RCT, at least part of the ninth grade program must be designed to provide review of both the science content and science process skills contained in the ten syllabus blocks for middle/junior high school. The situation is complicated by the nature of the student population involved, which is a heterogeneous group of students who vary in academic ability, learning and retention rates, attitudes toward school, science, and computers, and ability to remain on-task. These less successful children have the poorest retention rates and do not traditionally do well on tests (McKinney & Feagans, 1983).

One possible solution to these problems is to utilize the strengths of microcomputers to develop supplemental programs to review science content and science skills for this target population. Many characteristics of microcomputers are beneficial for use with children with learning problems (Boettcher, 1983; Armstrong, Henson, & Savage, 1985). One of the most notable advantages of using microcomputers with this target group of children is the degree of individualization obtainable (Price & Marsh, 1985; Kolich, 1985; Friedman & Hofmeister, 1984; Whiting, 1985; England, 1985; Lawton & Gerschner, 1982; Tindall, 1984; Hannaford, 1983; Hazen, 1985). Microcomputers allow for one-to-one instruction (Hazen, 1985) and supplemental instruction for high or low ability students and drill-and-practice and tutorial instruction for low ability students (Kolich, 1985). Microcomputers can supply individualized instruction for large numbers of students (Whiting, 1985) while providing an interactive environment (Hannaford, 1983; England, 1985). According to Hazen (1985), the interaction feature is the most important characteristic of instructional computing software. Microcomputers allow students to be self-pacing (Rosegrant, 1985; Kolich, 1985; Salend & Salend, 1985), are highly motivating (Kolich, 1985; Torgesen & Young, 1983; Geoffrion, 1983), and are non-threatening (Rosegrant, 1985; Dalton & Hannafin, 1985; Hazen, 1985). Computers have infinite patience (Kolich, 1985; Deitel, 1984; Lawton & Gerschner, 1982) and increase on-task behavior (Kolich, 1985). The use of feedback in computer-assisted instruction has been especially recommended for use with children with learning problems (Boettcher, 1983; Mercer & Mercer, 1985).

Purpose

The purpose of this study was to determine if trial repetition and explanatory feedback in computer-assisted instruction would have greater effects on achievement and science and computer attitudes of less successful students in secondary science than computer-assisted instruction that lacks these conditions of feedback.

It is difficult to interpret results of prior feedback research because few studies are replications and many factors of feedback have been researched with conflicting results. Feedback has also been defined differently in the research literature because it can have both an informational and a motivational role in instruction. Results of a meta-analysis of feedback effects done by Getsie, Langer, and Glass (1985) showed that the value of feedback is more informational than motivational. Motivational feedback, which is concerned with encouraging the persistence of new behaviors, has been referred to as reinforcement (Kowitz & Smith, 1985).

In this study, positive reinforcement was a constant; subjects in all four treatment groups received identical statements for positive reinforcement of correct responses. Explanatory feedback was a form of informational feedback that provided the learner with an explanation for the correctness or incorrectness of the response. Trial repetition feedback allowed the learner to try again if the initial response was not correct. This provided some learners with additional information about the nature of the response.

Theoretical Framework

Feedback in a Behavioral Context

The definition of feedback in a behavioral context was synonymous with reinforcement and was based on operant conditioning theory. Skinner used the term reinforcement to describe any behavioral consequence that strengthens behavior (Bell-Gredler, 1986) and can be detected by noting an increase in response rate. In this context, reinforcement was widely extended to explain student behavior. Primary, secondary, positive, and negative reinforcers were identified (Skinner, 1953), and these concepts were used to modify student behavior in the classroom.

Gilman (1969) noted that using knowledge of results (KOR) as a feedback mode is based on the principle of reinforcement. Such reinforcement of correct results was thought to enhance learning and strengthen the behavior. Programmers who design instructional materials that just provide knowledge of results feedback are proponents of behavioral theory who believe that reinforcement occurs when the learner's response is correct. Not all research has supported the concept of feedback following positive responses as being reinforcing for the learner (Anderson, Kulhavy, & Andre, 1972; Kulhavy, 1977; Roper, 1977; Bardwell, 1981).

Feedback in a Cognitive Context

Gagne (1982) noted that the feedback aspects of the behavioral view of learning still remain current. Cognitive learning theorists refer to the feedback for a response as being reinforcing; this is still accepted as a necessary condition of learning. Estes (1978) related reinforcement to confirmation of the learner's expectancy. Gagne (1982) believes that the expectancy described by Estes is confirmed when learners are informed of the instructional objectives at the beginning of the program.

Instructional Design Theory

Psychologists and educators have shown an increasing interest in cognitive processes over the past twenty years (Vander Zanden & Pace, 1984). Reif (1987) stated that "the effective educational use of information technologies depends crucially on good instructional design based on an adequate understanding of cognitive processes (p. 309)." Research results have been utilized to develop guidelines for effective instructional design of microcomputer software (Jay, 1983).

Gagne (1977) developed the nine stages of processing (phases) that are essential to learning. These gave rise to the principles of instruction (Bell-Gredler, 1986) and specific guidelines for CAI authoring (Gagne, Wager, & Rojas, 1981). Two of Gagne's stages of processing are reinforcement and cueing retrieval. In CAI, reinforcement is augmented by providing information feedback. This includes giving answers to questions and using encouraging statements (Gagne, Wager, & Rojas, 1981). Cueing retrieval is augmented by assessing student performance and reporting the score.

Trial Repetition and Explanatory Feedback

One of the advantages of using microcomputers for instruction of children with learning problems is the ability to provide immediate feedback (Wallace & Kauffman, 1978; Boettcher, 1983; Deitel, 1984; Donhardt, 1984; Mercer & Mercer, 1985). Wallace and Kauffman (1978, p. 91) demonstrated that "children must be informed frequently, immediately, and clearly of the adequacy of their performance" in order to learn efficiently. To be most effective, feedback should be specific (Gronlund, 1981) as well as immediate. Explanatory feedback provides specific feedback to the learner for both correct and incorrect responses. If the response is correct, the learner is told why it is correct and if the response is incorrect the learner is told why the response is incorrect.

Orwig (1983) recommended repeating the correct answer as reinforcement in feedback. Trial repetition provides the learner with an opportunity to try again if an initial response is incorrect. Subjects who received repeated feedback in a study done by Lhyle and Kulhavy (1987) showed the greatest probability of correcting instructional errors.

Definition of Terms

The independent variable in this study was the type of treatment. Four intervention groups were established: Group 1 lacked trial repetition and explanatory feedback; Group 2 had trial repetition but lacked explanatory feedback; Group 3 had explanatory feedback but lacked trial repetition; and Group 4 had both trial repetition and explanatory feedback. Dependent variables were measures of science and computer attitudes and performance (achievement).

Carter (1984) classified feedback variables into four groups:

<u>timing</u>: Timing of feedback is either immediate or delayed.

<u>scheduling</u>: Scheduling of feedback varies according to whether it is provided following correct responses, incorrect responses, or both.

<u>function</u>: The function of feedback is either reinforcing or informational.

<u>type</u>: The type of feedback deals with the nature of the corrective message provided to the learner.

Type of feedback served as the treatment variable in the present study. Programs differed in the presence or absence of trial repetition and explanatory feedback. Timing, scheduling, and function were constant for the four treatment groups in this study. Specifically, all of the computer programs provided: a) immediate feedback item-by-item with a 0-second time delay; b) knowledge of correct results feedback for both incorrect and correct responses; and c) identical positive reinforcement statements. A more detailed explanation of the feedback variables incorporated into the design of the four types of computer programs used in the study is found in Chapter III.

<u>Explanatory feedback</u> is defined in this study as feedback for correct responses that tells why the response is correct, and feedback for incorrect responses which explains why the response is incorrect. Explanatory feedback is different from providing just knowledge of results (KOR) which contains a message that tells the student whether the answer is correct or incorrect. It is also different from knowledge of correct results (KCR) which tells

the student the correct answer if his/her response is incorrect.

Trial repetition is defined in this study as the provision of the opportunity for the learner to try again if the response is incorrect. Subjects in groups receiving trial repetition were given three chances to get the right answer. If they were not successful by the third try, they were either given the correct answer (Group 2) or were given the correct answer with an explanation of why the response they selected was incorrect (Group 4).

Attitude was defined as an emotional predisposition (Thornburg, 1973) of the student toward computers and science. This was measured by using a Computer Attitude Scale (Loyd & Gressard, 1984) and the Price Science Attitude Inventory (Price, 1978) to pretest and posttest all subjects involved in the study.

Performance was defined as the level of achievement on the pretest and the posttests in the science content area. Degree of success on these tasks was directly proportional to the number of science questions answered correctly. The pretest and posttests all contained thirty questions regarding knowledge of science content.

Less successful students in secondary science were defined as students enrolled in ninth and tenth grade science courses designed for students who were not recommended by their science teachers from the previous year to take a Regents science course. This group of 184 students included 103 males and 81 females from twelve science classes.

Design and Nature of the CAI Programs

Three software programs were designed for this research using an instructional design model proposed by Gagne, Wager, and Rojas (1981). The programs were tutorial in nature and incorporated eight of the nine phases identified in that model. Phase 1 involved gaining the learner's attention and introducing the directions. The learner was introduced to the instructional objectives during Phase 2. Phase 3 involved stimulating recall of prior learning and then systematically presenting the instructional content (Phase 4). Graphics were used to guide learning during Phase 5 and frequent question frames were interspersed with the instructional frames during Phase 6 to keep students actively involved. Phase 7 varied in the presence or absence of trial repetition and/or explanatory feedback which functioned as the independent variables of the study. At the end of each program, student performance was assessed through the use of a quiz consisting of 10 questions (Phase 8).

The programs used in the study were designed using the authoring system, Apple SuperPILOT. Content for the programs was selected from the General Biology syllabus developed by the Science Bureau of the New York State Education Department. Questions used for pretesting, posttesting, and program design were selected from General Biology exams that were administered from June, 1982 until June, 1986.

Description of the Study

Sample

The school system involved in this study was a rural school district with an approximate population of 200 students per grade level. It was a centralized school district with one high school (grades 9-12), one middle school (grades 6-8), and three elementary schools (grades K-5). The students chosen to participate in the study were enrolled in 12 science classes: 6 classes of Science 9, 3 classes of General Biology, and 3 classes of School Biology. The course each student was enrolled in was coded and recorded as data to be included in the correlation matrix. The original sample consisted of 184 students: 103 males, 81 females, 89 ninth graders, 76 tenth graders, 14 eleventh graders, 5 twelth graders, 29 repeaters, and 7 students identified by the Committee on

Special Education. The subjects were randomly assigned to one of four groups for intervention (N = 46). During the course of the study, 31 students were eliminated from the original sample: 14 students left either school or their science class during the study, 12 students missed either the pretest or one of the posttests, and 5 students were eliminated from the study for using disks other than those of their assigned group. The analysis sample consisted of 153 students: 89 males, 64 females, 73 ninth graders, 64 tenth graders, 12 eleventh graders, 4 twelth graders, 25 repeaters, and 4 students identified by the Committee on Special Education. Treatment groups had an unequal number of members during analysis: Group 1 = 40, Group 2 = 36, Group 3 = 38, and Group 4 = 39.

Procedures

All students were pretested using a Computer Attitude Scale (Gressard & Loyd, 1984), the Price Science Attitude Inventory (Price, 1978), and a researcher-designed content pretest. All students were assigned to the computer center for one class period of treatment for each of three consecutive weeks. The length of the treatment sessions was 42 minutes and records were kept of student time-on-task and attendance during the treatment sessions. At the end of the three-week treatment period, all students were posttested using the Computer Attitude

Scale, the Price Science Attitude Inventory, and a researcher-designed science content posttest. Nine days later, all students were again posttested using a second researcher-designed posttest of science content and the same science and computer attitude scales.

Assumptions

The first major assumption in this study was that feedback is necessary in tutorial programs for computer-assisted instruction (Anderson, Greer, & Odle, 1978; Kolich, 1985). Gaps exist in the research literature on which types of feedback are most effective for use with children with learning problems. Based on a review of the literature, feedback timing, function, and scheduling were maintained as constants in this study. The presence or absence of trial repetition and explanatory feedback served as the independent variables for this research.

A second major assumption made during the design of the programs was that the subjects had limited computer skills. The programs were designed accordingly.

A third set of assumptions were made about the nature of the programs and the treatment sessions. It was assumed that the software programs were effective instructional tools that could result in student's learning the content. Three treatment sessions were assumed to be long enough in duration to produce the desired effects. It was assumed that the students would experience the treatments in the same way except for the feedback variables. It was also assumed that the researcher could control time-on-task during intervention.

Research Questions

Questions of primary interest concerned differences in performance and science and computer attitudes on measurement instruments between students in four groups receiving treatment with or without trial repetition and/or explanatory feedback. Three research questions were formulated:

1. Is the performance of students in the trial repetition and explanatory feedback group significantly better on the achievement and retention posttests than that of students in the other three treatment groups ?

2. Are the computer and science attitudes of students in the trial repetition and explanatory feedback group significantly better than that of students in the other three treatment groups ?

3. Are the effects of combining the two feedback types in treatment cumulative ?

Further post hoc analyses resulted in the formulation of two additional research questions relating to possible effects and interactions of sex and ability level on the dependent variables. The two questions asked here were:

4. Are there significant main effects for sex and ability level for any of the dependent variables ?

5. Are there significant interactions between treatment group, sex, and ability level for any of the dependent variables ?

Hypotheses

The hypotheses tested in this study evolved from the primary research questions and a review of the literature. Research done by both Gilman (1969) and Roper (1977) indicated that subjects who received informational feedback during computer-assisted instruction performed better than subjects who only received knowledge of results. Learners also benefit from having more than one opportunity to answer a question (Jay, 1983). Allowing a learner to correct errors was part of Cohen's (1985) definition of informational feedback. Explanatory feedback and trial repetition feedback are both characteristics of informational feedback because they provide learners with more information about the correctness or incorrectness of the response.

Hypothesis 1: If the provision of more informational feedback which includes explanations and the opportunity to try again are both important feedback characteristics in computer-assisted instruction, then students in the treatment group having trial repetition and explanatory feedback should perform significantly better on the achievement posttest than students in treatment groups lacking these characteristics.

If both feedback factors have equal effects and are cumulative, students in treatment groups having either trial repetition or explanatory feedback should perform significantly better on the achievement posttest than students in the treatment group where these feedback factors are missing.

Hypothesis 2: The amount of information feedback is also an important factor affecting retention (Gilman, 1969). If this is so, students in the treatment group having both explanatory feedback and trial repetition should perform significantly better on the retention posttest than students in the treatment groups lacking these forms of informational feedback.

If both feedback factors have equal effects and are cumulative, students in treatment groups having either trial repetition or explanatory feedback should perform significantly better on the retention posttest than students in the treatment group where these feedback factors are missing.

One question being posed in research is whether achievement affects self-esteem or self-esteem affects achievement. Substantial positive relationships have been established between self-concept measures and achievement in correlational studies (Gage & Berliner, 1984). The direction of causality in such studies has not been clearly established. Willson (1983) performed a meta-analysis of research results for the correlation between science achievement and attitude. He found that this correlation remains consistently positive for students in grade 7 through grade 11. There is a higher correlation for achievement causing attitude at elementary and junior high school levels; this is reversed for the senior high level.

Hypothesis 3: If there is a correlation between student achievement and attitude, then the students who achieve better should have more positive attitudes both toward the computer and the subject matter. If the effects of more feedback are cumulative, then students in the treatment group having explanatory feedback and trial repetition should have significantly higher attitudes.

CHAPTER II

Review of the Literature

The first portion of the review of the literature focuses on Gagne's learning theories and on the guidelines of authoring computer-assisted instruction developed by Gagne, Wager, and Rojas (1981). The next portion of the review examines results of feedback research studies which used computer software as the delivery mechanism of feedback during intervention. Finally, the studies are reviewed that resulted in the development of the computer and science attitude instruments used in the present study.

Cognitive Nature of the Learner

Gagne (1977) referred to the internal states and cognitive processing of the learner as the internal conditions of learning. The outcomes of learning depend on the internal conditions of learning because each learner possesses a different set of prerequisite skills and cognitive processing steps (Bell-Gredler, 1986). The internal conditions of learning also interact with stimuli from the environment: the external events of instruction.

Gagne (1977) classified the outcomes of learning into five broad categories: verbal information, intellectual skills, motor skills, attitudes, and cognitive strategies. The relationship of Gagne's essential components of learning and instruction are summarized in Figure 1.

```
                                        -------------------------
                                           LEARNING OUTCOMES
----------------------                  -------------------------
INTERNAL CONDITIONS OF                  :                       :
      LEARNING                          :                       :
----------------------                  :  -Verbal Information  :
:                    :                  :                       :
:Internal State and  :---------->       :  -Intellectual skills :
:                    :                  :                       :
:Cognitive Process-  :---------->       :  -Motor skills        :
:                    :                  :                       :
:ing of the Learner  :---------->       :  -Attitudes           :
:                    :                  :                       :
----------------------                  :  -Cognitive Strategies:
        :                               :                       :
        :                               -------------------------
    Interaction
        :
        :
--------------------------
      ENVIRONMENTAL
         STIMULI
--------------------------
:                        :
: -External Conditions   :
:    of Learning         :
:                        :
: -Instructional Events  :
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Figure 1 . <u>Gagne's Essential Components of Learning and Instruction</u>

Guidelines for CAI Authoring

Categorizing the type of learning outcome is one of the first steps in designing computer-assisted instruction (Gagne, Wager, and Rojas, 1981). The learning outcome of the programs designed for the present study stressed the acquisition of verbal information. The emphasis was on remembering, either by recall or recognition, the terms presented in the tutorial. This encompasses Level 1 of Bloom's Taxonomy (Bloom, 1984).

Following an analysis of the task required of the learner, the next step in design of computer-assisted instruction is to proceed with a sequence of steps to present the material (Gagne, Wager, & Rojas, 1981). Gagne (1977) identified nine internal learning processes and corresponding events of instruction, and Gagne and Briggs (1979) developed a set of principles for instructional design that corresponded to the nine events of learning. In any complete act of learning, these nine events of instruction must be present although the specific displays that represent each event may vary (Gagne, Wager, & Rojas, 1981). The specific form of the nine events incorporated into computer-assisted instruction depends on the category of learning outcome being taught (Gagne, Wager, & Rojas, 1981).

The specific guidelines recommended by Gagne, Wager, and Rojas (1981) for authoring computer-assisted instruction when the outcome category is verbal information are summarized in Table 1 along with the corresponding internal learning processes and external instructional events identified by Gagne (1977). Step 7 (providing informative feedback) is still a controversial research topic. In some cases, the results of feedback research have been generalized to computer-assisted instruction without adequate empirical evidence for its incorporation. The effects of feedback with computer-assisted instruction should be specifically investigated (Carter, 1984). Gagne (1977), Gagne and Briggs (1979), and Gagne, Wager, and Rojas (1981) have provided a theoretical basis for designing computer-assisted instruction based on cognitive learning theory. It is still the task of the researcher to provide empirical data to support the generalization of principles of cognitive learning theory to instructional design theory. The nature of the informational feedback used in computer-assisted instruction has not been clearly defined by Gagne, Wager, and Rojas (1981).

Feedback Research

The research articles reviewed here all examined the effects of different types of informational feedback in com-

Table 1 Summary of Gagne's Internal Processes of Learning, the External Instructional Events Which May be used to Support Them, and Guidelines of CAI Authoring Recommended by Gagne, Wager, and Rojas (1981) for Verbal Information

Internal Learning Processes	External Instructional Events	Guidelines of CAI Authoring
1. Alertness (attending)	1. Gain Attention	1. Call attention to the screen by using visual cues, movement....present operating instructions.
2. Expectancy	2. Inform Learner of Objectives	2. State the learning objectives of what the learner will be able to do after instruction. Use simple terms.
3. Retrieval of relevant information to working memory	3. Stimulate recall of prior learning	3. Link what the learner is going to learn to what the learner already knows.
4. Selective perception of stimulus features	4. Present stimuli with distinctive features	4. Present new information to be learned systematically. Emphasize distinctive features.
5. Semantic encoding	5. Guide learning	5. Tie the new information to what the student already knows. Use concrete examples for abstract ideas. Illustrate.
6. Retrieval and responding	6. Elicit performance	6. Ask questions throughout the instructional material to keep the student actively involved.
7. Reinforcement	7. Provide informative feedback	7. Give answers to questions about correctness or partial correctness of learner's answers. Use encouraging statements.
8. Cueing retrieval	8. Assess performance	8. Present five to ten questions to test the learner's knowledge level. Report the score; if it is satisfactory, say so. If not, what next?
9. Generalizing	9. Enhance retention and learning transfer	9. Give additional linking information about the instructional content.

Compiled from information presented by Gagne, Wager, and Rojas (1981).

puter-assisted instruction. The studies reviewed varied considerably in content, sample, methods, and design. Such diversities make it difficult to interpret results in order to determine the most effective factors of informational feedback to include in design of computer-assisted instruction. The content, format, sample, methods, hardware, design, and results of the eight research studies reviewed have been summarized in Table 2.

Another major source of confusion in feedback research is the variety of definitions used in such research for intervention. The feedback treatment groups used in the eight research studies reviewed are summarized in Table 3. None of the studies used the same feedback treatment conditions for intervention.

Significant effects were found for the use of more informational feedback in computer-assisted instruction in studies done by Gilman (1969), Roper (1977), Dalton and Hannafin (1985), Geibpresert (1986), Waldrop, Justen, and Adams (1986), and Collins, Carnine, and Gersten (1987). All of these studies, except the study done by Collins, Carnine, and Gersten (1987), were done at the university level using students with presumably efficient information processing skills. The study done by Collins, Carnine, and Gersten (1987) used LD and remedial students at the secondary level.

Table 2. Summary of Research Studies Using Informational Feedback in Computer-Assisted Instruction

Researcher	Content/Format	Sample/Methods	Hardware
Gilman (1969)	30 general science concepts taught using 30 identical frames of MC questions	75 university upperclassmen; 5 Groups (N=15); Random Assortment	IBM 1410 computer; IBM 1050 teletypewriter
Roper (1977)	36 statistics concepts taught using MC format for questions	36 university undergraduates; 3 Groups (N=12); Random Assortment	Rank Xerox Sigma computer; Kode teletype terminal
Dalton & Hannafin (1985)	3 sets of 10 randomly generated MC drill and practice problems	44 8th grade mathematics students; 4 Groups; Random Assortment	Microcomputers
Geibpresert (1986)	Methods taught for solving proportion problems	73 university undergraduates; 3 Groups; Random Assortment	Not Reported
Waldrop, Justen, & Adams (1986)	Drill and practice MC questions on types of behavioral consequences	30 university undergraduates/graduates; 3 Groups; Random Assortment	Not Reported
Collins, Carnine, Gersten (1987)	Rule learning reasoning skills taught using a tutorial with 30 MC questions	28 LD and remedial students at secondary level; 2 Groups (N=14); Random assortment	Apple II microcomputers
Lhyle & Kulhavy (1987)	20 program frames on human eye; 80 words in each frame and 1 MC question	60 university undergraduates; 3 Groups; Random Assortment	Not Reported
Merrill (1987)	Xenograde terminology and concepts taught using CBE lesson	154 chemistry juniors at secondary level; 4 Groups (unequal Ns); Random assortment	Not Reported

Table 2. (Continued)

Researcher	Design	Results
Gilman (1969)	1st trial-pre.data 2nd trial-incorrect responses,how many trials; Post.=paper and pencil task	Students in treatment groups with more informational feedback performed significantly better than students in no feedback or KR feedback group.
Roper (1977)	% of correct responses recorded during treatment; 25-item parallel posttest administered after treatment	Subjects who received more informational treatment scored significantly higher on posttest; the informational feedback acted primarily to correct errors.
Dalton & Hannafin (1985)	Ss spent 90 minutes doing 3 sets of problems; data recorded; Pre and posttest for self-esteem	No significance was found between performance of high or low achievers; general trend in improvement in computer-related self-esteem.
Geibpresert (1986)	Pretest; 1 session of treatment; Posttest directly after treatment	Simplification feedback is significantly better for solving inverse proportion problems; no effect on direct proportion or transfer problems.
Waldrop, Justen,& Adams (1986)	Lecture; treatment session (40 minutes); Criterion measure test after treatment	Immediate extended feedback following correct and incorrect responses is superior to minimal feedback. Results were significant.
Collins, Carnine, Gersten (1987)	5 sessions (20-30 minutes);Posttest with Test of Formal Logic and Transfer Test	Significant effect found for elaborated corrective feedback on the immediate and maintenance posttests and the transfer posttest.
Lhyle & Kulhavy (1987)	1 session treatment followed by criterion test of same 20 MC questions in program	No significant effect found for scrambled feedback; regardless of format, feedback had a significant effect.
Merrill (1987)	1 session treatment followed by Posttest I and Posttest II	Ss in high level question group performed significantly better; no effect found for feedback type.

Table 3. Summary of Treatment Groups Used in Eight Feedback Research Studies

Researcher (Date)	Feedback Treatment Groups Established
Gilman (1969)	(1) no feedback (2) knowledge of results -"correct"/"wrong" (3) feedback of correct response (4) response-contingent feedback (5) combination of 2, 3, and 4
Roper (1977)	(1) no feedback (2) knowledge of results (3) knowledge of results plus the correct answer stated in the context of the question.
Dalton & Hannafin (1985)	(1) affirmation of response (2) affirmation of response plus positive reinforcement for correct responses (3) affirmation and negative reinforcement for incorrect responses (4) affirmation and positive and negative reinforcement
Geibpresert (1986)	(1) correct answer (2) dynamic diagram - simulated relationship between problem variables (3) simplification - step-by-step guide to helping student understand problem
Waldrop, Justen, & Adams (1986)	(1) minimal - knowledge of results (2) minimal plus extended - knowledge of results 3 times...then extended explanation of correct answer (3) extended - detailed explanation of correct answer-next example

Table 3. (Continued)

Researcher (Date)	Feedback Treatment Groups Established
Collins, Carnine, & Gersten (1987)	(1) basic feedback - correct answers given for errors (2) elaborated feedback - explanation of how to apply the rule
Lhyle & Kulhavy (1987)	(1) no feedback (2) feedback repeated (3) feedback statement scrambled
Merrill (1987)	(1) low question level with correction feedback (2) low question level with attribute isolation feedback (3) high question level with correction feedback (4) high question level with attribute isolation feedback

While the nature of the population of their sample is most similar to that of the present study, the level of the task being taught in their study involved rule learning which is is a more complex cognitive task (Gagne, 1985) than that of verbal recall or recognition.

Gilman (1969) found that students in treatment groups that received more informational feedback performed significantly better than students in treatment groups that received no feedback or only knowledge of results feedback. In Gilman's study, students at the university level were taught 30 general science concepts written in the form of multiple choice questions. Data from the first exposure of subjects to the items constituted the pretest data. In subsequent trials, students only had to respond to questions previously answered incorrectly. The number of trials performed and the results of a paper and pencil posttest were recorded for each subject. Questions in this study were at the recall/recognition level and were presented in a multiple choice format. Gilman incorporated a mastery approach in that all subjects were required to try again to correctly answer questions initially missed during treatment.

Roper's (1977) results were consistent with those of Gilman's (1969) study. Roper found that subjects who received more informational feedback scored significantly higher on the posttest than subjects receiving no feedback or knowledge of results feedback. Roper's (1977) study paralleled Gilman's (1969) study in several respects: students tested were enrolled at the university level, the nature of the computer-assisted instructional task was less complex and one treatment session was followed by a 25-item parallel posttest.

Geibpresert (1986) found that all three types of feedback were equally effective for increasing student's achievement in solving direct proportion or transfer problems but that simplification feedback was significantly more effective for increasing student achievement in solving inverse proportion problems. The nature of the population in this study paralleled that of Gilman's (1969) and Roper's (1977) studies. The nature of the task differed in that Geibpresert used computer-assisted instruction to teach university students methods for solving proportion problems. This is a higher level of cognitive processing than recall or recognition of verbal information or rule learning. The solving of problems requires the possession of intellectual skills, cognitive strategies, and a set of schemata (Gagne, 1985).

Dalton and Hannafin (1985) used 8th grade remedial mathematics students to examine the effects of four types of feedback in a drill and practice program for multiplication facts. Dalton and Hannafin found that there was no significant difference in performance of any of the feedback treatment groups but there was a general trend in improvement in computer-related self-esteem across all four treatment groups. Their combination of affirmation of response feedback with different combinations of what they defined as positive and negative reinforcement did not enhance the effectiveness of the information feedback.

Waldrop, Justen, and Adams (1986) found that subjects who received extended feedback consisting of a detailed explanation of the correct answer performed significantly better than subjects who received just knowledge of results. This study parallels those done by Gilman (1969), Roper (1977), and Geibpresert (1986) except that computer-assisted instruction was used to deliver a drill and practice program on types of behavioral consequences. A lecture session was followed by the computer session which culminated in a test to measure criterion. Results of this study indicated that there was no significant difference between subjects who received repeated feedback and those who received knowledge of results feedback.

Collins, Carnine, and Gersten (1987) found a significant effect for elaborated corrective feedback on both the achievement and retention posttests. The sample included 28 learning disabled and remedial students at the secondary level. The nature of their population is similar to the nature of the population used in the present study but the nature of the task varied considerably. Subjects in the study done by Collins, Carnine, and Gersten were taught how to apply a rule using computer-assisted instruction. A provision was built into the program to provide for review of all missed items. The pool of potential participants was first tested for knowledge of classification. Those who scored below 90 % on this prerequisite skill were excluded from the study. The 28 students who scored above 90 % on the classification test were randomly assigned to one of two groups for intervention. The study done by Collins, Carnine, and Gersten (1987) involved subjects in 5 treatment sessions of 20 to 30 minutes each to teach a tutorial lesson with 30 questions in multiple choice format. This is considerably longer than the time alloted to subjects involved in studies at the university level to teach a roughly equivalent number of questions.

Lhyle and Kulhavy (1987) found that both repeated feedback and scrambled feedback significantly increased the amount of information university students remembered from a computer-assisted instruction tutorial program. Subjects who received repeated feedback showed the greatest probability of correcting an instructional error.

Merrill (1987) found that students in high-level question treatment groups performed significantly better on both achievement and retention posttests than students in low-level question treatment groups. There was no feedback form main effect for either corrective feedback or attribute isolation feedback. This study supported the efficacy of levels of question as an instructional factor in courseware design but it did not support the efficacy of informational feedback.

Conclusions

Most of the research studies on the use of informational feedback in computer-assisted instruction have been done at the university level using students who possessed at least adequate cognitive processing skills. In general, the research studies reviewed found that feedback was superior to no feedback and that more informational feedback was superior to just knowledge of results feedback. There is no consensus on what the nature of the informational feedback should be. Few research studies on the use of informational feedback in computer-assisted instruction have been done at the secondary level, especially with students who may be deficient in their cognitive processing skills. This research study will contribute to what is presently known about using informational feedback in computer-assisted instruction with less successful students in secondary science. Results from the present study also raise some instructional questions that need to be addressed in future research studies involving the use of computer-assisted instruction in the science classroom.

Review of the Literature on Attitude Instruments

A final important review of the literature involved a search for studies that involved the development and validation of computer and science attitude instruments. This search led to the selection and modification of the computer and science attitude instruments used in the pilot study. Further revisions were made in the computer attitude instruments used for this research study.

An Instrument for Measuring Computer Attitude

A search of the testing center revealed that there were no commercially available instruments for measuring student attitudes toward computers. The search was extended to a review of literature for instruments developed within the five years prior to the study. Only instruments that had a high reliability (> .80) and that had been validated for use with secondary students were considered. Only one study was found that reported on the use of an instrument that fit all of these characteristics and also included a copy of the instrument in the literature review.

In 1984, Loyd and Gressard performed a study to examine the validity and reliability of a computer attitude scale that they developed. The subjects in this study were 155 students in grades 8 through 12 in a large school district. All students were enrolled in a computer-based education program and their ages ranged from 13 to 18; 81 were males and 104 were females. Classroom teachers administered the Computer Attitude Scale to the students. The instrument consisted of 30 Likert-type items which could be divided into three categories: anxiety or fear of computers; liking computers; and confidence in ability to learn about computers. The items were coded so that a higher score on the total scale indicated a more positive attitude toward computers. Means, standard deviations, and alpha correlations were computed for the entire scale as well as the three subscales. Correlations among the three subscales were computed and a 30 x 30 matrix of item intercorrelations was formed. The coefficient alpha reliability of the total scale was .95.

Further studies were done by Loyd and Gressard to validate and refine the instrument. The researcher contacted Loyd and Gressard to obtain the updated copy of the revised instrument that was used in the pilot study.

An Instrument For Measuring Science Attitude

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	1. always	
	2. usually	
I	3. sometimes	like to talk about school.
	4. rarely	
	5. never	

Price substituted "SCIS science" for the word "school" to devise a 15-item Likert-type instrument. She found a test-retest reliability of .85 for this instrument which was used with 6th grade students. The format of Price's instrument was further adapted for the pilot study of this research by eliminating "SCIS" and just using the term "science."

CHAPTER III

Methodology

This study was an experimental field investigation in which students were randomly assigned to one of four treatment groups for intervention with computer-assisted instruction. In this study the researcher investigated the effect of trial repetition and explanatory feedback in computer-assisted instruction on the science and computer attitudes and performance of less successful students in secondary science.

The design of the study was a modified version of the experimental pretest-posttest design proposed by Campbell and Stanley (1963); a summary appears in Table 4. No non-treatment control group was used in the study and all students received computer feedback treatment.

Feedback Variables

The independent variables in this study were the feedback treatment: Group 1 lacked trial repetition and explanatory feedback; Group 2 had trial repetition but lacked explanatory feedback; Group 3 had explanatory feedback but lacked trial repetition; Group 4 had both trial repetition and explanatory feedback. Dependent variables in this research were measures of science and computer attitude and performance on an achievement posttest and a retention posttest.

Table 4. Feedback Study Design

Pretest	Treatment	Posttest 1 (Achievement)	Posttest 2 (Retention)
X	No Trial Repetition No Explanatory Feed-back	X	X
X	Trial Repetition No Explanatory Feed-back	X	X
X	No Trial Repetition Explanatory Feedback	X	X
X	Trial Repetition Explanatory Feedback	X	X

Program Variables

Carter (1984) classified feedback features into four groups: timing, scheduling, function, and type. These categories were used to analyze how feedback was being used in the programs designed for the study and how the timing, function, scheduling, and type of feedback compared in the four treatment groups. A summary of this comparison appears in Table 5. The software design conditions held constant throughout the programs are summarized in Table 6.

Nature of the CAI Programs

Curriculum Content. General Biology was selected as the source of the curriculum content for development of the software programs. There were four reasons for selecting this content area: 1) It is a non-Regents level course which is generally offerred to students in grades 9 or 10; 2) Many questions were available from previous General Biology exams since this course has been in existence in New York State for many years; 3) The procedure for developing the General Biology exam is similar to that being used to develop the RCT; 4) There was no available pool of State generated RCT questions since that exam was not administered until June, 1988. Therefore, an alternate State course (General Biology) was selected for syllabus content and as a source of questions for the pretest and posttests that were designed and administered during the experimental phase.

Table 5. Summary of Feedback Conditions Used in Program Design

FEEDBACK CONDITIONS	TREATMENT GROUP			
	GROUP 1	GROUP 2	GROUP 3	GROUP 4
CONSTANT CONDITIONS				
TIMING				
Immediate	X	X	X	X
FUNCTION				
Provide Knowledge of Correct Results	X	X	X	X
Provide Personalized, positive reinforcement	X	X	X	X
SCHEDULING				
Subsequent to correct and incorrect responses	X	X	X	X
VARIABLE CONDITIONS				
TYPE				
Explanatory feedback			X	X
Trial repetition		X		X

Table 6. Computer Design Conditions Held Constant

Apple or Apple-compatible computers were used.
Apple SuperPILOT was the authoring system used.
The programs were user friendly.
Data was recorded and stored on student progress.
Multiple-choice and open-ended questions were used.
No pre-requisite computer skills were essential for success.
Content objectives were the same for all programs.
Students controlled the rate of pacing.
Sequencing was linear.
Presentation included identical text, questions, and graphics.

Questions used for the pretests and posttests during the research phase were selected from General Biology exams which were administered from June, 1982 through June, 1986.

Instructional Content. The three software programs designed for this research were all tutorial in nature and were all developed using an instructional design model proposed by Gagne, Wager, and Rojas (1981) and the authoring system Apple SuperPILOT. The program developed for Frame Q7 of *Ecology: Nutritional Relationships* is shown in Table 7 to illustrate the differences among feedback types used in the programs.

Gagne, Wager, and Rojas (1981) recommended incorporating nine phases into program design. The programs developed for this study used eight of the nine phases. Phase 1 involved getting the learner's attention and introducing instruction. All programs designed for all treatment groups were identical in this respect. The researcher's logo (ABC Science) was shown on the screen in large letters to gain attention. Students were then asked to type in their first and last name and were asked if they had used the program before and, if so, if they wanted to start over or just do the quiz at the end. This was to allow students to come back to the program at a later time if they just needed or wanted to take the quiz again.

Phase 2 introduced the learner to the instructional ob-

Table 7. <u>Illustration of Feedback Design for FrameQ7 in Four Different Feedback Treatment Groups</u>

GROUP 1

NO TRIAL REPETITION

NO EXPLANATORY FEEDBACK

```
*FrameQ7
pr:u
g:es
K:S,ques7
t:7.Which organism listed
:below is a predator ?
t:
t:   A.   an owl
t:   B.   a grasshopper
t:   C.   algae
t:   D.   a mouse
t:
a:$q$
m:%end%
jy:end
m:%A%
c:s$="A, an owl"
KS: 7, $q$ 1;#(%a)/#(tim(O))
ty:Great, $f$ !  Well done!
w:3
jy:@p
tn:Sorry, $f$ ! The correct
:answer is $s$ !
gx:return
a:
j:@P
```

GROUP 2

TRIAL REPETITION PRESENT

NO EXPLANATORY FEEDBACK

```
*FrameQ7
pr:u
g:es
K:S,ques7
t:7. Which organism listed
:below is a predator ?
t:
t:   A.   an owl
t:   B.   a grasshopper
t:   C.   algae
t:   D.   a mouse
t:
a:$q$
m:%end%
jy:end
m:%A%
c:s$="A, an owl"
KS: 7, $q$ 1;#(%a)/#(tim(O)
ty1:Great, $f$ ! Well done!
ty2:Good thinking, $f$ !
:Right on the second try.

ty3:That's it, $f$ ! Now
:you're thinking.
w:3
jy:@p
t:
t(%a<3):That is not cor-
:rect,$f$ ! Please try
:again.
w:2
jc:@a
t:The correct answer is
:$s$ !
a:
j:@p
```

Table 7. (Continued)

GROUP 3 NO TRIAL REPETITION EXPLANATORY FEEDBACK PRESENT	GROUP 4 TRIAL REPETITION PRESENT EXPLANATORY FEEDBACK PRESENT
*FrameQ7 pr:u g:es K:S,ques7 t:7. Which organism listed :below is a predator ? t: t: A. an owl t: B. a grasshopper t: C. algae t: D. a mouse t: a:q m:%end% jy:end m:%A% c:s$="A, an owl" KS: 7, q 1;#(%a)/#(tim(0)) ty:Yes, f ! An owl does catch :and kill its own prey. w:3 jy:@p t(q$="B"):A grasshopper does :not catch prey...it eats :plants like grass. t(q$="C"):Algae are plant-like :and make their own food. t(q$="D"):A mouse eats seeds :and other parts of plants. t:The correct answer is s ! gx:return a: j:@p	*FrameQ7 pr:u g:es K:S,ques7 t:7. Which organism listed :below is a predator ? t: t: A. an owl t: B. a grasshopper t: C. algae t: D. a mouse t: a:q m:%end% jy:end m:%A% c:s$="A, an owl" KS: 7, q 1;#(%a)/#(tim(0) ty1:Great, f ! An owl :does kill its prey. ty2:Yes, f ! An owl does :kill and eat other ani- :mals. ty3:That's it, f ! Owls :are predators. w:3 jy:@p t: t(q$="B"):A grasshopper :does not catch prey... :it eats plants like grass. :Please try again, f ! t(q$="C"):Algae are plant- :like and make their own :food. Please try again ! t(q$="D"):A mouse eats :seeds and other parts of :plants. Please try again, :f ! gx:return a: jc:@a j(%a=3):The correct answer :is s ! jc:@p

jectives. Three programs were designed from the life science content area of the curriculum: (1) The Cell: Structure and Function, (2) Life Processes, and (3) Ecology: Nutritional Relationships. A summary of the number of content instructional frames, interspersed question frames, and assessment question frames incorporated into design of the programs appears in Table 8. Instructional objectives were written for each of these programs and students were given the list of objectives prior to beginning the actual instructional sequences. A list of the objectives for the program *The Cell: Structure and Function* is shown in Table 9 to illustrate the format of the instructional objectives used. The screen was cleared between each objective and key words were highlighted by capitalization. Students were then given a statement that told them there would be a quiz at the end.

Phase 3 involved stimulating recall of prior learning. This differed in each of the content programs. An outline of the sequence of frames developed for the program *The Cell: Structure and Function* is illustrated in Figure 2.

Phase 4 involved a systematic presentation of the instructional content. Learning was guided (Phase 5) by using diagrams to provide concrete illustrations whenever possible. Abstract ideas were related to concrete examples and new information was linked to prior knowledge. Frequent question frames were interspersed with the instructional frames to

Table 8. Summary of Number of Content Instructional Frames, Interspersed Question Frames, and Assessment Question Frames Incorporated Into Program Design

	CONTENT AREA		
	Ecology	Cells	Life Processes
Number of content instructional frames	45	42	49
Number of interspersed question frames	20	20	20
Number of assessment question frames	10	10	10

Table 9. Instructional Objectives for *The Cell: Structure and Function*

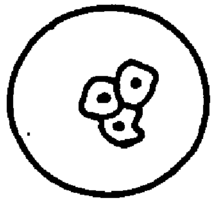
When you have completed this program you should be able to :

1. Identify the CELL as the unit of structure and function of all living things.
2. Identify the parts of the cell as ORGANELLES.
3. LABEL the parts (ORGANELLES) of an animal cell and a plant cell.
4. DESCRIBE the function of the major organelles.
5. Identify which ORGANELLES are found ONLY IN plant cells or ONLY IN animal cells.

-You may have seen cells under the microscope before.

-Cheek cells can easily be scraped from the inside of your cheek to view under the microscope.

Graphic:

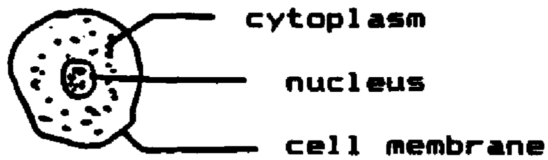


This is what they looked like.

Remember?

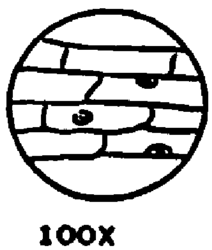
-You may have had to label the parts of the cheek cell:

Graphic:



-You may also have made a slide of onion skin cells to look at under the microscope.

Graphic:

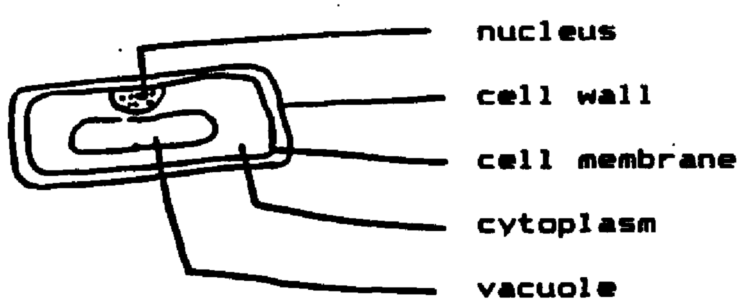


This is what they looked like.

Did you ever see them before?

-You may have had to label the parts of the onion cell:

Graphic:



-If you did see these things, you already know a lot about cells.

Figure 2. <u>Outline Developed for Phase 3 of the program</u> <u>*The Cell: Structure and Function*</u>

keep students actively involved or to elicit performance (Phase 6).

The presence or absence of trial repetition and/or explanatory feedback varied for the four treatment groups within each of the three programs (Phase 7). A summary of how the feedback factors varied within the four treatment groups appears in Figure 3.

Performance was assessed (Phase 8) at the end of each program through the use of a 10-question quiz. Students were informed at the beginning of the program that they should answer at least 8 out of 10 questions correctly to go on to the next program. If they responded correctly to 6 or 7 questions, they were told that was not quite good enough and that they would do better if they went through the program one more time. If they answered fewer than 6 questions correctly, they were instructed to talk to the teacher about what to do to improve their scores. Phase 9 (enhancing retention and learning) was not actually included in any of the programs. This would be the instructional link in the classroom for the teacher to either provide homework, select another program, or assign a special project. It may also be the stage at which the teacher would prescribe special remediation for students who do not achieve mastery on the quiz at the end of the program.

	TRIAL REPETITION	
	NO	YES
KNOWLEDGE OF CORRECT RESULTS	GROUP 1	GROUP 2
KNOWLEDGE OF CORRECT RESULTS AND EXPLANATION OF CORRECT AND INCORRECT RESPONSES	GROUP 3	GROUP 4

Figure 3. Summary of Feedback Variables Incorporated Into Program Design

Pilot Study

A pilot study of this research question was done from October until December of 1986. A copy of the pilot study report appears in Appendix A. The five primary goals of the pilot study were to:

(1) establish reliability and validity data for the instruments that were used in the main study,

(2) pilot-test the computer program prototype,

(3) gather feedback on unanticipated problems that could arise in the computer center during treatment,

(4) utilize the results of statistical analysis of the data from the pilot study to alter the hypotheses, and

(5) examine results of the data feedback for evidence of possible treatment interactions to attend to in the main study.

Specific results of the pilot study will be referred to in reference to the reliability and validity of the instruments developed for the main study.

Instrumentation

Instruments were developed to measure student performance, attitude toward science, and attitude toward computers.

Performance. Three similar forms of a science content evaluation instrument were devised by the researcher to evaluate performance: pretest, posttest 1, posttest 2.

Questions were selected from two content areas of the General Biology syllabus of New York State: Similarities Among Living Things (Unit 1) and Living Things and Their Environment (Unit 7). Three computer programs were designed based on the curriculum content in these two units. They were titled *The Cell: Structure and Function, Ecology: Nutritional Relationships, and Life Processes*. The method of selection of items from the General Biology exams used in the pilot study appears in Appendix B. There were initially 35 items: one question was selected at random from the appropriate content areas from each of the five units from each of the seven General Biology exams administered from June, 1982 until June, 1986. Alpha reliabilities and mean difficulties were determined from the pilot study results for the pretest, posttest 1, and posttest 2. Based on these comparisons and on the results of an item analysis, the content tests were revised by deleting one question from each unit in each test. Alpha correlations and mean difficulty levels of the tests were computed based on the 30 items rather than 35 items. A summary of the alpha correlations and mean difficulty levels of the tests before and after revision appears in Table 10.

A correlation matrix was generated using all of the variables in the pilot study. The following correlations were obtained: pretest and posttest 1 = .80; pretest and

Table 10. Summary of the Reliabilities and Mean Difficulty Levels of the Original and the Revised Science Content Tests

Science Content Test	Original 35-Item Tests		Revised 30-Item Tests	
	Alpha	Mean Difficulty	Alpha	Mean Difficulty
Pretest	.75	46.54	.79	51.87
Posttest 1	.85	43.60	.88	50.23
Posttest 2	.85	38.31	.89	50.47

posttest 2 = .73; posttest 1 and posttest 2 = .77.

Some of the content areas were eliminated from the pilot study for the main study. The performance tests were revised to make them more similar to each other. Ten questions were selected from the pretest and each of the posttests of the pilot study in each of the content areas of cell structure and function, ecology, and life processes. These thirty questions constituted the immediate posttest and were revised or modified to make two similar versions: one for the pretest and one for the retention posttest. An example of how this process was executed is shown in Table 11. Copies of the final instruments developed appear in Appendix C.

Attitude Toward Computers. The computer attitude instrument used in the pilot study was adapted from an instrument developed by Gressard and Loyd (1984) which had a reported alpha reliability of .95. The researcher contacted Gressard and Loyd to obtain a copy of the most recent version of this instrument. The Computer Attitude Scale used in the pilot study consisted of 40 Likert-type items. The scale can be subdivided into four subscales: anxiety; confidence; liking; usefulness. An example of a positive and a negative statement from the Computer Attitude Scale appear in Figure 4.

Table 11. Method of Item Revision for the Performance Pretest and Posttests

---

Item Taken from the Pilot Study to be part of posttest 1:

4. Pigments for photosynthesis are contained in the

A. cytoplasm	C. mitochondria
B. chloroplast	D. vacuole

This item deals with the structure of organelles. Revision for the pretest should also deal with the location of cell organelles and their parts:

4. Enzymes for cell respiration are contained in the

A. cytoplasm	C. mitochondria
B. chloroplast	D. vacuole

Revision for posttest 2 should also deal with the location of cell organelles and their parts:

4. The cell organelles are contained in the

A. cytoplasm	C. mitochondria
B. chloroplast	D. vacuole

Positive Statement

	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
I would like working with computers.	[ ]	[ ]	[ ]	[ ]

Negative Statement

	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
Working with com- would make me very nervous.	[ ]	[ ]	[ ]	[ ]

Figure 4. A Sample of a Positive and a Negative Statement From the Computer Attitude Scale

Positive statements were assigned number values as follows: strongly agree = 4; slightly agree = 3; slightly disagree = 2; strongly disagree = 1. Negative statements were assigned number values as follows: strongly agree = 1; slightly agree = 2; slightly disagree = 3; strongly disagree = 4. The total score was then computed for each subject. Students with higher scores had more positive attitudes toward working with and using computers. Scores could range from 40 to 160 with 40 being the lowest score and 160 being the highest score.

Results of the pilot study provided data on the alpha reliability of the Computer Attitude Scale used for pretesting and posttesting. Many of the items in this attitude instrument were repetitious and the instrument was too lengthy for the purposes of the main study. It was revised by dropping the last twenty items off of the original instrument. There are still equal numbers of items distributed among the four subscales and there are still equal numbers of positive and negative statements. The alpha reliabilities of the original instrument and the revised instrument for evaluating attitude toward computers are summarized in Table 12. Reliabilities of the pretest, posttest 1 , and posttest 2 used in the pilot study were .94, .95, and .96 respectively. There was a correlation of .82 between the pretest and posttest 1 and between posttest 1 and posttest 2 for computer attitude.

Table 12. <u>Summary of Reliabilities for the Computer Attitude Tests Before and After Revision</u>

Computer Attitude Test	Before Revision (40 Items)	After Revision (20 Items)
Pretest	.94	.88
Posttest	.95	.89
Parallel Posttest	.96	.90

Attitude Toward Science. Price (1978) developed an instrument to measure student attitude toward SCIS science of sixth grade students. The instrument, consisting of 15 Likert-type items relating to SCIS science, was modified for the pilot study by dropping out the "SCIS." An example of of a positive and a negative statement from the modified instrument used for the pilot study appears in Figure 5.

Positive statements were assigned number values as follows: always = 5; usually = 4; sometimes = 3; rarely = 2; never = 1. Negative statements were assigned number values as follows: always = 1; usually = 2; sometimes = 3; rarely = 4; never = 5. The total score was then computed for each subject. Students with higher scores had more positive attitudes toward science. The range of possible scores was from 15 to 75 with 15 being the lowest possible score and 75 being the highest possible score.

Results of the pilot study provided data on the alpha reliability of the Science Attitude Scale used for pretesting and posttesting. The statements used in the pilot study were not changed for the main study; the original 15 statements were retained. The format was modified to fit a scan-tron sheet format. An example of this change is shown in Figure 6.

Positive Statement

	Always	Usually	Sometimes	Rarely	Never
I like to talk about science.	[ ]	[ ]	[ ]	[ ]	[ ]

Negative Statement

	Always	Usually	Sometimes	Rarely	Never
Science is a waste of time.	[ ]	[ ]	[ ]	[ ]	[ ]

Figure 5. A Sample of a Positive and a Negative Statement from the Price Science Attitude Instrument

Statement Format for Pilot Study

	Always	Usually	Sometimes	Rarely	Never
I like to talk about science.	[ ]	[ ]	[ ]	[ ]	[ ]

Statement Format for Main Study

I like to talk about science.

A. always B. usually C. sometimes D. rarely E. never

Figure 6. Sample of Modification Used to Fit Question Format to a Scan-tron Sheet Format

The alpha reliabilities obtained in the pilot study for the science attitude tests were: pretest = .90; posttest 1 = .91; posttest 2 = .81. Results from the correlation matrix were: pretest - posttest 1 correlation = .87; pretest - posttest 2 correlation = .86; posttest 1 - posttest 2 correlation = .75.

Main Study

Data Collection, Recording, and Time Line

The times established for testing and treatment for the study are summarized in Table 13. A copy of the actual testing and treatment schedule that was given to the teachers during the study appears in Appendix E.

Data was recorded for each student for performance on the pretest and posttests and for time-on-task during treatment. Data for a number of demographic variables was also recorded for each subject: treatment group, grade level, age, teacher, science course taken the previous year, sex, whether identified by the Committee on Special Education or not, and scores for reading, vocabulary, and mathematics from the Iowa Test of Basic Skills which was administered to the students involved in the study at the end of 8th grade.

The three tests (science content, computer attitude, and science attitude) were combined into one document con-

Table 13. Testing and Treatment Schedule and Time Line

TESTING AND TREATMENT SCHEDULE

Test/Treatment	Day, Date	Periods
Pretest -Content A Computer & Science Attitude	Monday, March 14	
Treatment 1	Thursday, March 17 Friday, March 18	Periods 1,2,3,5,6,7 Periods 1,3,5,6,7,8
Treatment 2	Thursday, March 24 Friday, March 25	Periods 1,2,3,5,6,7 Periods 1,3,5,6,7,8
Treatment 3	Wednesday, March 30 Thursday, March 31	Periods 1,3,5,6,7,8 Periods 1,2,3,5,6,7
Posttest 1 -Content B Computer & Science Attitude	Tuesday, April 5	
Posttest 2 -Content C Computer & Science Attitude	Thursday, April 14	

TIME LINE

3 days　　4 days　　9 days

Pretest--------Treatment--------Posttest 1-------Posttest 2

(3-42 minute)
sessions
1 session per week
for three weeks

sisting of 65 items. The computer attitude and science attitude components (questions 31 - 65) of all three instruments were identical. The science content component (questions 1 - 30) were similar, but were not identical. Copies of the three instruments used in the main study are found in Appendix C. Items 1-30 tested science content, items 31-50 tested computer attitude, and items 51-65 tested science attitude. Responses to all items were changed to the letters A-E to fit the scan-tron sheet format. Students recorded their responses on the scan-tron sheet by bubbling in the circle of the letter of their choice with a #2 pencil. The scan-tron sheets were then processed and analyzed in the computer center and the results were stored on tape. The information from the tape was then accessed and incorporated into the analyses performed by the researcher.

Population and Sampling

The school system involved in this study was a rural school district of an approximate population of 200 students per grade level. It was a centralized school district with one high school (grades 9-12), one middle school (grades 6-8), and three elementary schools (grades K-5). All students involved in this study were enrolled in either Science 9, General Biology, or School Biology. The original sample contained 184 students enrolled in 12 science classes taught by five teachers. The students were randomly assigned to one of four groups for intervention (N = 46). During the study, 31 students were eliminated from the original sample: 14 students either left school or left the science class before the end of the study, 12 students missed either the pretest or one of the posttests, and 5 students were eliminated for using disks outside of their assigned treatment group. The analysis sample consisted of 153 students: 89 males, 64 females, 73 ninth graders, 64 tenth graders, 12 eleventh graders, 4 twelth graders, 25 repeaters, and 4 students identified by the Committee on Special Education. The resulting group Ns were unequal: Group 1 = 40, Group 2 = 36, Group 3 = 38, and Group 4 = 39. A comparison of the original population sample to the population sample used for analysis appears in Table 14. During the study, all students were pretested, received treatment, and were posttested twice using similar instruments.

Field Procedures

Teachers were briefed on the procedures for administration of the pretest and posttests. The testing instruments, scantron sheets, and #2 pencils were provided for each teacher. Teachers were all requested to test students on the same days, if possible. Students who were absent during pretesting were pretested the first day they returned to school. A three-day time period was planned between pretest-

Table 14. Comparison of Original Population Sample to Population Sample Used for Analysis

ORIGINAL POPULATION SAMPLE

Class	N	SEX		GRADE LEVEL				GROUP			
		Male	Female	9	10	11	12	1	2	3	4
1	16	13	3	12	4	0	0	5	4	5	2
2	20	10	10	19	1	0	0	5	3	6	6
3	14	8	6	14	0	0	0	1	7	3	3
4	22	13	9	19	3	0	0	7	4	6	5
5	13	7	6	12	1	0	0	3	5	2	3
6	14	8	6	13	1	0	0	2	2	7	3
7	13	10	3	0	11	1	1	4	4	1	4
8	15	7	8	0	12	2	1	4	6	3	2
9	13	9	4	0	11	2	0	2	4	5	2
10	16	9	7	0	10	4	2	5	2	2	7
11	11	3	8	0	8	2	1	3	2	3	3
12	17	6	11	0	14	3	1	5	3	3	6
TOTALS	184	103	81	89	76	14	5	46	46	46	46

ANALYSIS POPULATION SAMPLE

Class	N	SEX		GRADE LEVEL				GROUP			
		Male	Female	9	10	11	12	1	2	3	4
1	10	8	2	6	4	0	0	4	2	4	0
2	20	10	10	19	1	0	0	5	3	6	6
3	14	8	6	14	0	0	0	1	7	3	3
4	14	11	3	11	3	0	0	4	2	3	5
5	11	7	4	11	0	0	0	3	5	1	2
6	13	8	5	12	1	0	0	2	2	6	3
7	12	9	3	0	11	0	1	4	4	1	3
8	8	4	4	0	7	1	0	3	2	2	1
9	10	8	2	0	8	2	0	2	2	4	2
10	15	9	6	0	9	4	2	5	2	2	6
11	11	3	8	0	8	2	1	3	2	3	3
12	15	4	11	0	12	3	0	4	3	3	5
TOTALS	153	89	64	73	64	12	4	40	36	38	39

ing and the first treatment to include as many students in the study as possible. Students were assigned to the computer center for treatment during science class periods. Each student received a time card to record the days in the computer center, the number of the lesson disk used, the group they were assigned to, the lesson they were working on, and the time spent using the program. A copy of the student time card appears in Appendix D. Students were informed that they could obtain passes to use the programs during free periods and/or after school as long as they kept track on their time card. The Computer Center Aide was briefed on the purpose of the study and the requirements of the students.

Students used two disks during each computer treatment: a lesson disk and a Systems.log disk. The lesson disk had to be loaded into disk drive # 1 and the Systems.log disk had to be loaded into disk drive # 2. Instructions for loading the disks properly were written on the top of the students' time cards and students were guided through the proper procedure for loading the disks prior to each computer treatment.

The Systems.log disks stored information on each student that could be accessed by the reseacher following treatment. The time card was cut to fit into the jacket of the Systems.log disk. The lesson disks were numbered and students recorded the number of the disk used in each treatment in the appropriate space provided on the time card. This provided a check to ensure that students were using disks within the group they were assigned to.

Statistical Analysis

The major question of interest in this study concerned the effect of the presence or absence of trial repetition and explanatory feedback in computer-assisted instruction on student performance and science and computer attitudes.

Research Hypotheses

The following research hypotheses were tested to answer the research questions:

Hypothesis 1a: Students in the trial repetition and explanatory feedback group should perform significantly better ($p < .05$) on the achievement posttest than students in the treatment groups lacking trial repetition and explanatory feedback combined.

Hypothesis 1b: Students in the trial repetition without explanatory feedback group and the explanatory feedback without trial repetition group should perform significantly better ($p < .05$) on the achievement posttest than students in the treatment group lacking trial repetition and explanatory feedback.

Hypothesis 2a: Students in the trial repetition and explanatory feedback group should perform significantly better ($p < .05$) on the retention posttest than students in the treatment groups lacking trial repetition and explanatory feedback combined.

Hypothesis 2b: Students in the trial repetition without explanatory feedback group and the explanatory feedback without trial repetition group should perform significantly better ($p < .05$) on the retention posttest than students in the treatment group lacking trial repetition and explanatory feedback.

Hypothesis 3a: Students in the trial repetition and explanatory feedback group should have attitudes toward science and computers that are significantly more positive ($p < .05$) than those of students in the treatment groups lacking trial repetition and explanatory feedback combined.

Hypothesis 3b: Students in the trial repetition without explanatory feedback group and the explanatory feedback without trial repetition group should have significantly more positive attitudes ($p < .05$) toward science and computers than students in the treatment group lacking trial repetition or explanatory feedback.

Analysis

Means and standard deviations were determined for each group. Comparisons were made among mean scores for students in Groups 1, 2, 3 and 4 to see if they differed in the predicted direction. Students within groups were sorted into subgroups according to sex (male or female) and ability level (high or low). Ability level was determined from the Iowa Test of Basic Skills (ITBS) scores reported at the end of grade 8. The mean was determined for all of the reading, vocabulary, and mathematics scores. High ability students were defined as students with ITBS scores above the mean. Low ability science students were defined as students with ITBS test scores at or below the mean. Three MANOVAs were performed comparing results of the achievement posttest (posttest 1), the retention posttest (posttest 2), the computer attitude posttest, and the science attitude posttest by treatment group, sex, and ability level. Repeated measures designs were used and the data was examined for significant main effects and interactions.

CHAPTER IV

Analysis of Data

Instrument Summary

Instruments were developed or modified by the researcher during the pilot study to measure student performance and attitudes of students toward science and computers. Three similar forms of a science content test were developed to pretest and posttest students for knowledge of science content. A Computer Attitude Scale and the Price Science Attitude Inventory were modified for use in the pilot study. The nature of design of these instruments was described in detail in Chapter III; reliability data for the pretest, posttest 1, and posttest 2 from the pilot study were also presented.

The instruments used in the main study were revised from those used in the pilot study. The new instruments used in the main study were examined for reliability and validity.

Instrument Reliability

The pretest and two posttests for science content were not identical. They were designed to be equivalent forms of the content test. The pretests and posttests used to measure student computer and science attitudes were identical.

The internal consistency of all of the pretests and posttests used during the main study was determined by using Cronbach's alpha statistic. The data obtained for the reliability analysis of the instruments used in the main study is summarized in Table 15. This data indicates that all of the tests used in the main study had acceptable levels of internal consistency; the Cronbach alphas ranged from .66 to .92.

A second reliability concern was the degree of equivalence of the pretests and posttests. Pearson correlation coefficients (r) were determined for all of the pretests and posttests. A summary of this data appears in Table 16. The Pearson correlations were all positive, ranging from .58 to .77. All correlations reported were statistically significant ($p < .0005$). Based on the data, the pretests and posttests were judged to be effective measures for assessing student performance and pupil attitudes toward science and computers.

Instrument Validity

The instruments used for pretesting and posttesting subjects for content knowledge were validated by expert review. Two Biology teachers examined the three content instruments to determine how closely the instruments tested the content of the computer programs. A copy of the evaluation instrument appears in Appendix G. Teacher A rated 82 out of 90 (91 %) of the test items as valid and Teacher B rated 87 out of 90 (97 %) of the test items as valid.

Evaluating the Hypotheses

Means and standard deviations were determined for each

Table 15. Reliability Analysis of Instruments Used in the Main Study

TEST	CRONBACH'S ALPHA	N
Science Content Pretest	.66	160
Computer Attitude Pretest	.89	159
Science Attitude Pretest	.92	154
Science Content Posttest 1	.79	160
Computer Attitude Posttest 1	.88	159
Science Attitude Posttest 1	.91	156
Science Content Posttest 2	.73	152
Computer Attitude Posttest 2	.88	151
Science Attitude Posttest 2	.91	149

Table 16. Pearson Correlation Coefficients of Pretests With Posttests

Test 1	x	Test 2	r
Precon	x	Postcon 1	.59***
Precon	x	Postcon 2	.58***
Postcon 1	x	Postcon 2	.63***
Precat	x	Postcat 1	.75***
Precat	x	Postcat 2	.69***
Postcat 1	x	Postcat 2	.72***
Presat	x	Postsat 1	.70***
Presat	x	Postsat 2	.67***
Postsat 1	x	Postsat 2	.77***

Precon = Science Content Pretest
Postcon 1 = Science Content Posttest 1
Postcon 2 = Science Content Posttest 2
Precat = Computer Attitude Pretest
Postcat 1 = Computer Attitude Posttest 1
Postcat 2 = Computer Attitude Posttest 2
Presat = Science Attitude Pretest
Postsat 1 = Science Attitude Posttest 1
Postsat 2 = Science Attitude Posttest 2

*** $p < .0005$

group. Students within groups were sorted into subgroups according to sex (male or female) and ability level (high or low). Ability level was determined from the Iowa Test of Basic Skills scores reported for each subject at the end of grade 8. The mean was determined for all of the reading, vocabulary, and mathematics scores and an average was computed. High ability students were defined as students with Iowa Test of Basic Skills average scores above the mean (> 46.8). Low ability students were defined as students with Iowa Test of Basic Skills averages at or below the mean average (< or = 46.8). The first MANOVA compared pretest, achievement posttest (posttest 1) and retention posttest (posttest 2) scores by treatment group, sex and ability level using a repeated measures design. The data for main effects and effects of interaction between subjects and within-subjects obtained from this MANOVA is summarized in Table 17. Two similar MANOVAs were performed comparing results of posttests for computer attitude and science attitude by treatment group, sex, and ability level using a repeated measures design. The data for main effects and effects of interaction between subjects and within subjects from the MANOVA for computer attitude is summarized in Table 18 and similar data for science attitude is summarized in Table 19. Mean results for all of the pretests and posttests for science content, science attitude, and computer attitude are summarized in Table 20.

Table 17. MANOVA Summary for Performance Pretest, Posttest 1, and Posttest 2 by Treatment Group, Sex, and Ability Level

EFFECTS	SS	DF	MS	F	P
MAIN:					
Group	89.35	3	29.78	.64	.593
Sex	76.64	1	76.64	1.64	.203
Ability	661.94	1	661.94	14.13	.000***
INTERACTION (Between Subjects Effects):					
Group x Sex	105.28	3	35.09	.75	.525
Group x Abil.	29.63	3	9.88	.21	.889
Sex x Abil.	10.95	1	10.95	.23	.630
Group x Sex x Ability	27.63	3	9.21	.20	.899
TIME (Within Subjects Effects):					
Time	935.50	2	467.75	53.13	.000***
Group x Time	30.52	6	5.09	.58	.748
Sex x Time	51.53	2	25.77	2.93	.055
Abil.x Time	.32	2	.16	.02	.982
Group x Sex x Time	32.84	6	5.47	.62	.713
Group x Abil. x Time	124.17	6	20.70	2.35	.031*
Sex x Abil. x Time	69.47	2	34.74	3.95	.020*
Group x Sex x Abil.x Time	62.61	6	10.43	1.19	.314

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 18. MANOVA Summary for Computer Attitude by Treatment Group, Sex, and Ability Level

EFFECTS	SS	DF	MS	F	P
MAIN:					
Group	395.71	3	131.90	.77	.510
Sex	109.13	1	109.13	.64	.425
Ability	67.11	1	67.11	.39	.531
INTERACTION (Between Subjects EFfects):					
Group x Sex	856.23	3	285.41	1.68	.175
Group x Abil.	855.25	3	285.08	1.67	.176
Sex x Abil.	3.65	1	3.65	.02	.884
Group x Sex x Ability	1822.31	3	607.44	3.57	.016*
TIME (Within Subjects Effects):					
Time	142.39	2	71.20	3.65	.027*
Group x Time	191.30	6	31.88	1.64	.138
Sex x Time	43.41	2	21.70	1.11	.330
Abil.x Time	23.71	2	11.86	.61	.545
Group x Sex x Time	43.57	6	7.46	.37	.896
Group x Abil. x Time	183.33	6	30.56	1.57	.157
Sex x Abil. x Time	51.76	2	25.88	1.33	.267
Group x Sex x Abil.x Time	186.75	6	31.13	1.60	.148

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 19. MANOVA Summary for Science Attitude by Treatment Group, Sex, and Ability Level

EFFECTS	SS	DF	MS	F	P
Group	427.90	3	142.63	.46	.713
Sex	9.40	1	9.40	.03	.863
Ability	1109.66	1	1109.66	3.55	.062
INTERACTION (Between Subjects Effects):					
Group x Sex	826.52	3	275.51	.88	.452
Group x Abil.	2234.84	3	744.95	2.38	.072
Sex x Abil.	771.62	1	771.62	2.47	.118
Group x Sex x Ability	2937.42	3	979.14	3.13	.028*
TIME (Within Subjects Effects):					
Time	.73	2	.36	.01	.990
Group x Time	137.93	6	22.99	.62	.714
Sex x Time	38.32	2	19.16	.52	.597
Abil.x Time	54.90	2	27.45	.74	.478
Group x Sex x Time	407.96	6	67.99	1.83	.093
Group x Abil. x Time	118.93	6	19.82	.53	.782
Sex x Abil. x Time	158.58	2	79.29	2.14	.120
Group x Sex x Abil.x Time	237.91	6	39.65	1.07	.381

$* p < .05$ $** p < .01$ $*** p < .001$

Table 20. MANOVA Mean Results for Pretests and Posttests of Science Content, Science Attitude, and Computer Attitude

		PRETEST		POSTTEST 1		POSTTEST 2	
	N	MEAN	SD	MEAN	SD	MEAN	SD
SCIENCE CONTENT:							
GROUP 1	40	14.7	4.4	17.2	5.4	15.8	5.1
GROUP 2	38	14.3	4.0	18.3	4.9	16.2	4.7
GROUP 3	35	13.1	4.2	17.3	5.0	14.9	4.3
GROUP 4	37	14.6	4.6	18.8	5.5	16.0	5.0
COMPUTER ATTITUDE:							
GROUP 1	40	55.3	8.4	57.0	9.0	56.0	8.7
GROUP 2	38	58.0	9.6	58.5	9.3	57.8	9.7
GROUP 3	35	57.8	9.4	58.3	8.7	56.9	8.5
GROUP 4	37	57.1	7.9	56.9	7.8	54.0	7.6
SCIENCE ATTITUDE:							
GROUP 1	40	42.0	12.3	43.3	11.0	43.6	9.8
GROUP 2	38	44.5	12.7	44.6	11.2	44.5	11.2
GROUP 3	35	43.4	10.2	43.3	11.7	43.8	8.4
GROUP 4	37	43.2	13.9	44.9	12.4	43.9	13.0

Note: The maximum scores possible were 30 for the Science Content Tests, 75 for the Science Attitude Tests, and 80 for the Computer Attitude Tests.

Hypotheses

The major question of interest in this study concerned the effect of the presence or absence of trial repetition and explanatory feedback in computer-assisted instruction on the performance and science and computer attitudes of less successful students in secondary science. The following research hypotheses were tested to answer the research questions.

Hypothesis 1

The first hypothesis that was tested related to performance and was subdivided into two sections that stated:

> Hypothesis 1a: Students in Group 4, having trial repetition and explanatory feedback will perform significantly better ($p < .05$) on the achievement posttest than either students in Groups 1, 2, or 3.

> Hypothesis 1b: Students in Groups 2 and 3 will perform significantly better ($p < .05$) than students in Group 1 on the achievement posttest.

Since the effects of group were not significant (group effects: $F = .64$, $df = 3$, $p = .593$) nor were there any interaction effects, all groups performed equally well. Consequently, the conclusions regarding hypotheses 1a and 1b were as follows:

Results of Hypothesis 1a: Students in Group 4, having trial repetition and explanatory feedback, did not perform significantly better ($p < .05$) on the achievement posttest than students in Groups 1, 2, or 3. This research hypothesis was not supported by the data.

Results of Hypothesis 1b: Groups 2 and 3 did not perform significantly better ($p < .05$) than students in Group 1 on the achievement posttest. This research hypothesis was not supported by the data.

A graph comparing the means of the four treatment groups on the science content pretest, the achievement posttest, and the retention posttest appears in Figure 7 and the data for this graph appears in Table 21.

Hypothesis 2

The second hypothesis related to retention and was subdivided into two sections that stated:

> Hypothesis 2a: Students in Group 4, having trial repetition and explanatory feedback, will perform significantly better ($p <.05$) on the retention posttest (posttest 2) than students in Groups 1, 2, or 3.
>
> Hypothesis 2b: Students in Group 2 having only trial repetition and students in Group 3 having only explanatory feedback will perform significantly better ($p <.05$) on the retention posttest (posttest 2) than students in Group 1.

Since the effects of group were not significant (group effects: $F = .64$, $df = 3$, $p = .543$) nor were there any interaction effects, all groups had equivalent performance on the retention posttest. Consequently, the conclusions regarding hypotheses 2a and 2b were as follows:

Results of Hypothesis 2a. There were no significant differences ($p < .05$) in the performance of any of the groups on the retention posttest. This research hypothesis

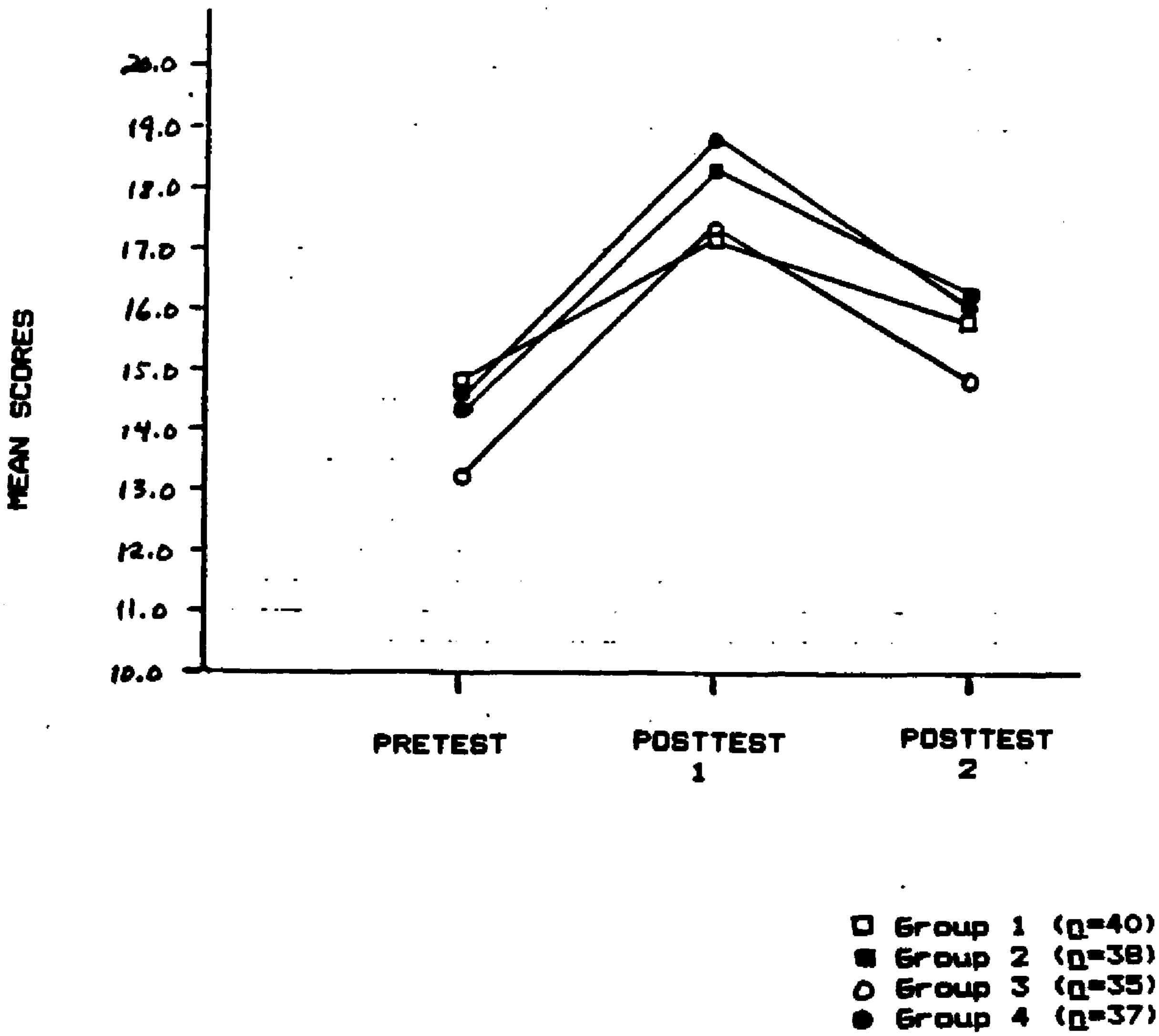


Figure 7. Mean Comparison for Science Content Pretest, Posttest 1, and Posttest 2 by Group

Table 21. MANOVA Mean Results for Science Content Pretest, Posttest 1, and Posttest 2

		PRETEST		POSTTEST 1		POSTTEST 2	
	N	MEAN	SD	MEAN	SD	MEAN	SD
SCIENCE CONTENT:							
GROUP 1	40	14.7	4.4	17.2	5.4	15.8	5.1
GROUP 2	38	14.3	4.0	18.3	4.9	16.2	4.7
GROUP 3	35	13.1	4.2	17.3	5.0	14.9	4.3
GROUP 4	37	14.6	4.6	18.8	5.5	16.0	5.0

Note: The maximum score possible was 30 for the Science Content Tests.

was not supported by the data. Group 4 did not have significantly better retention than any of the other three treatment groups.

Results of Hypothesis 2b. There were no significant differences ($p < .05$) in the performance of any of the groups on the retention posttest. This research hypothesis was not supported by the data. Groups 2 and 3 did not have significantly better retention than Group 1. This data is summarized in Table 21 and is graphicly represented in Figure 7.

Hypothesis 3

The third hypothesis that was tested related to science and computer attitudes and was subdivided into two sections that stated:

> Hypothesis 3a: The attitudes of students in Group 4 will be significantly more positive ($p < .05$) toward science and computers than students in either Groups 1, 2, or 3.
>
> Hypothesis 3b: The attitudes of students in Groups 2 and 3 will be significantly more positive ($p < .05$) toward science and computers than students in Group 1.

Multivariate tests of significance indicated that there was no significant difference between means in any of the groups on any of the pretests or posttests for science attitudes (group effects: $F = .46$, $df = 3$, $p = .713$) or for computer attitudes (group effects: $F = .77$, $df = 3$, $p = .510$). Consequently, the conclusions regarding hypothesis

3a and 3b were as follows:

Results of Hypothesis 3a. There was no significant difference between any of the four treatment groups on pretests or posttests for science or computer attitudes. This research hypothesis was not supported by the data.

Results of Hypothesis 3b. The differences between the four treatment groups were not significant for either science or computer attitude. Attitudes of students in Groups 2 and 3 were not significantly more positive than those of students in Group 1 so this research hypothesis was not supported by the data. A graph comparing the means of the four treatment groups on the science and computer attitude pretests and posttests appears in Figure 8 and the data for this graph is summarized in Table 22.

Conclusions. Examination of the data in the graph shown in Figure 7 indicates that the means for all four treatment groups increased proportionately on the achievement posttest. Students in all four groups learned from the instructional treatment. There was no significant difference between any of the groups in how well they learned. When data is examined at the group level, any of the feedback combinations would result in approximately equivalent rates of achievement. Inclusion of trial repetition and explanatory feedback, either alone or in combination, did not have a significant effect on the learning rate of students involved

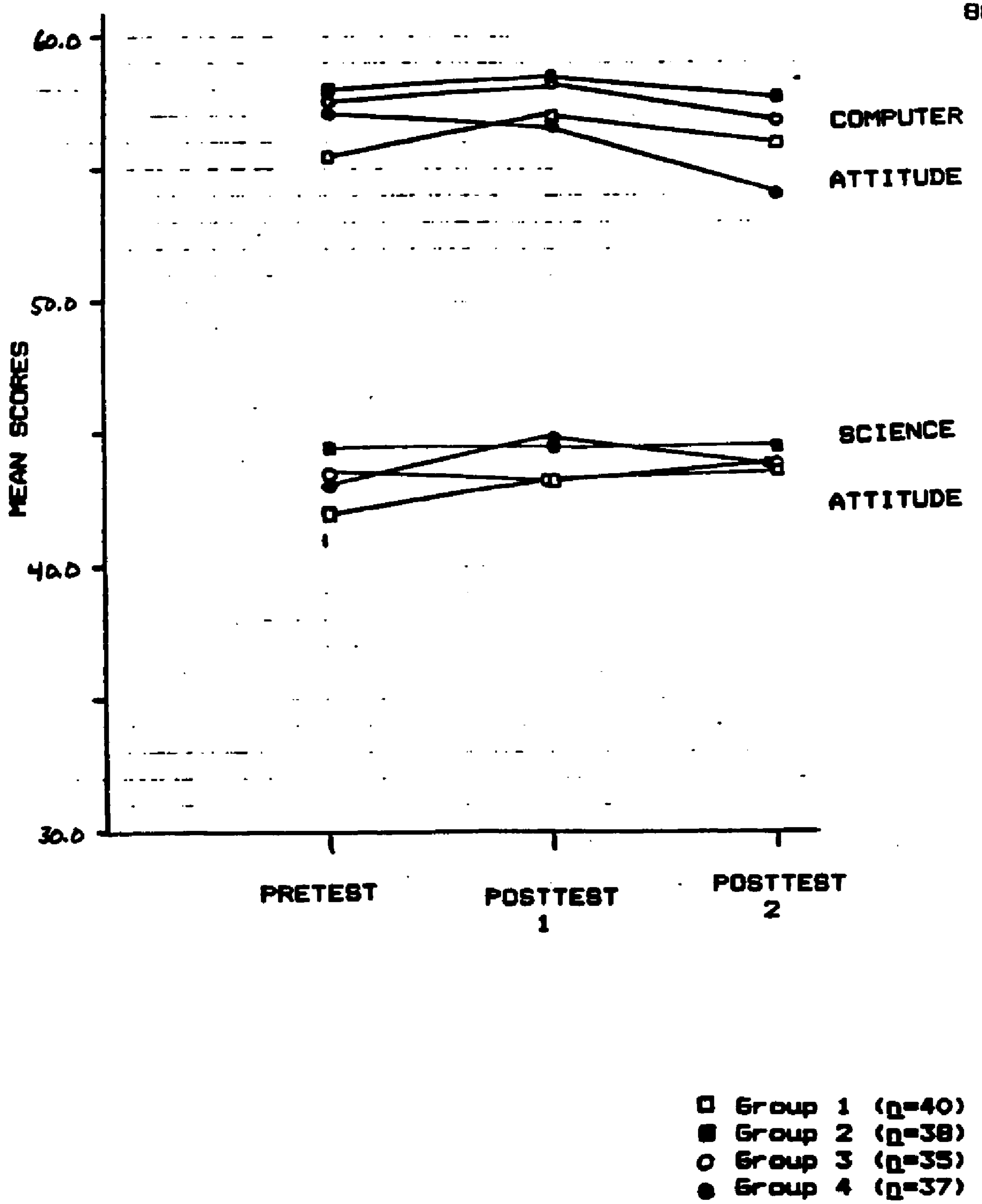


Figure 8. Mean Comparison for Science and Computer Attitudes on the Pretest, Posttest 1, and Posttest 2 According to Group

Table 22. MANOVA Mean Results for Pretests and Posttests of Computer and Science Attitude

	N	PRETEST MEAN	PRETEST SD	POSTTEST 1 MEAN	POSTTEST 1 SD	POSTTEST 2 MEAN	POSTTEST 2 SD
COMPUTER ATTITUDE:							
GROUP 1	40	55.3	8.4	57.0	9.0	56.0	8.7
GROUP 2	38	58.0	9.6	58.5	9.3	57.8	9.7
GROUP 3	35	57.8	9.4	58.3	8.7	56.9	8.5
GROUP 4	37	57.1	7.9	56.9	7.8	54.0	7.6
SCIENCE ATTITUDE:							
GROUP 1	40	42.0	12.3	43.3	11.0	43.6	9.8
GROUP 2	38	44.5	12.7	44.6	11.2	44.5	11.2
GROUP 3	35	43.4	10.2	43.3	11.7	43.8	8.4
GROUP 4	37	43.2	13.9	44.9	12.4	43.9	13.0

Note: The maximum scores possible were 75 for the Science Attitude Tests and 80 for the Computer Attitude Tests.

in the study. Multivariate tests of significance indicated that there were no significant differences between means in any of the groups on any of the pretests or posttests for science or computer attitudes.

Further Analyses

The three MANOVAs used to analyze the data for the primary research questions were designed to examine main effects and interactions of sex and ability level as well as treatment group. Further analyses encompassed the questions of effect and interaction of sex, ability level, and treatment group on each of the dependent variables as well as the within-subjects effects and interactions of time.

Main Effects

A significant main effect was found for ability level ($F = 14.13$, $df = 1$, $p = .000$) on the achievement and retention posttests for science content. Examination of the means indicated that higher ability students performed significantly better on the posttests than lower ability students. This is consistent with what learning theory would predict should happen. No significant main effects were found for either computer attitude or science attitude.

Treatment Interactions

No significant interactions were found between group, sex, or ability level for either achievement or retention of science content. There was a significant interaction between group, sex, and ability level for both computer attitude (F = 3.57 , df = 3 , p = .016) and science attitude (F = 3.13 , df = 3 , p = .028). Means were compared and graphed to determine the direction of these interactions. The means for group by sex by ability level for computer attitudes and science attitudes are summarized in Table 23 and the graphs are shown in Figure 9.

Computer Attitude. Group means were compared for significant differences in computer attitudes. The computer attitudes of low ability males in Group 2 were significantly more positive than the computer attitudes of low ability males in Groups 1, 3, or 4. Examination of pretest data revealed that there was a significant difference in the computer attitudes of low ability males in Group 2 on the pretest and this difference was sustained throughout the study.

Science Attitudes. High ability females in Group 4 had significantly more positive attitudes toward science than low ability females in Group 4. This can be attributed to the low N (N = 3) for low ability females in Group 4 and a significant difference in attitude toward science that was present in Group 4 females during pretesting that was sustained throughout the study.

Table 23. Means for Group by Sex by Ability Level for Computer and Science Attitudes

Group	COMPUTER ATTITUDE N	COMPUTER ATTITUDE MEAN	SCIENCE ATTITUDE N	SCIENCE ATTITUDE MEAN
Group 1 (Regular Feedback):				
Male	14	51.91	14	38.60
Low ability				
High ability	12	56.86	12	43.86
Female				
Low ability	6	56.56	6	45.22
High ability	7	60.95	7	46.38
Group 2 (Trial Repetition):				
Male				
Low ability	7	65.28	7	47.14
High ability	11	55.82	11	43.79
Female				
Low ability	8	55.75	8	42.38
High ability	11	58.55	11	45.79
Group 3 (Explanatory Feedback):				
Male				
Low ability	10	53.20	10	43.70
High ability	8	60.11	8	44.46
Female				
Low ability	9	61.04	9	44.63
High ability	8	56.917	8	41.00
Group 4 (Trial Repetition and Explanatory Feedback):				
Male				
Low ability	16	55.04	16	43.48
High ability	10	56.73	10	43.07
Female				
Low ability	3	57.11	3	28.11
High ability	9	56.59	8	52.08

Note : The maximum possible score for the computer attitude instrument is 80 and for the science attitude instrument is 75.

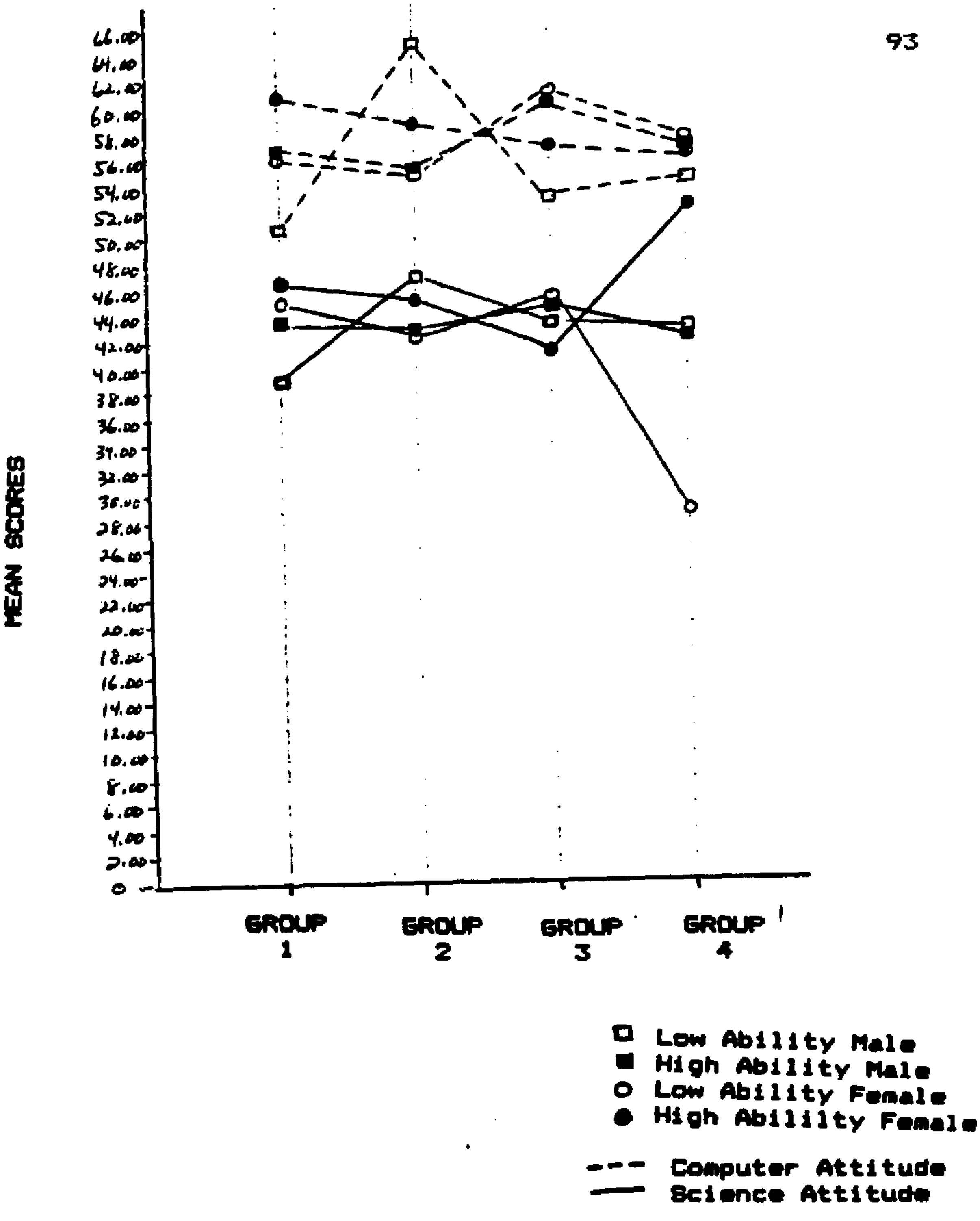


Figure 9. Graphs of Means for Computer Attitude and Science Attitude for Group x Sex x Ability Level

Time Effects

A significant effect for time was found for science content ($F = 53.13$, $df = 2$, $p = .000$) and for computer attitude ($F = 71.20$, $df = 2$, $p = .027$). The eta^2 was computed for each to determine the strength of association of time to the dependent variables. Only 5.5 % of the variability in computer attitude can be attributed to the significance found for time. This is not very large. However, 42.1 % of the variability of the results for science content can be attributed to the significance of time.

Group x Ability x Time. A significant interaction was found for science content between group, ability level, and time ($F = 2.35$, $df = 6$, $p = .031$). The data for this comparison is summarized in Table 24 and is represented graphicly in Figure 10. The following significant differences were found:

1. High ability students in Group 4 performed significantly better ($p < .05$) than low ability students in Groups 1, 2, or 3 on Posttest 1; they did not perform significantly better ($p < .05$) than other high ability students.

2. High ability students in Group 2 ($p < .01$) and Group 4 ($p < .05$) performed significantly better than low ability students in Groups 1, 2, 3, and 4 on Posttest 2.

3. High ability students in Group 2 performed significantly better ($p < .05$) than high ability students in Group 3 on Posttest 2.

Table 24. Means for Group by Ability x Time and for Sex x Ability x Time for AChievement (Posttest 1)

GROUP X ABILITY X TIME:

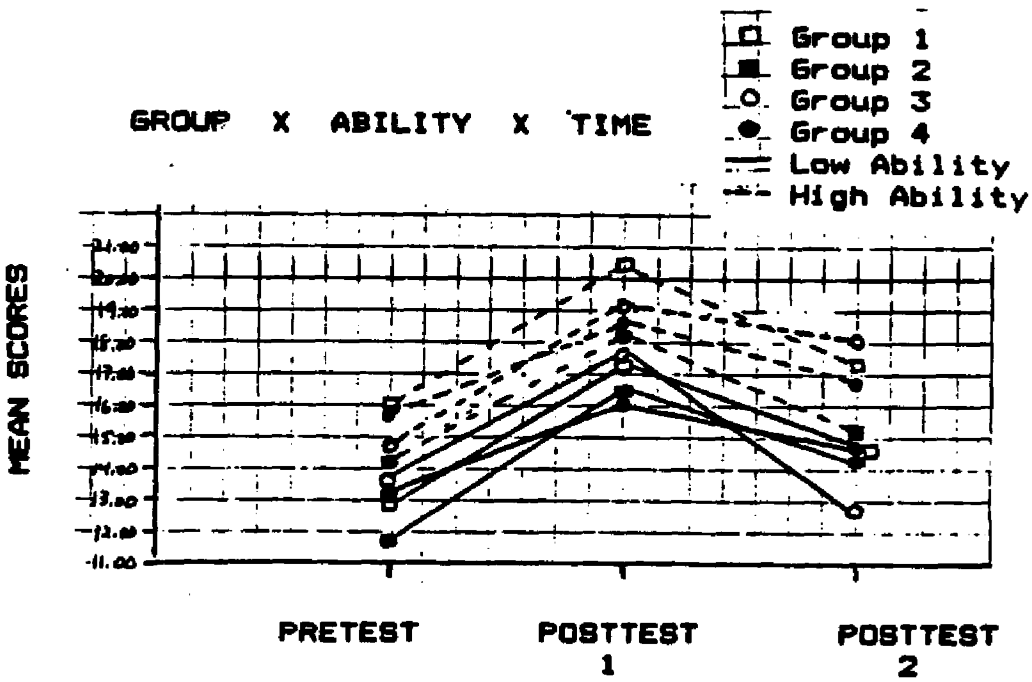
Group	Ability	N	Pretest Mean	Posttest 1 Mean	Posttest 2 Mean
Group 1					
	Low ability	20	13.35	16.05	14.75
	High ability	19	15.89	18.63	16.89 *L(2)
Group 2					
	Low ability	15	13.53	16.87	12.93
	High ability	22	14.77	19.05	18.23 *H(3) **L(1-4 *L(2)
Group 3					
	Low ability	19	11.79	16.11	14.68
	High ability	16	14.56	18.62	15.13
Group 4					
	Low ability	20	13.15	16.85	14.45
	High ability	19	16.11	20.68 *L (1,2,3)	17.47 *L(4) **L(1-4 *L(2)

SEX X ABILITY X TIME:

Sex	Ability	N	Pretest Mean	Posttest 1 Mean	Posttest 2 Mean
Male	Low	47	13.02	15.66	13.79
	High	41	15.24 *LM	19.68 **LM	16.22 *LM
Female	Low	27	12.78	17.81 *LM	15.15
	High	35	15.46 **LF	18.77	18.03 **LF *HM

* p < .05 ** p < .01

Compared to: L=low; H=high; M=male; F=female; (1-4)=Groups



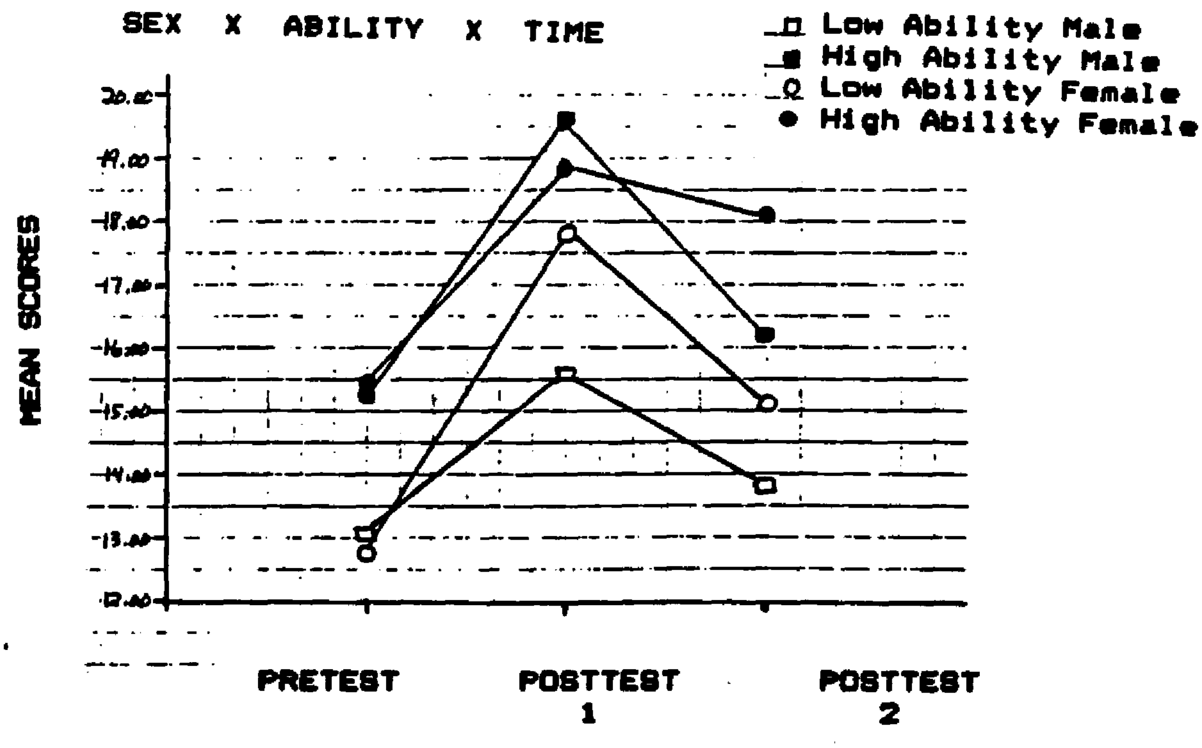


Figure 10. Graphs for Group x Ability x Time and Sex x Ability x Time for Achievement (Posttest 1)

4. High ability students in Groups 1, 2, and 4 performed significantly better ($p < .05$) on Posttest 2 than low ability students in Group 2.

5. High ability students in Group 4 performed significantly better ($p < .05$) than low ability students in Group 4 on Posttest 2.

Sex x Ability x Time. A significant interaction was found for science content between sex, ability level, and time ($F = 3.95$, $df = 2$, $p = .020$). The data for this comparison is summarized in Table 24 and is represented graphicly in Figure 10. The following significant differences were found:

1. Both high ability males ($p < .05$) and high ability females ($p < .01$) performed significantly better on the science content pretest and retention posttest (Posttest 2) than their low ability counterparts.

2. High ability males performed significantly better ($p < .01$) than low ability males on the achievement posttest (Posttest 1); this was not true for the females.

3. Low ability females performed significantly better ($p < .05$) than low ability males on the achievement posttest (Posttest 1). This was not true for the high ability males and females.

4. High ability females performed significantly better ($p < .05$) on the retention posttest (Posttest 2) than high ability males.

In summary, some students of different sexes or ability levels performed significantly better in some groups on either the achievement posttest or the retention posttest. These effects were not consistent across groups, ability levels, or sex. Results also indicated that the performance of low ability and high ability students and of male and female students was not consistent from achievement posttesting to retention posttesting.

Achievement Posttest x Group x Sex x Ability Level. Cell means and standard deviations resulting from the MANOVA for the achievement posttest by group, sex, and ability level were compared for significant differences. The achievement posttest results are summarized in Table 25. The following significant differences were found:

1. In Group 1, high ability males performed significantly better ($p < .01$) than low ability males and low ability females performed significantly better ($p < .05$) than low ability males.

2. In Group 2, high ability males performed significantly better ($p < .01$) than low ability males.

3. In Group 3, high ability females performed significantly better ($p < .01$) than low ability males; low ability females performed significantly better ($p < .05$) than low ability males.

Table 25. Cell Means and Standard Deviations for Achievement Posttest by Treatment Group, Sex, and Ability Level with MANOVA Results

Group	N	MEAN	SD
Group 1 (Regular Feedback):			
Male			
Low ability	14	15.2	6.1
High ability	12	19.9 **LM	3.7
Female			
Low ability	6	18.0 *LM	5.1
High ability	7	16.4	5.9
Group 2 (Trial Repetition):			
Male			
Low ability	7	15.6	3.7
High ability	11	20.1 *LM	6.2
Female			
Low ability	8	18.0	4.3
High ability	11	18.0	4.1
Group 3 (Explanatory Feedback):			
Male			
Low ability	10	14.3	5.5
High ability	8	17.6	6.0
Female			
Low ability	9	18.1 *LM	3.7
High ability	8	19.6 **LM	3.3
Group 4 (Trial Repetition and Explanatory Feedback):			
Male			
Low ability	16	16.9	5.9
High ability	10	20.6	5.4
Female			
Low ability	4	16.5	3.9
High ability	8	20.8 *LM	4.4

* $p < .05$ ** $p < .01$

Compared to: L=low H=high M=male F=female

4. In Group 4, high females performed significantly better ($p < .05$) than low ability males.

Retention Posttest x Group x Sex x Ability Level. Cell means and standard deviations resulting from the MANOVA for the retention posttest by group, sex, and ability level were compared for significant differences. The retention posttest results are summarized in Table 26. The following significant differences were found:

1. In Group 1, high ability females performed significantly better ($p < .05$) than low ability females and low ability males.

2. In Group 2, high ability females performed significantly better ($p < .01$) than low ability males or females.

3. In Group 3, both low ability and high ability females performed significantly better ($p < .05$) than low ability males; high ability females performed significantly better ($p < .05$) than high ability males.

Conclusions

The only significant main effect found was for ability level on the achievement and retention posttests for science content. Significant interactions were found between group, sex, and ability level for both computer attitude and science attitude. Significant effects for time were found for the achievement and retention posttests and for computer

Table 26. Cell Means and Standard Deviations for Retention Posttest by Treatment Group, Sex, and Ability Level with MANOVA Results

Group	N	MEAN	SD
Group 1 (Regular Feedback):			
Male			
Low ability	14	14.5	5.3
High ability	12	15.8	6.1
Female			
Low ability	6	15.3	3.5
High ability	7	18.9 *LF/LM	3.7
Group 2 (Trial Repetition):			
Male			
Low ability	7	12.6	1.6
High ability	11	18.3	4.8
Female			
Low ability	8	13.3	4.1
High ability	11	18.2 **LF/LM	4.3
Group 3 (Explanatory Feedback):			
Male			
Low ability	10	13.2	4.8
High ability	8	12.9	5.5
Female			
Low ability	9	16.3 *LM	1.7
High ability	8	17.4 *HM/LM	3.2
Group 4 (Trial Repetition and Explanatory Feedback):			
Male			
Low ability	16	14.1	5.1
High ability	10	17.2	5.4
Female			
Low ability	4	16.0	2.1
High ability	8	17.2	4.2

* $p < .05$ ** $p < .01$

Compared to: L=low H=high M=male F=female attitude. Significant interactions of group, ability level, and time and of sex, ability level, and time were also found for the achievement and retention posttests.

Summary

No significant difference was found on tests of achievement, science and computer attitudes, or retention of students in four different feedback treatment groups. MANOVA statistics were used to compare group means and multivariate tests were performed to determine significance. The only significant interactions found were for group, sex, and ability level for computer and science attitudes.

CHAPTER V

Overview, Summary of Findings, Recommendations, and Implications

Overview

Science education in the United States is in serious trouble (Sousa, 1984). According to Heylin (1982), recent studies indicate a steady decline in science achievement test scores over the last decade and a decrease in science course enrollment. Bloch (1986) noted the growing level of illiteracy in science and technology as a national problem.

In 1983, the National Commission on Excellence in Education issued a report titled *A Nation at Risk*. This document stressed the need for revision of science curricula to incorporate "appropriate scientific and technological knowledge (National Commission on Excellence in Education, 1983, p. 25)."

Use of microcomputers to supplement science instruction is motivating for students (Kolich, 1985; Torgesen & Young, 1983; Geoffrion, 1983) and incorporation of microcomputers into science curricula increases exposure of students to one important technological advance while providing students with an interesting mode of instruction. This, in part, addresses one of the problems identified by the national studies in reference to science education.

The purpose of this research study was to determine if trial repetition and explanatory feedback in computer-assisted instruction, either alone or in combination, have an effect on achievement, science and computer attitudes, or retention of less successful students in secondary science.

Students who participated in this study were enrolled in either Science 9, General Biology, or School Biology. The original sample consisted of 184 students: 103 males, 81 females, 89 ninth graders, 76 tenth graders, 14 eleventh graders, 5 twelth graders, 29 repeaters, and 7 students identified by the Committee on Special Education. The subjects were randomly assigned to one of 4 groups for intervention (N = 46). During the course of the study, 31 subjects were eliminated: 14 left either school or the science course they were enrolled in, 12 subjects missed either the pretest or one of the posttests, and 5 students used disks other than those of their assigned group number. The analysis sample consisted of 153 students: 89 males and 64 females. Treatment groups had unequal Ns: Group 1 = 40, Group 2 = 36, Group 3 = 38, and Group 4 = 39. Subjects were pretested three days prior to the beginning of intervention. Treatment sessions lasted for 15 days with subjects being assigned to one 42-minute computer treatment session one period per week for three consecutive weeks. All students were given posttest 1 on the Tuesday following treatment. This was a time span of 4 days. Posttest 2 was given nine days after posttest 1. All subjects received feedback during treatment. Presence or absence of trial repetition and explanatory feedback functioned as the independent variables in this study. Students in Group 1 lacked trial repetition and explanatory feedback; students in Group 2 had trial repetition but lacked explanatory feedback; students in Group 3 had explanatory feedback but lacked trial repetition; students in Group 4 had both trial repetition and explanatory feedback.

The three software programs designed for this research were all tutorial in nature and were all developed using an instructional design model proposed by Gagne, Wager, and Rojas (1981) and the Apple SuperPILOT authoring system. Curriculum content was selected from the General Biology syllabus. All of the programs had identical objectives, information, and questions.

The research questions concerned significance of main effects and interactions of treatment group, sex, and ability level on the dependent measures: achievement, retention, and science and computer attitudes. Three MANOVAs were performed comparing the dependent measures by treatment group, sex, and ability level. Repeated measures designs were used and data was examined for significance of main effects and interactions.

Summary of Findings

Results

The following results, corresponding to the research questions, were based on the data obtained from the three

MANOVAs performed during analysis:

1. Students in all four treatment groups performed significantly better ($p < .01$) on the achievement posttest (posttest 1) than they did on the pretest. Students in Groups 2 and 3 also performed significantly better ($p < .05$) on the retention posttest (posttest 2) than they did on the pretest. However, the performance of students having trial repetition and explanatory feedback was not significantly better ($p<.05$) on the achievement or retention posttests than that of students in the other three treatment groups. All four groups were essentially equivalent in performance on both the achievement and retention posttests.

2. Neither the computer attitudes nor the science attitudes of students having trial repetition and explanatory feedback were significantly better ($p<.05$) than those of students in the other three groups. All four treatment groups had essentially equivalent attitudes; there was no significant difference in the pretest-posttest 1 attitude scores of students in any of the treatment groups.

3. The effects of combining trial repetition and explanatory feedback were not cumulative since students in the group having both of these feedback conditions did not perform significantly better than students in any of the other three treatment groups.

4. Significant main effects were found for ability ($p <.01$) on the achievement posttest and for sex ($p < .05$)

and ability ($p < .01$) on the retention posttest. There were no significant main effects for treatment group on any of the dependent variables.

5. Significant interactions were found for group, sex, and ability level for both computer and science attitudes.

6. Significant effects for time were found for achievement and computer attitude. There were also significant interactions in achievement for group, ability, and time and for sex, ability, and time.

A summary of the results for each of the dependent variables by treatment group, sex, and ability level appears in Table 27.

Conclusions

Based on the results of the study, the following conclusion can be drawn when computer-assisted instruction is used and the programs are tutorial in nature:

There is evidence in this study that the inclusion of trial repetition and explanatory feedback in computer-assisted instruction, either alone or in combination, will not have a significant effect on the achievement, retention, or computer and science attitudes of students in similar target populations and under similar treatment conditions when the feedback treatment group is the only independent variable, the target group includes less successful students enrolled in science courses at the secondary level, and the treatment conditions include three-42 minute sessions of

Table 27. Summary of the Results for Dependent Variables by Treatment Group, Sex, and Ability Level

	ACHIEVEMENT	COMPUTER ATTITUDE	SCIENCE ATTITUDE	RETENTION
TREATMENT GROUP	NSD	NSD	NSD	NSD
SEX	NSD	NSD	NSD	FEMALES PERFORMED SIGNIFICANTLY BETTER ($p<.05$) THAN MALES IN GROUP 3. (TABLE 26)
ABILITY LEVEL	HIGH ABILITY FEMALES IN GROUPS 3 AND 4 DID SIGNIFICANTLY BETTER ($p<.05$) THAN LOW ABILITY MALES; HIGH ABILITY MALES IN GROUP 1 DID SIGNFICANTLY BETTER ($p<.01$) THAN LOW ABILITY MALES. (TABLE 25)	NSD	NSD	HIGH ABILITY FEMALES IN GROUPS 1 AND 2 DID SIGNIFICANTLY BETTER ($p<.05$) THAN LOW ABILITY FEMALES; HIGH ABILITY FEMALES IN GROUP 3 DID SIGNIFICANTLY BETTER ($p<.05$) THAN MALES. (TABLE 26)

NSD = No Significant Difference ($p<.05$)

computer-assisted instruction of three different life science programs having a total of 136 instructional frames and 90 questions frames.

Educational Implications

The literature on feedback research provides conflicting conclusions about the best structure for feedback. According to Carter (1984), the main function of feedback should be informational rather than reinforcing. This view is supported in research done by Gilman (1969), Roper (1977), Lasoff (1981), and Bardwell (1981). Immediate feedback enhances learning for students engaged in rote memory or discrimination tasks (Kulhavy & Anderson, 1972). A critical aspect of scheduling of feedback is that error correction occur (Carter, 1984). This is accomplished by feedback that corrects errors by explaining why an incorrect response is incorrect and why a correct response is correct. Feedback should be the type that corrects errors (Gilman, 1968; Roper, 1977).

Feedback designed for all four treatment groups in this study was intended to be reinforcing as well as informational, was immediate rather than delayed, and provided students with knowledge of correct results. The basic feedback incorporated into computer-assisted instruction programs used in the study had all of the critical feedback components identified by Carter (1984) and other researchers (Gilman, 1969; Roper, 1977). The feedback variables that were incorporated into the design of lessons for Groups 2, 3, and 4 included trial repetition and explanatory feedback. According to the results of this study, inclusion of these feedback variables did not have a significant effect on the achievement, science or computer attitudes, or retention of students in Groups 2, 3, or 4. When similar target populations are involved in instruction, educators should not have to include either of these feedback variables in computer-assisted tutorial instruction when the dependent variables are the same as the ones used in this study.

Design Implications

The researcher prepared a log of "design time" for the computer programs which were produced for the study. The summary of the production time (in hours) is shown in Table 28. The first program designed was Life Processes. Since the researcher was learning how to use Apple SuperPILOT during the design of this program, many more hours were required for the production of the first program. The time required for program design and production decreased as the researcher became more knowledgeable. The basic program for Group 1 was always designed first. Many more hours of design time were required to add trial repetition and explanatory feedback to the basic Group 1 program to create the programs for Group 4. Once the programs for Group 4 were completed, they were modified for Group 2 by removing the explanatory feedback and for Group 3 by removing the trial repetition. This revision process was not as time-consuming as actual production of the programs was.

The researcher spent a total of 282.6 hours designing programs for students in Group 1. An additional 100 hours was required to modify the Group 1 programs to include trial repetition and/or explanatory feedback for students in Groups 2, 3, and 4. According to the results of this research study, inclusion of trial repetition and explanatory feedback did not have a significant effect on achievement, science or computer attitudes, or retention of students in Groups 2, 3, or 4. Many hours of design time can be eliminated by not including these feedback variables in program design or by not using computers to deliver the instruction.

Field Procedure Implications

There is one reality a researcher must face when dealing with students who are less successful in science. These students are also often less successful in school. They have lower self-esteem and more negative attitudes toward school. There were some problems that arose in the study due to the behavior of some of these students. Incidents which occurred that may have affected the results of the study need to be recounted here.

Table 28. DESIGN TIME LOG FOR THE FEEDBACK STUDY

PROGRAM	PRODUCTION TIME (HOURS) GROUP 1	GROUP 4	GROUP 2	GROUP 3
LIFE PROCESSES	127.8	33.9	6.4	4.5
THE CELL: STRUCTURE AND FUNCTION	96.1	23.4	2.7	3.8
ECOLOGY: NUTRITIONAL RELATIONSHIPS	58.7	18.6	3.1	3.6
TOTAL TIME	282.6	75.9	12.2	11.9

Five students used disks other than those of their assigned group number during treatment. This information was picked up in the System.log file kept on each student. These five students had to be eliminated from the study because of disk-swapping.

Students were given the option at the beginning of the program to just do the quiz. This was done to allow slower students to come back to a program to do the quiz if they did not have time during the assigned session. Few students took advantage of the opportunity to spend extra time working on the disks. Six students (Group 1 = 2, Group 2 = 1, Group 3 = 1, Group 4 = 2) circumvented instruction and went directly to the quizzes during one of the treatment sessions. They repeated the quizzes during the treatment session rather than going through the programs. In retrospect, this option would be removed from the programs if the study were repeated. Not all students can be relied on to act responsibly during treatment.

Some students learned how to progress through the programs without reading all of the frames. They were observed not reading the feedback but moving on as soon as the cursor appeared. It was impossible to know if students were reading the feedback or not. It is also impossible to control for this in a computer center with twenty students and one teacher. As in any instructional situation, just because the instruction is presented does not ensure that the student will take advantage of the opportunity to learn from the instruction.

There were five students who simply would not take the attitude tests seriously. Since the computer and science attitude tests were identical, these students decided by the third time they saw it that it was no longer a serious endeavor. They circled all # 3s just to fill in the scan-tron sheet. There is little the researcher can do to keep some students from doing this. All five of these students also had missing data and were eliminated from the study on that basis.

There was a problem with the programs developed for students in Group 4. The inclusion of both trial repetition and explanatory feedback in the same program increased the time required for feedback to occur. Because of limited memory, microcomputers do take longer than mainframe computers to process the feedback messages. The researcher noted a number of students in Group 4 becoming frustrated during treatment because they had to wait. This situation was aggravated by the fact that often they were sitting next to students who did not have to wait as long. Combinations of feedback for use with programs designed for microcomputers should not result in frustrating "wait-time."

The researcher designed three separate programs in three different content areas. The programs were designed to take up the entire 42-minute time period for treatment so there would be no problem of what to do with students who finished early. This is not the most effective design for instruction. Students could have been overwhelmed by the amount of material they were asked to learn and remember in only three treatment sessions. There was also no classroom support from the teacher for the instructional content of the programs.

There were some very positive effects of the study on a number of teachers involved. One teacher was initially terrified of computers. Yet, she spent many hours previewing programs that were designed for the study. She also requested more time for her students in the computer center for treatment. This was time beyond that originally assigned for treatment. Two of the teachers signed up for their first computer course and three of them borrowed computers to take home for the summer. The indirect impact of the study on the amount of computer use in the school could be an important side-effect of the study if computers have instructional importance.

Theoretical Implications

One of the most important theoretical implications of the present study is that the feedback variables used in the design of the software used for treatment was only a small part of the actual design of the programs. The feedback variables used may not be as important as the actual design of the programs for less successful students at the secondary level. Students at this level are easily overwhelmed by too much content in too little time. One of the basic assumptions of the study could have been violated in that the programs might not have been effective instructional tools. These students also learn best when instructional content is presented by different modalities. The important support from the classroom teacher to reinforce the instructional content was missing since efforts were made to control for exposure of subjects to the instructional content. Effective instruction via computer should supplement classroom instruction rather than being presented to students in isolation from classroom instructional content.

The studies on feedback variables have been diverse. Most have occurred at the university level (Gilman, 1969; Roper, 1977; Lasoff, 1981; Geibpresert, 1986) and have involved the use of mainframe computers (Gilman, 1969; Roper, 1977; Lasoff, 1981; Geibpresert, 1986). There is a difference in the cognitive abilities of students in college and precollege students who are less successful in school. Lower ability students may be deficient in skills that involve abstract reasoning, attentional-perceptual coding, perceptual processing, and analysis (Allen, 1975). Less successful students may lack the cognitive skills necessary to benefit from more informative feedback. The results of this study indicate that trial repetition and explanatory feedback did not affect student achievement.

The results of this research study are largely consistent with conclusions drawn by other researchers. Gilman (1969) found that the most important factor for enhancing student learning was informing the learner as to which response was correct. This researcher concurs with Gilman on that point. All students in the present study received knowledge of correct results. There was no significant difference in the performance of any of the students on the achievement posttest or the retention posttest. The researcher did not find evidence to support Gilman's conclusion that the amount of information contained in feedback is an important factor affecting retention. Trial repetition and explanatory feedback could have increased the quantity of feedback without increasing the amount of information provided to the learner. More feedback does not necessarily mean better feedback or more informative feedback.

Allen (1975) noted that provision of corrective feedback in instructional materials may increase the learning of that material for all mental ability groups. The present study does not support this point. Adding trial repetition and explanatory feedback do not further enhance student achievement. The most important component of feedback may be knowledge of correct results.

Attitudes are included in Gagne's essential components of learning and instruction as one of the outcomes of learning. Attitudes do not determine specific acts (Bell-Gredler, 1986) but they do increase the chances of an individual engaging in certain activities (Gagne, 1977). With the present national state of science and technology, a desired end-product of instruction is for students to have more positive attitudes toward science and computers. The inclusion of trial repetition and explanatory feedback did not have significant effects on attitudes of students toward science or computers during the three week time frame for the study. If computers are used in science classrooms, this use should not be restricted only to the use of tutorial programs and should not occur in isolation from the classroom instructional content (Dence, 1980).

Trial repetition and explanatory feedback did not significantly effect retention in this study for less successful or lower ability students. "Given the poorer attentional and information processing skills of this group, the facilitating, correcting, and reviewing function served by such procedures would appear to be more beneficial to the lower than to the higher ability learners (Allen, 1975, p. 155)." The results of this research did not concur with Allen on this point. The results of the study did not support the efficacy of feedback repetition and/or context-sensitive feedback for facilitating either achievement or retention.

Recommendations For Further Research

Students vary considerably in their ability to acquire information and skills (Dunn, 1984). Because students differ cognitively, computer-assisted instruction may be better suited for some learners than for others. Ausburn and Ausburn (1978) emphasized the importance of cognitive style as a learner characteristic. They have identified 11 dimensions for the differences in the ways individuals process information. Further research should emphasize the classification of individuals into cognitive style categories to examine possible effects of trial repetition and/or explanatory feedback on students of varying cognitive styles. Different feedback variables should also be used as independent variables. Some of this type of research is already being done but there is more latitude in this direction for research.

Instructional design theory has definitely shifted from a behavioral perspective to a cognitive perspective (Sprague, 1981). Along with this shift, there is a need to re-evaluate old concepts of how learning can be promoted by instruction (Sprague, 1981). Wittrock and Lumsdaine (1977) noted that, from a cognitive perspective:

> ...to understand the effects of instruction upon learning and memory one must comprehend how learners use their cognitive processes, knowledge, abilities, aptitudes, and interests to transform the nominal stimuli of instruction into functional ones. These cognitive processes include attention, motivation, verbal and imaginal encoding, storage, and retrieval. (p. 418)

Further research should examine the effect of feedback variables on these cognitive processes to further define the cognitive role of feedback in instruction.

One limitation of this study was the time subjects were actually involved in treatment. Subjects received only three treatment sessions of 42 minutes each. Students were removed from normal classroom science instruction in order to participate in the study. This participation was totally dependent on both teacher and student cooperation. Therefore, the number of times normal instruction was interrupted had to be kept to a minimum. Further studies should involve students in longer CAI treatments. Longer durations of treatment may prove to be more effective and may result in significant main effects for treatment group. Other levels of students may perform differently than the target population of this study. Students in Regents level science courses may be more adept at processing more informational feedback. Different results may also be obtained in studies that involve different course content or that use question formats other than multiple choice.

Summary

Inclusion of trial repetition and explanatory feedback did not have a significant effect on achievement, retention, or science and computer attitudes of less successful students in secondary science. There were no significant main effects found for treatment group on any of the dependent variables. Significant interactions were found for group, sex, and ability level for both computer and science attitudes. The only significant differences in performance between student groups were found for low and high ability students under some treatment conditions on the achievement and retention posttests. The conditions where differences were found were not the same for the achievement posttest and the retention posttest.

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APPENDIX A

PILOT STUDY REPORT

The Effects of the Degree of Interaction of CAI on the Participation, Attitude, and Performance of Less Successful Students in Secondary Science

Purpose

A pilot study of this research problem was executed between October and December of 1986. The five primary goals of this pilot study were to:

(1) establish reliability data for the instruments that will be used in the main study,

(2) pilot-test the computer program prototye being developed,

(3) gather feedback on unanticipated problems that could arise in the computer center during treatment,

(4) utilize the results of statistical analyses of the data from the pilot study to alter the hypotheses, and

(5) examine results of data feedback for evidence of any possible treatment interactions.

Design of the CAI prototype. The computer programs were designed using an authoring program, Apple SuperPILOT. The variables that differ in each program are summarized in Table 1.

Table 1 Goes About Here

All three programs were exactly alike in the following areas authoring system used for design; computer used; content objectives; text presented; questions asked; and type of sequencing (linear).

The programs designed for Group 3 (minimal interaction) had delayed feedback and lacked repetition. They also lacked graphics. Students in this group recorded their answers on an answer sheet. The corrected answer sheet was their only feedback on whether they had responded correctly or not during treatment. They did not receive this sheet back until the day after treatment.

Table 1. Comparison of CAI Programs.

Variable	Group 1	Group 2	Group 3
Graphics	Yes	No	No
Feedback	-Immediate -Knowledge of Results -Positive Reinforcement	-Immediate -Knowledge of Results	-Delayed
Repetition	-Questions Repeated 3 times -Optional Review of Text before answering again	-Questions Repeated 3 times	-None

The programs designed for Group 2 (moderate interaction) also lacked graphics. Feedback for this group was immediate but consisted only of knowledge of results. This program was designed to allow the student to attempt to answer the question correctly three times. If they answered correctly, feeback consisted of the response, "That is correct." If they answered incorrectly, they were told: "No, that is not correct. Please try again." On the third incorrect try, the correct answer was provided and the students were moved on to the next text and question.

The programs designed for Group 1 (maximum interaction) included graphics, provided immediate feedback with a variety of positively reinforcing statements, and included a repetition of the relevant text before allowing the student to try to answer the question again.

Definition of Terms. The concepts in this pilot study were defined as follows: (1) Degree of Interaction of CAI was defined as the degree of active involvement of the student with the computer. It consisted of physical involvement (touching the keys of the computer) and mental involvement (reading text, answering questions, and responding to feedback). The amount and type of physical interaction varied within the three groups. The type of feedback, reinforcement, and repetion students were exposed to in the three programs also varied. It was anticipated that students who received immediate feedback in the form of positive reinforcement, who were given the option of reviewing the text prior to answering the questions again, and who had graphic displays would be more actively involved (higher degree of interaction) that students who received delayed feedback and no repetition.

(2) Participation was defined as the actual time-on-task during the treatment in the computer center. It was anticipated that students that were more motivated to perform the task would spend more time at it.

(3) Attitude was defined as the predisposed tendency of a student to respond favorably to the environment (computer treatment) and to the content presented (science).

(4) Performance was defined as the level of achievement of students on a science content test.

(5) Less successful students in secondary science were defined as high school students in grades 9-12 who were enrolled in non-Regents science courses. It is anticipated that these students will not be able to qualify for a Regents diploma. In most cases, these students will not continue their education after high school and will not be qualified for higher paying or more prestigious jobs.

Methodology

Design of the Pilot Study. The pilot study was an experimental investigation. Three classes of students were used (n=45). The students were randomly assigned to one of the three groups. All students were to be pretested, receive treatment, be posttested, and be parallel posttested. Only 40 students were actually present for treatment and some students missed one or more of the testing sessions. All students with missing data were eliminated from the final analysis. Based on the high mortality rate in the pilot study the following considerations will be made during the main study: (1) Students missing testing sessions will be asked to make these sessions up, (2) Students will be allowed to use the computer programs at any time and a log will be for each student to record their time-on-task, and (3) Students who miss treatment will be allowed to voluntarily make up the time in the computer center. This information will be kept in each student's log book.

The pilot study was designed to represent one-fifth of the main study. An anticipated comparison between the pilot study and the research study is summarized in Table 2.

Table 2. Comparison of the Pilot Study to the Research Study.

VARIABLE	PILOT STUDY	RESEARCH STUDY
NUMBER OF STUDENTS	40	200
NUMBER OF TREATMENT SESSIONS	1-30 MINUTE SESSION	5-30 MINUTE SESSIONS

Students did receive treatment for one session that was approximately 30 minutes of actual time-on-task. There were actually only 23 students out of the original 45 that were present for treatment and for all three testing sessions. Therefore, the data produced from the pilot study will be considered more important for refining the main study than for answering hypothetical questions.

Three classes of non-Regents science students were selected for the pilot study: one ninth grade Non-Regents Competency (NRC) class (N=13); one tenth grade General Biology class (N=19); and one tenth grade NRC class (N=8). A summary of all of the demographic variables compared for the 40 students present for treatment is found in Appendix E. Of the students that were present for treatment: (a) 57.5% were in tenth grade; 32.5% were in ninth grade; and 10% were eleventh and twelth grade repeaters. (b) 67.5% were aged 15; 22.5% were aged 16. (c) 64.5% reported having more than 6 months of experience using computers. (d) 32.5% were enrolled in 8th grade science the year before; 42.5% were enrolled in General Science 9. The rest of the students were in a variety of courses. (e) 60% of the students were males; 40% were females. (f) 15% were identified by the Committee on the Handicapped (COH).

Students from the three classes were assigned at random to one of the three groups for treatment. The three groups were equal initially (N=15). However, the groups were not equal after students with missing data were eliminated from the study (Group 1=7; Group 2=6; Group 3=10).

Development of Instruments. The type of treatment was the independent variable in this study. Dependent variables consisted of participation, attitude, and performance. In addition, a number of demographic variables were examined for possible effects and interactions. Instruments were designed to measure computer attitude, science attitude, and student performance (achievement) on a science content test. Participation was measured as time-on task in the computer center. It was not an important variable in the pilot study since students only went to the computer center for one 30-minute treatment. It was not possible to determine the effect of the degree of student-computer interaction on student motivation to participate. It is anticipated that this may be an important variable in the actual research study. Time-on-task will be recorded by each student in a log book and will be closely monitored.

Computer Attitude. A review of the literature revealed few studies which reported results of computer attitude testing. One computer attitude instrument was reported by Gressard and Loyd (1984). Their intitial study involved an examination of the reliability and factorial validity of the Computer Attitude Scale that they had developed. A total number of 155 students in grades 8 through 12 were involved in this study. A coefficient alpha reliability of .95 was obtained for this attitude instrument. Gressard and Loyd (1984) noted that this scale could be convenient to use to document changes in computer attitudes as a result of a computer education program.

The Computer Attitude Scale originally consisted of 30 Likert-type items. The most recent format has 40 items which can be divided into four subscales: anxiety, confidence, liking, and usefulness. A copy of the Survey of Attitudes Toward Learning About and Working With Computers (Computer Attitude Scale) developed by Gressard and Loyd (1984) is found in Appendix B. This was the format used in the pilot study. Results of the pilot study provided data on the alpha reliability of the computer attitude instrument used for pretesting, posttesting, and parallel posttesting. These results are summarized in Table 3. The same format of this Computer Attitude Scale was used in all testing sessions.

Table 3. Summary of Reliabilty of the Computer Attitude Scale Before and After Revision.

	ORIGINAL ALPHA	REVISED ALPHA
PRETEST	.94	.88
POSTTEST	.95	.89
PARALLEL POSTTEST	.96	.90

Many of the items in this attitude instrument were repetitious and the instrument was rather lengthy for the purposes of the main study. The instrument was revised by using only the first 20 items from the original instrument included in Appendix B. There are still equal numbers of items distributed among the four subscales. The alpha reliabilities of the revised attitude instrument that will be used in the main study appear in Table 3. A correlation matrix was generated using all variables in the study. There was a correlation of .82 between the pretest computer attitude scores and the posttest computer attitude scores.

Science Attitude. Student attitude toward science was measured in a study done by Price (1978). She developed an instrument to measure student attitude toward SCIS science in sixth grade students. The instrument that she developed consisted of 15 Likert-type items relating to SCIS science. The original instrument contained such questions as:

1. always
2. usually

I 3. sometimes like to talk about SCIS science.

4. rarely
5. never

This instrument was modified by eliminating "SCIS" and designing a checkbox format using the same responses. A copy of the evaluation instrument used for measuring student attitude toward science in found in Appendix C. The design of this instrument has been further modified to enable the responses to fit an A-B-C-D-E scan-tron answer sheet format for the main study.

Alpha reliabilities for the science attitude instrument are summarized in Table 4. The pretest-posttest correlation was .87.

Table 4. Alpha Reliabilities of the Science Attitude Tests.

SCIENCE ATTITUDE TEST	ALPHA
PRETEST	.90
POSTTEST	.91
PARALLEL POSTTEST	.81

Science Performance. Three parallel forms of a science content evaluation instrument were devised by the researcher. Questions were selected from five content areas of the General Biology syllabus: Similarities Among Living Things (Unit 1); Living Things and Their Environment (Unit 7); Human Biology (Unit 3); Continuation of Life: Reproduction (Unit 4); Variety Among Living Things (Unit 2). The content of the computer programs that will be used in the main study will encompass these five areas. The content of the computer programs used in the pilot study encompassed only Unit

1, Similarities Among Living Things. It is anticipated that, in the main study, students will receive one 30-minute treatment in each of these content areas. They will also have the option of spending out-of-class time on these programs. The time spent by each student on each program content area will be carefully monitored and will be recorded in a log kept on each student.

A more detailed summary of the procedure used to select questions for the three science content tests is found in Appendix F. Three sets of thirty-five questions were selected from General Biology exams administered from June of 1982 until June of 1986. Seven questions were selected from each of the five targeted content areas. A summary of reliability data for the three science content tests is found in Table 5.

Table 5.

SCIENCE CONTENT TEST	ALPHA	MEAN DIFFICULTY	REVISED ALPHA	REVISED MEAN DIFFICULTY
PRETEST	.75	46.54	.79	51.87
POSTTEST	.85	43.60	.88	50.23
PARALLEL POSTTEST	.85	38.31	.89	50.47

A difficulty index was determined for each item on each of the science content tests. The difficulty index was calculated as the percentage of students answering the item correctly. This information was used to determine a mean difficulty score for each test. This information is found in Table 5. It appears that the pretest was easier than the posttest or parallel posttest. Based on this information, one item from each content area in each of the three tests was eliminated. The final science content instruments, which will be used in the main study, contained 30 questions (6 questions in each of the five targeted content areas). The revised alpha reliabilities and mean difficulty levels of each of the three tests is shown in Table 5. There was a correlation of .80 between the science content pretest and the science content posttest.

Data Collection and Analysis Techniques. The following data was collected for each student: grade level, group, age, teacher, amount of computer experience, science course taken the previous year, final average in science for the previous year, sex, science course taken during the current year, identified by the Committee on the Handicapped or not, % of days in attendance, present for treatment or not, pretest score for computer attitude, pretest score for science attitude, pretest score for science content, posttest score for computer attitude, posttest score for science attitude, posttest score for science content, parallel posttest score for computer attitude, parallel posttest score for science attitude, parallel posttest score for science content, and number of minutes on-task during treatment.

A summary of these variables and the parameters of each variable appears in the Code Book in Appendix D. Only students who were present for treatment were included in the data analysis. A correlation matrix was computed using all of the variables listed above. A summary of the correlations between variables that were greater than r = .35 is shown in Table 6.

Table 6. Correlation Matrix Summaries ($r > .35$)

VARIABLES	CORRELATION
Teacher x Final average for previous year	.41
Teacher x Sex	.38
Teacher x Pretest for Science Content (Precon)	.72
Teacher x Posttest for Science Content (Postcon)	.74
Teacher x Parallel Posttest for Science Content (PPostcon)	.80
Course last year x Course this year	.80
Sex x Parallel Posttest for Computer Attitude (PPostcat)	.39
Pretest for Computer Attitude (Precat) x Postcat	.82
Precat x PPostcat	.64
Postcat x PPostcat	.82
Computer Experience x Posttest Science Attitude (Postsat)	.35
Pretest Science Attitude (Presat) x Postsat	.87
Presat x Parallel Posttest for Science Attitude (PPostsat)	.86
Postsat x PPostsat	.75
Presat x Precon	.46
Presat x Postcon	.48
Postsat x Precon	.44
Postsat x Postcon	.47
PPostsat x Precon	.51
PPostsat x Postcon	.44
Precon x Postcon	.80
Precon x PPostcon	.73
Postcon x PPostcon	.77

There was a high correlation between the teacher students were assigned to and performance on the science content test. Students in the General Biology class out-performed students in the other two classes. There was a high correlation between the teacher students were as-signed to and performance on the science content test. Students in classes. Since the science content questions were selected from past General Biology examinations, there was a test bias in favor of these students. There was also a high correlation between the course students took during the previous year, the students' final averages in those courses, and the teacher and course they were assigned to during the present year. At least one criterion for placement of students for succeeding years, especially at the high school level, is their success in science courses taken during the previous year. Students who are put in science courses based on poor grades one year are usu- ally less successful in following years. Grades are one of the criteria used to recommend placement of students in science courses.

There were high positive correlations between all of the computer attitude tests, all of the science attitude tests, and all of the science content tests. There was also a fairly high positive correla- tion between all of the science attitude test scores and performance scores on the science content tests. Students who had higher attitudes toward science performed better on the science content tests.

APPENDIX B

METHOD OF SELECTION OF ITEMS FOR THE PERFORMANCE (ACHIEVEMENT) INSTRUMENTS

METHOD OF SELECTION OF ITEMS FROM GENERAL BIOLOGY EXAMS USED IN THE PILOT STUDY TO DESIGN THE SCIENCE CONTENT TESTS

EXAMS USED:

A. EXPERIMENTAL SYLLABUS - JUNE 1986
B. 1971 SYLLABUS - JUNE 1986
C. EXPERIMENTAL SYLLABUS - JUNE 1985
D. 1971 SYLLABUS - JUNE 1985
E. 1971 SYLLABUS - JUNE 1984
F. 1971 SYLLABUS - JUNE 1983
G. 1971 SYLLABUS - JUNE 1982

UNITS SELECTED:

UNIT 1 - Similarities Among Living Things

UNIT 7 - Living Things and Their Environment

UNIT 3 - Human Biology

UNIT 4 - Continuation of Life: Reproduction

UNIT 2 - Variety Among Living Things

ITEMS USED IN THE PRE-TEST FOR SCIENCE CONTENT:

	ITEM NUMBER SELECTED				
EXAM	UNIT 1	UNIT 7	UNIT 3	UNIT 4	UNIT 2
A	1	96	16	62	47
B	7	54	15	34	42
C	3	103	15	63	49
D	5	55	19	100	41
E	2	64	22	97	41
F	3	54	20	103	41
G	1	61	71	81	56

ITEMS USED IN THE POST-TEST FOR SCIENCE CONTENT:

	ITEM NUMBER SELECTED				
EXAM	UNIT 1	UNIT 7	UNIT 3	UNIT 4	UNIT 2
A	2	97	19	63	49
B	4	53	19	37	43
C	4	104	17	62	46
D	4	51	21	105	45
E	3	65	23	98	42
F	6	56	23	105	42
G	2	62	73	82	59

ITEMS USED IN THE PARALLEL POST-TEST FOR SCIENCE CONTENT:

	ITEM NUMBER SELECTED				
EXAM	UNIT 1	UNIT 7	UNIT 3	UNIT 4	UNIT 2
A	4	94	20	65	45
B	3	60	11	35	44
C	1	101	16	65	52
D	3	52	18	42	10
E	6	63	20	45	8
F	1	9	21	32	44
G	3	63	75	83	58

APPENDIX C

INSTRUMENTS USED FOR MEASUREMENT

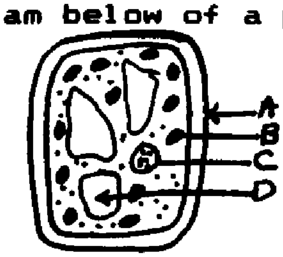
PRE-TEST FOR SCIENCE CONTENT

<u>DIRECTIONS</u> For each statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answers on the SCANTRON sheet by filling in the letter of the answer you choose with a NUMBER 2 PENCIL.

1. Which organelle contains chlorophyll to carry on photosynthesis?

   A. nucleus
   B. chloroplast
   C. mitochondrion
   D. plasma membrane

2. Which cell part labeled in the diagram below of a plant cell is also found in animal cells?



   A. A
   B. B
   C. C
   D. D

3. Which structure provides support and protection for plant cells?

   A. cell wall
   B. cell membrane
   C. chloroplast
   D. vacuole

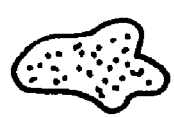
4. Enzymes for cell respiration are contained in the

   A. cytoplasm
   B. chloroplast
   C. mitochondrion
   D. vacuole

5. The semi-permeable structure that controls transport in a cell is the

   A. nucleus
   B. cytoplasm
   C. plasma membrane
   D. cell wall

6. The diagram below represents an ameba. Which essential part of this one-celled organism is missing in the diagram below?



   A. cell membrane
   B. cytoplasm
   C. cell wall
   D. nucleus

7. Which cell organelle produces protein for the cell?

   A. ribosome
   B. vacuole
   C. mitochondrion
   D. nucleus

8. Which structure is found in a green plant cell but not in an animal cell?

A. cytoplasm
B. cell membrane
C. nucleus
D. cell wall

9. Which organisms contain chlorophyll in their cells?

A. earthworms
B. perch
C. geraniums
D. humans

10. Which structure is present only in an animal cell?

A. chloroplast
B. cell membrane
C. lysosome
D. chromosome

11. The chemical breakdown of food for use by a cell is best described as

A. digestion
B. excretion
C. reproduction
D. synthesis

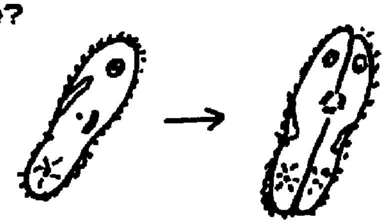
12. Carbon dioxide accumulates in the cells as a result of

A. synthesis
B. excretion
C. respiration
D. digestion

13. Food and oxygen are transported to the inside of a cell by

A. excretion
B. diffusion
C. synthesis
D. photosynthesis

14. Examine the diagram below which represents a paramecium. Which activity is taking place?



A. photosynthesis
B. reproduction
C. fertilization
D. meiosis

15. Protein production in the human body is an example of the life process of

A. respiration
B. synthesis
C. excretion
D. digestion

PRETEST

Directions: For each phrase in questions 16 through 18, select the life process, chosen from the list below, that is most closely associated with that phrase. Then record its number on the separate answer paper.

Life Processes

A. Digestion
B. Excretion
C. Synthesis
D. Respiration

16. The manufacture of complex substances in a cell

17. The removal of metabolic wastes from a cell

18. The chemical breakdown of food

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19. By which life process does a leaf produce both carbon dioxide and water?

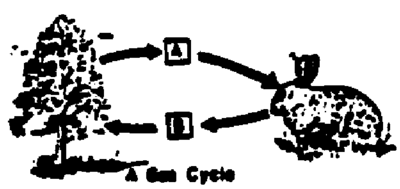
A. respiration
B. excretion
C. locomotion
D. photosynthesis

20. Which substances are products of photosynthesis?

A. sugar and salt
B. oxygen and sugar
C. water and carbon dioxide
D. sugar and carbon dioxide

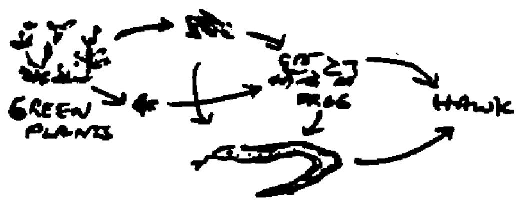
21. Examine the diagram below. The process that produces gas A is

A. transpiration
B. respiration
C. digestion
D. photosynthesis



22. According to the diagram drawn below, how many different types of organisms is the frog a source of food for?

A. 1
B. 2
C. 3
D. 4



23. The primary source of energy for living things is

A. oxygen
B. carbon dioxide
C. water
D. sunlight

24. The diagram below represents a food

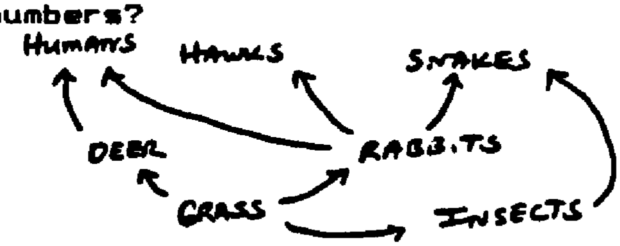
A. chain
B. web
C. pyramid
D. succession

25. Which organisms are omnivores?

A. humans and bears
B. crickets and mice
C. frogs and owls
D. green plants and lice

26. Which organisms in the diagram below are most likely present in the largest numbers?

A. hawks
B. deer
C. snakes
D. grass

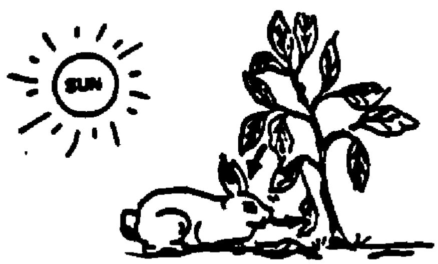


27. Animals which eat only plants are known as

A. scavengers
B. herbivores
C. predators
D. decomposers

28. The plants in the diagram below are known as

A. carnivores
B. herbivores
C. scavengers
D. producers



29. Which organism would be classified as a producer in a food web?

A. fish
B. ameba
C. yeast
D. algae

30. Which organisms could be the decomposers in a food chain?

A. fungi
B. algae
C. protozoa
D. lice

SCIENCE CONTENT POSTTEST 1

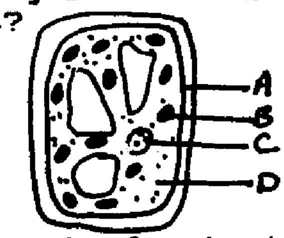
DIRECTIONS For each statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answers on the SCANTRON sheet by filling in the letter of the answer you choose with a NUMBER 2 PENCIL.

1. Which organelle contains enzymes necessary for cellular respiration?

   A. nucleus C. mitochondrion
   B. chloroplast D. plasma membrane

2. Which cell part labeled in the diagram below of a plant cell is not found in animal cells?

   A. A
   B. B
   C. C
   D. D



3. Which structure controls the movement of materials into and out of the cell?

   A. cell wall C. chloroplast
   B. cell membrane D. vacuole

4. Pigments for photosynthesis are contained in the

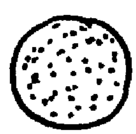
   A. cytoplasm C. mitochondrion
   B. chloroplast D. vacuole

5. The stiff outer part of a plant cell is the

   A. nucleus C. plasma membrane
   B. cytoplasm D. cell wall

6. The diagram below represents a human cheek cell. Which essential part of the cell is missing in this diagram?

   A. cell membrane
   B. cytoplasm
   C. cell wall
   D. nucleus



7. Which cell organelle regulates most cell activities?

   A. ribosome C. mitochondrion
   B. vacuole D. nucleus

8. Which structure is found in an onion cell but <u>not</u> in a cheek cell?

A. cytoplasm
B. cell membrane
C. nucleus
D. cell wall

9. Which organisms contain chlorophyll in their cells?

A. algae
B. earthworms
C. grasshoppers
D. tapeworms

10. Which structure is present only in a plant cell?

A. cell wall
B. cell membrane
C. lysosome
D. chromosome

11. The removal of metabolic wastes from a cell is best described as

A. digestion
B. excretion
C. reproduction
D. synthesis

12. Salts accumulate on the surface of the skin as a result of

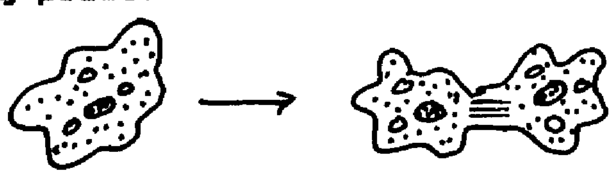
A. respiration
B. excretion
C. digestion
D. synthesis

13. Food and oxygen pass into a cell by

A. excretion
B. synthesis
C. diffusion
D. photosynthesis

14. Examine the diagram below which represents an ameba. Which activity is taking place?

A. photosynthesis
B. reproduction
C. fertilization
D. meiosis



15. Hormone production in the human body is an example of the life process of

A. respiration
B. synthesis
C. excretion
D. digestion

<u>Directions</u>: For each phrase in questions 16 through 18, select the life process, chosen from the list below, that is most closely associated with that phrase. Then record its number on the separate answer paper.

Life Processes

A. Digestion
B. Excretion
C. Reproduction
D. Respiration

16. The production of new organisms that are essentially the same as their parents

17. The release of energy from foods

18. The mechanical breakdown of food

---

19. By which life process does a leaf produce sugar?

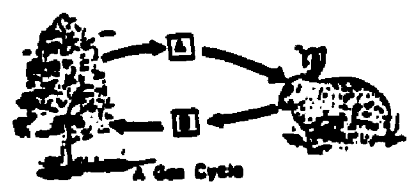
A. respiration
B. excretion
C. locomotion
D. photosynthesis

20. Which substances are waste products of respiration?

A. sugar and salt
B. carbon dioxide and sugar
C. water and carbon dioxide
D. sugar and starch

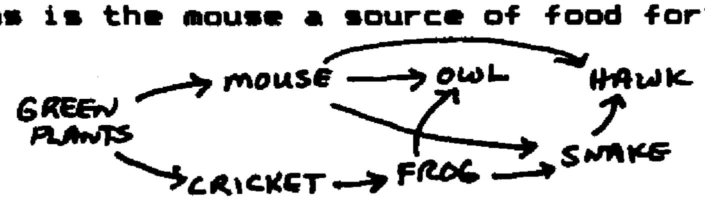
21. Examine the diagram below. The process that produces gas B is

A. transpiration
B. respiration
C. digestion
D. photosynthesis



22. According to the diagram drawn below, how many different types of organisms is the mouse a source of food for?

A. 1
B. 2
C. 3
D. 4



23. The primary source of energy for all life on Earth is

A. oil
B. coal
C. sunlight
D. wood

24. The diagram below represents

A. a food chain
B. a parasitic relationship
C. mutualism
D. a food web

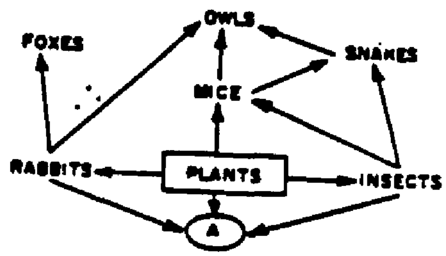
PLANTS ⟶ RABBITS ⟶ FOXES

25. Which organisms are herbivores?

A. cricket and mouse
B. frog and owl
C. snake and hawk
D. green plants and lice

26. Which organisms in the diagram below are most likely present in the largest numbers?

A. green plants
B. hawks
C. owls
D. snakes



27. Animals which kill and eat other animals are known as

A. scavengers
B. herbivores
C. predators
D. decomposers

28. The owls in the diagram below are known as

A. carnivores
B. herbivores
C. scavengers
D. producers

29. Which organism would be classified as a producer in a food web?

A. maple tree
B. hydra
C. owl
D. tapeworm

30. Which organisms could be the decomposers in a food chain?

A. grasshoppers
B. protozoa
C. algae
D. bacteria

SCIENCE CONTENT POSTTEST #2

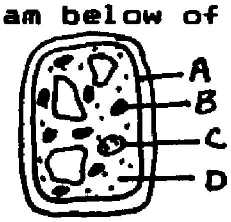
DIRECTIONS For each statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answers on the SCANTRON sheet by filling in the letter of the answer you choose with a NUMBER 2 PENCIL.

1. Which organelle contains chromosomes to transmit hereditary information?

   A. nucleus C. mitochondrion
   B. chloroplast D. plasma membrane

2. Which cell part labeled in the diagram below of a plant cell is not found in animal cells?

   A. A C. C
   B. B D. D



3. Which structure is the site of photosynthesis in plant cells?

   A. cell wall C. chloroplast
   B. cell membrane D. vacuole

4. The cell organelles are contained in the

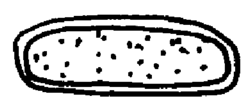
   A. cytoplasm C. mitochondrion
   B. chloroplast D. vacuole

5. The fluid of a cell for intracellular transport is the

   A. nucleus C. plasma membrane
   B. cytoplasm D. cell wall

6. The diagram below represents an onion skin cell. Which essential part of the cell is missing in this diagram?

   A. cell membrane C. cell wall
   B. cytoplasm D. nucleus



7. Which cell organelle stores materials for the cell?

   A. ribosome C. mitochondrion
   B. vacuole D. nucleus

8. Which structure is found in both an onion cell and a cheek cell?

   A. chloroplast C. lysosome
   B. cytoplasm D. cell wall

9. Which organisms contain chlorophyll in their cells?

A. humans
B. maple trees
C. grasshoppers
D. perch

10. Which structure is present only in a plant cell?

A. cell membrane
B. chloroplast
C. lysosome
D. chromosome

11. The production of starch from simple sugars by a cell is best described as

A. digestion
B. excretion
C. reproduction
D. synthesis

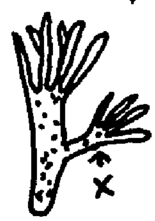
12. Complex molecules are converted into simple molecules as a result of

A. synthesis
B. excretion
C. respiration
D. digestion

13. The passage of food and oxygen into a cell occurs because of

A. excretion
B. synthesis
C. diffusion
D. photosynthesis

14. Examine the diagram below which represents a hydra. Which activity is taking place at X?



A. photosynthesis
B. reproduction
C. fertilization
D. meiosis

15. Enzyme production in the human body is an example of the life process of

A. respiration
B. synthesis
C. excretion
D. digestion

<u>Directions</u>: For each phrase in questions 16 through 18, select the life process, chosen from the list below, that is most closely associated with that phrase. Then record its number on the separate answer paper.

Life Processes

A. Synthesis
B. Growth
C. Respiration
D. Excretion

16. Increase in size or numbers of cells

17. The removal of waste products of metabolism

18. The release of energy from food for use by the organism

---

19. By which life process does a leaf produce both sugar and oxygen?

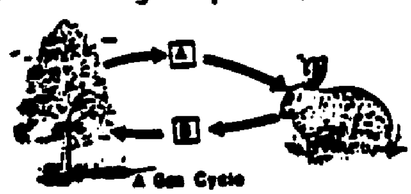
A. respiration
B. excretion
C. locomotion
D. photosynthesis

20. Which substances are required for respiration to occur in plants and animals?

A. sugar and salt
B. oxygen and sugar
C. water and carbon dioxide
D. sugar and starch

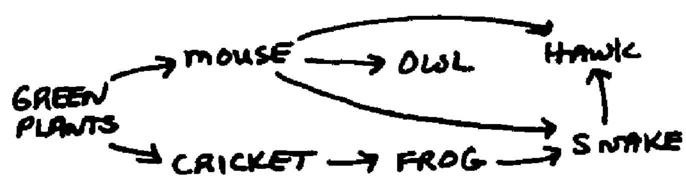
21. Examine the diagram below. The gas produced at A is

A. hydrogen
B. carbon dioxide
C. oxygen
D. nitrogen



22. According to the diagram drawn below, how many different types of organisms depend on the green plants as a source of food?

A. 1
B. 2
C. 3
D. 4

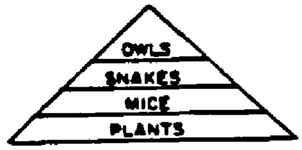


23. Energy for all life on Earth is primarily supplied by

A. sunlight
B. water
C. oil
D. coal

24. The diagram below represents a food

A. chain
B. web
C. pyramid
D. succession

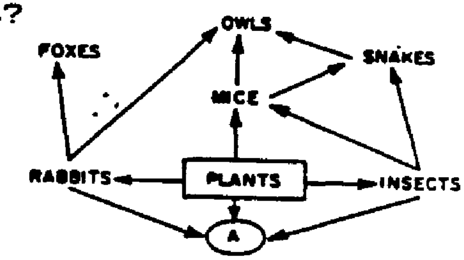


25. Which organisms are carnivores?

A. humans and bears
B. crickets and mice
C. frogs and owls
D. green plants and lice

26. Which organisms in the diagram below are most likely present in the largest numbers?

A. mice
B. foxes
C. plants
D. insects

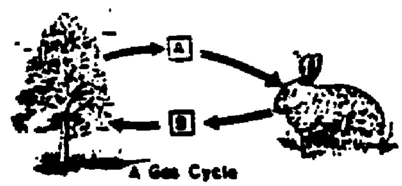


27. Animals which feed on other dead animals are known as

A. scavengers
B. herbivores
C. predators
D. decomposers

28. The rabbits in the diagram below are known as

A. carnivores
B. herbivores
C. scavengers
D. producers



29. Which organisms would be classified as producers in a food web?

A. insects
B. humans
C. grass plants
D. lice

30. Which organisms could be the decomposers in a food chain?

A. grasshoppers
B. bacteria
C. lice
D. protozoa

A SERIES OF STATEMENTS RELATING TO HOW YOU FEEL ABOUT COMPUTERS APPEARS LISTED BELOW. FOR EACH STATEMENT, FILL IN THE LETTER ON YOUR SCANTRON SHEET THAT BEST DESCRIBES HOW YOU FEEL ABOUT THE STATEMENT. FILL IN "A" IF YOU STRONGLY AGREE (SA), "B" IF YOU AGREE (A), "C" IF YOU DISAGREE (D), AND "D" IF YOU STRONGLY DISAGREE (SD) THAT THE STATEMENT DESCRIBES YOU.

31. Computers do not scare me at all.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

32. I'm no good with computers.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

33. I would like working with computers.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

34. Working with a computer would make me very nervous.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

35. Generally, I would feel OK about trying a new problem on the computer.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

36. The challenge of solving problems with computers does not appeal to me.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

37. I do not feel threatened when others talk about computers.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

38. I don't think I would do advanced computer work.

A. STRONGLY AGREE　　C. DISAGREE
B. AGREE　　D. STRONGLY DISAGREE

39. I think working with computers would be enjoyable and stimulating.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

40. It wouldn't bother me at all to take computer courses.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

41. I am sure I could do work with computers.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

42. Figuring out computer problems does not appeal to me.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

43. Computers make me feel uncomfortable.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

44. I'm not the type to deal well with computers.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

45. When there is a problem with a computer run that I can't immediately solve, I would stick with it until I have the answer.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

46. I would feel at ease in a computer class.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

47. I am sure I could learn a computer language.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

COMPUTER ATTITUDE

48. I don't understand how some people can spend so much time working with computers and seem to enjoy it.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

49. I get a sinking feeling when I think of trying to use a computer.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

50. I think using a computer would be very hard for me.

A. STRONGLY AGREE
B. AGREE
C. DISAGREE
D. STRONGLY DISAGREE

SCIENCE ATTITUDE

DIRECTIONS: PLEASE RATE YOUR ATTTITUDE TOWARD SCIENCE BY FILLING IN THE APPROPRIATE BUBBLE ON YOUR SCANTRON SHEET. PLEASE FILL IN ONLY ONE BOX FOR EACH STATEMENT AND PLEASE DO NOT LEAVE ANY STATEMENTS BLANK.

51. I like to talk about science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

52. I am glad to get away from science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

53. I like science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

54. I am better in science than most of my classmates.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

55. I get bored during science class.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

56. I dislike science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

57. I like to study science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

58. I think science is fun.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

59. I dislike getting up in the morning on science lab days.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

60. Science is a waste of time.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

61. Science is the best part of the day.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

62. I am successful when I do science.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

63. We are doing many fun things in science class.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

64. I like science class better than my other subjects.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

65. If I had my choice, I would NOT go to science class.

A. ALWAYS
B. USUALLY
C. SOMETIMES
D. RARELY
E. NEVER

APPENDIX D

TIME CARD

DEAR STUDENT:

Thank you for agreeing to participate in my study. There are a few things you need to know before your trip to the Computer Center.

1. You have been assigned to one of four groups. Your group number appears with your name on your disk. PLEASE USE ONLY THE LESSON DISKS THAT HAVE THE SAME GROUP NUMBER ON THEM THAT YOU HAVE BEEN ASSIGNED TO. THIS IS VERY IMPORTANT.

2. There will be two disks for you to deal with. The lesson disk will be placed in Disk Drive #1. The disk with your name on it will be place in Disk Drive #2. You will then turn on the monitor and the computer. The button for the computer is in the back on the right side. While you are waiting for the disks to load, you should record the data on your Time Card which is in the jacket with your disk. A copy of the Time Card appears below:

TIME CARD -- FEEDBACK STUDY

NAME *JOHN JONES* TEACHER *MRS. HAYDEN*
GROUP *(4)* PERIOD *6*

INSTRUCTIONS:
1. Put the lesson disk in Drive #1 and the disk with your name on it in Drive #2...close the drive doors.
2. Turn on the monitor and the computer.
3. While the program is loading, complete the information below:

Date	Start Time	Lesson	Group #	Disk #	Finish Time
3/17	11:58	ECOLOGY	4	35	12:21
3/22	7:59	ECOLOGY	4	33	8:27
3/24	11:55	CELLS	4	39	12:20
3/25	7:57	CELLS	4	40	8:25
3/31	11:56	LIFE PROCESSES	4	31	12:22

3. You may come to the Computer Center during study halls, ninth period, or any other free time. You may use the lesson disks as much as you want to on your free time as long as you complete the proper section of the time card for each visit. YOU MAY USE THE LESSONS AS MUCH AS YOU WANT TO !!!

Mrs. Myers

APPENDIX E

SCHEDULE FOR TESING AND TREATMENT

TO: Ms. Maxstadt, Mrs. Hayden, Mr. Sapone, and Mrs. Brousseau
From: Bonnie Myers
Re: Schedule for Testing and Treatment for the Feedback Study

The schedule for testing and treatment for the feedback study appears below. If there are any problems, please let me know. Thank you !

Pretest: In all classes on Monday, 3/14. Scan-tron sheets and pretests will be delivered to you Monday morning.

Posttest 1: In all classes on Tuesday, 4/5.

Posttest 2: In all classes on Thursday, 4/14.

COMPUTER TREATMENT

PERIOD	THURSDAY (3/17;3/24;3/31)	FRIDAY (3/18;3/25); WEDNESDAY (3/30)
1	MRS. HAYDEN - COMPUTER (15 STUDENTS) CENTER	MRS. BROUSSEAU - COMPUTER (13 STUDENTS) CENTER
2	MRS. MYERS - COMPUTER (10 STUDENTS) CENTER ROOM 45-10 STUDENTS	
3	MRS. HAYDEN - COMPUTER (15 STUDENTS) CENTER	MRS. BROUSSEAU - COMPUTER (15 STUDENTS) CENTER
5	MRS. HAYDEN - COMPUTER (7 STUDENTS) CENTER ROOM 45-10 STUDENTS	MR. SAPONE - COMPUTER (3 STUDENTS) CENTER ROOM 45 - 10 STUDENTS
6	MRS. HAYDEN - COMPUTER (13 STUDENTS) CENTER	MS. MAXSTADT - COMPUTER (16 STUDENTS) CENTER
7	MRS. MYERS - COMPUTER (4 STUDENTS) CENTER ROOM 45 - 10 STUDENTS	MS. MAXSTADT - COMPUTER (1 STUDENTS) CENTER ROOM 45 - 10 STUDENTS
8		MS. MAXSTADT - COMPUTER (17 STUDENTS) CENTER

APPENDIX F

COMPUTER PROGRAM EVALUATION FORM

COMPUTER PROGRAM EVALUATION

Dear ____________________,

Thank you for agreeing to examine and critique the computer programs that I have designed for use in my dissertation study. My proposal is titled *The Effect of Trial Repetition and Explanatory Feedback in Computer-Assisted Instruction on the Science and Computer Attitudes and Performance of Less Successful Students in Secondary Science.* The program(s) that you will examine are the programs that will be used by Group 1 in the study. The feedback variables for Groups 2, 3, and 4 will not be added until you have completed your evaluation and the appropriate changes have been made. It is important to the study that the content delivered to each student be the same. Would you please complete an evaluation form for each program you critique. Thank you again for you invaluable assistance in this endeavor.

Sincerely,

B.G. Myers

COMPUTER PROGRAM EVALUATION SHEET

Evaluator's Name_________________________Date_______________

Subject(s) Taught____

Number of Years of Teaching Experience in Science___________

Program Evaluated________________________Number of Disk____

Put the Disk in Drive #1 and turn on the compute and the monitor.

Did the program load without any problems ?______

Were there any areas of confusion in the program ?________

If your answer was "yes", please specify where:

Did you find any content inaccuracies in the program ?______

If so, please specify where:

List any spelling errors that need to be corrected:

Are there any mechanical errors ?_________

If so, where:

Do you have any suggestions for improving the program:

APPENDIX G

INSTRUMENT EVALUATION FORM

INSTRUMENT EVALUATION

Dear ____________________,

Thank you for agreeing to provide expert review of the instruments I will be using to pretest and posttest the students who will participate in my research study which is titled *The Effect of Trial Repetition and Explanatory Feedback in Computer-Assisted Instruction on the Science and Computer Attitudes and Performance of Less Successful Students in Secondary Science.* Please complete the Instrument Evaluation Sheet which is attached. Instructions for how to complete each section are given. Thank you again for your invaluable assistance in this endeavor.

Sincerely,

B.G. Myers

COMPUTER PROGRAM EVALUATION SHEET

Evaluator's Name________________________Date______________

Subject(s) Taught____

Number of Years of Teaching Experience in Science___________

Please compare the three documents attached item-by-item and complete the evaluation section for each item which appears below. Only items 1-30 need to be evaluated since items 31-65 are identical on each document. The following terms are defined for the purposes of this evaluation as:

identical = exactly the same (word-for-word)

parallel = testing the same content at the same difficulty level

tests for knowledge of = tests for recognition or recall of specific information

tests for application of knowledge = tests for ability to apply knowledge of specific information to new or novel situations.

<u>Question 1:</u>

	PRETEST		POSTTEST 1		POSTTEST 2	
	YES	NO	YES	NO	YES	NO
-tests knowledge of structure of cell organelles	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

The items on this test are:
[ ] identical [ ] parallel [ ] neither

On a scale of 1 (lowest) to 10 (highest), how similar are the items on the three tests in content and type (without being identical) ?

Lowest 1 2 3 4 5 6 7 8 9 10 Highest CIRCLE ONE
