THE EFFECT OF COLOR IN COMPUTER ASSISTED INSTRUCTION ON
VOCABULARY RETENTION RATES AND COMPUTER ATTITUDES
OF SELECTED UPWARD BOUND STUDENTS

DISSERTATION

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By

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The purpose of this study was to determine the effect on selected Upward Bound students' vocabulary retention rate and attitude toward computers when using color in a computer assisted instructional (CAI) program. Past research on the use of color in the educational process does not answer questions about possible effects it may have when used in CAI programs. Specific areas addressed by this study include: (1) differences in color computer assisted instructional software and achromatic versions of the lesson, (2) differences in the short-term vocabulary retention rate for color versus achromatic versions, (3) differences in the long-term vocabulary retention rate for color versus achromatic versions, (4) differences on the affective attitude scale for color versus achromatic versions, (5) differences in short-term memory based on gender and computer experience, (6) differences in long-term memory based on gender and computer experience and (7) differences on the affective attitude scale based on gender and computer experience.
Subjects in the experiment were high school students participating in Upward Bound programs at Texas Christian University and the University of North Texas. A pretest-posttest design was used and data were obtained from seventy-one students. A CAI program presented students with twenty words and definitions via a drill and practice mode. The words came from Schuster's list of rare and seldom used words considered easy to learn. Two computer systems were used in this study, achromatic and color. Students completed the Computer Attitude Scale at the beginning and end of the CAI lesson. A pretest, immediate posttest and two week delayed posttest were administered to both experimental groups.

Analysis of the data revealed a significant difference in long-term memory based on gender and computer experience. Girls using the color version of the lesson scored significantly higher on the delayed posttest than girls using the achromatic version.
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CHAPTER I
INTRODUCTION TO THE STUDY

Considerable research has been carried out over the past several years to determine the effect of using computer assisted instruction (CAI) in the educational process. Kulik, as early as the late seventies, identified fifty-one studies covering such diverse topics in computer assisted instruction as final examination performance, retention, attitude toward computers, attitude toward instructors and time needed to learn (Kulik, Barget & Williams 1983). In 1983, Kulik, Kulik and Cohen in his meta-analyses of research activities, found some two hundred studies across all grade levels on computer assisted instruction. Most of the studies were carried out between the years 1965 to 1980. In a special issue of Computers in the Schools, "Assessing the Impact of Computer-Based Instruction," eighty-five studies of computer assisted instruction from 1980-1987 were identified and reviewed (Roblyer, Castinet and King 1988). This review suggests that computing research may have dropped off slightly during the late 1970's but is on the rise again since 1984. A computer database search of dissertation topics which included the words "computer assisted instruction" revealed five hundred seventy-eight
studies in this area. It would appear that computers are not just another educational fad and that the study of computer assisted instruction will continue to be a topic of research for the foreseeable future.

The rapid increase in the total number of computer systems in our schools indicates its acceptance and use by teachers at all levels of education from preschool through college. According to Electronic Learning's Eighth Annual Survey taken in 1988, there were over one million, five hundred thousand computers in grades K - 12 in the United States (Electronic Learning 1988). The Ninth Annual Survey, released in October, 1989, shows that the number of computers in the twenty-five states returning data on the survey was then over two million (Electronic Learning 1989). This data excludes New York and California, two of the largest states. If data from the other twenty-five states had been included in this survey, there is little doubt that the total number of computers in our schools would be close to the two and one-half to three million mark. The continuing increase in the number of units and their expanded use in virtually all subject areas has resulted in, as Kulik (1980) says, "the computer becoming a major educational tool in the learning situation."

Judging from the business sections of newspapers and other related publications, it appears that the use of computers for educating and training employees has become
even more widespread in business and industry than Computer Assisted Instruction has in our educational institutions. The major difference between the two is what each institution calls the use of these high technology devices. Business and industry prefer to call its use Computer Based Training (CBT), while educational institutions use the term Computer Assisted Instruction (CAI). Hundreds of millions of dollars are being spent to establish computerized education and training programs for employees of both large and small corporations. In a recent television broadcast on the educational television station KERA, the subject of discussion was the parallel education and training programs that have been instituted by business and industry in America. The corporate world acknowledges the need for lifelong education and training of its employees and believes that computer based training (CBT) or computer assisted instruction (CAI) can provide them with the vehicle to accomplish this goal in the most effective and efficient manner.

In addition to the acknowledgement of computers as important teaching/learning tools, the corporate world has also recognized the effects that color can have on humans. Business giants such as IBM (Big Blue), General Motors (green cars don't sell very good), and McDonalds (orange and red make you hungry) have all exploited the color phenomena to their monetary advantage (Castigan 1984). Las Vegas
casino operators have long known that gamblers make more risky bets and gamble more under red light than under other colors and they design their gambling dens accordingly (Meer 1985). This finding was verified by research at Plymouth Polytechnic. Researchers found a difference in risk-taking behavior of twenty-eight students when exposed to red or blue light while taking part in gambling activities. Not only did students who sat under red lights gamble more, they also selected riskier bets than did those under blue lights (Judd & Wysaeccki 1975).

Color in an educational setting, in contrast to computer assisted instruction, has not been studied extensively since the 1950's when the use of television and film was first being used in the classroom as an educational tool. A few studies can be found on the effect of green versus white walls in the classroom and on color versus black-and-white sixteen millimeter film, etc. Color and computer assisted instruction have not been studied sufficiently as co-factors to allow us to answer important questions about their combined use in educational instruction and computer based training.

Major microcomputer companies recognize the significance of using color as evidenced by the introduction of a new generation of computers and peripheral devices that now have the capability to produce color output for printers as well as video display screens. Software publishing
companies are now producing programs to take advantage of improvements in the color capabilities of such new machines as the Macintosh II which claims to have the capacity to reproduce over sixteen million colors (two hundred fifty-six colors and two hundred fifty-six shades of gray at any one time) (MacWorld 1987, 29). Color printers, even very expensive laser printers costing up to ten or fifteen thousand dollars, are also being manufactured to allow computer users to print what they have created on their color monitors. Industry, it seems, is not satisfied with a achroma world and is steadily moving toward more sophisticated hardware and software that include color capabilities.

According to Farley and Grant (1976) the effect on learning of color as opposed to black-and-white presentations in film and television has generally indicated no significant learning differences. There is, however, reason to believe that color should influence memorial processes in learning. Considerable evidence suggests that color does have an effect on long-term retention (Farley & Grant 1976). Substantial evidence also suggests that physiological arousal during learning is a significant function of long-term retention. Our understanding of information can be significantly affected by the use of color and, as Durrett and Trezonia note, it can be a powerful manipulator of our attention and memory as well as
our understanding of material to be learned (1982). Color influences where you look and what you think about. It can be used to manipulate attention and it aids in organizing, coding and giving meaning to visual information.

One area, in which substantial evidence exists, suggests that color is aesthetically pleasing and thus, more motivating than black-and-white (Rambally & Rambally 1987). Motivation is an important factor in the learning process. The higher a student's motivation is, the greater the opportunity for learning to occur. It should also be noted that, as most parents know, children very seldom watch a black-and-white movie on television. To them, it does not seem as aesthetically pleasing as a color movie; it does not attract and hold their attention. Black-and-white movies barely get a glance when children flip through the channels looking for something to watch on a television.

Farley and Grant (1976) suggest that further analyses of color effects on reminiscence are needed using materials and media other than slide/tape presentations. This would surely include the study of color and computer assisted instruction. It is also noted that static presentations such as slides, illustrations and overhead transparencies may not provide enough stimulation to show differences of any significance resulting from the use of color (Farley & Grant 1976).
Hannafin (1985) notes that little concrete data is available about the use of color in screen design. He states that it is very important that screen design should become a precise science if the maximum efficiency of computers is to be attained. Color is an important variable in the design and cost of both instructional materials and computer hardware. We need to know whether the additional cost of color provides offsetting increases in learning efficiency and effectiveness.

Hativa and Teper also state that "Many studies have examined the use of color in other educational media, e.g., transparencies, slides, films and television" (1988, 304). She also notes that the use of color with computers has not been researched. Shaveloson and Salomon argue that we should research the media attributes that are important in learning and not emphasize the type of technology that provides the computer assisted instruction (1985). The knowledge from research on the use of color in other media should be applied to computers and computer assisted instruction as well, according to Hativa and Teper (1988). The research concerning its effectiveness in increasing student learning is at best inconclusive (Dwyer 1971).

The researcher in this study examined investigations on the effect of color on humans with emphasis in the areas of learning, attitude toward computers and experience working with computers. A study was also conducted on the effects
of using color in a computer assisted instruction lesson designed to teach vocabulary definitions to high school students.

**Statement of the Problem**

The problem of this study was to ascertain the effect of color as opposed to achromatic computer assisted instructional software in terms of vocabulary retention rates and computer attitudes of selected Upward Bound students.

**Purposes of the Study**

The purposes of this study were to compare the use of computer assisted instructional software in the following areas:

a) differences in color computer assisted instructional software and achromatic versions of the lesson

b) differences in the short-term vocabulary retention rate for color versus achromatic versions of the lesson

c) differences in the long-term vocabulary retention rate for color versus achromatic versions of the lesson

d) differences on the affective attitude scale for color versus achromatic versions of the lesson

e) differences in short-term vocabulary retention based on gender and computer experience
f) differences in long-term vocabulary retention based on gender and computer experience

g) differences on the CAS based on gender and computer experience.

Research Hypotheses

To do this study it was necessary to develop and test the six following null hypotheses using color and achromatic versions of a computer assisted instructional lesson:

1. Subjects using the color computer assisted instruction program will not differ significantly in short-term vocabulary retention rate from subjects using the achromatic program.

2. Subjects using the color computer assisted instruction program will not differ significantly in long-term vocabulary retention rate from subjects using the achromatic program.

3. There will be no significant difference between the mean scores on the Computer Attitude Scale for the color versus the achromatic group.

4. There will be no significant differences in short-term retention based on gender and computer experience.

5. There will be no significant differences in long-term retention based on gender and computer experience.
6. There will be no significant differences on the Computer Attitude Scale based on gender and computer experience.

Significance of the Study

Substantial research can be found for and against the contention that color has psychological and physiological effects on the human body. Does the color red increase blood pressure and the flow of numerous hormones in the body? Does the color pink, when used on prison walls, act as a soothing influence on inmates? Is the color green an appropriate color for schools and other learning environments? A definitive answer to these questions awaits further study. Tullis (1981) and Rambally and Rambally (1987) suggest that further study of the effects of color on the physiological and psychological functions of the human systems be performed. The use of color on computer terminal screens has also been investigated. These studies, however, investigated the functional use of color as a method of coding information and omitted studying any effects caused by color itself. Very little research exists on the effects of using color as a non-functional cue in computer assisted instruction. While scores of studies can be found on the effects of using color versus achromatic educational materials (slides, textbook pictures, transparencies, film and video), studies on the effect of using color in computer
assisted instruction, in a mode other than for coding, are scarce (Farley and Grant 1976).

This study provides information and insight, in the human factors area, concerning the use of color in computer assisted instructional software designed for secondary school students. The study investigated the relationship between both short-term and long-term memory and the use of color. The effect of color use on the attitude of users toward the computer assisted instructional lesson as well as difference based on gender and computer experience were also studied.

Data from this study is needed by educators who must make decisions about software and hardware uses and purchases. Answering these questions about color will help teachers and administrators make decisions about instructional delivery systems. Should they spend more money to upgrade their hardware to include color capability? Should software be discarded if it is not in color? When financial resources are limited these decisions become most important to schools. If color does not have an affect on students' learning and attitude then there may not be a need to purchase the more expensive color hardware systems or upgrade black-and-white software programs to color versions. As noted earlier, numerous experts in the area of learning as well as computer science have suggested further study to determine the effects of using color in computer assisted
instruction or computer based training. These include Farley (1976), Hannafin (1985) and Dwyer (1971). Lastly, Baron (1987) says of color, "... the investigation of their (color) potential impact on task performance seems justified."

**Definition of Terms**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CAI)</td>
<td>Computer Assisted Instruction - the use of microcomputers in the instructional process.</td>
</tr>
<tr>
<td>Chromatic</td>
<td>Consisting of one of the primary hues or shades and tints of these hues (color).</td>
</tr>
<tr>
<td>Color</td>
<td>One of the primary hues or shades and tints of these hues.</td>
</tr>
<tr>
<td>Attitude</td>
<td>The affect as determined by the Computer Attitude Scale.</td>
</tr>
<tr>
<td>Retention Rate</td>
<td>The number of word definitions retained as measured by a pretest and posttest.</td>
</tr>
<tr>
<td>Achromatic</td>
<td>White and black only.</td>
</tr>
<tr>
<td>Hue</td>
<td>One of the psychological primary colors - red, blue, yellow, green.</td>
</tr>
<tr>
<td>Black</td>
<td>The absence of color (all visible light wavelengths being absorbed).</td>
</tr>
<tr>
<td>White</td>
<td>The presence of all colors (the reflection of all wavelengths of visible light).</td>
</tr>
</tbody>
</table>
Short-term memory  Minutes after learning (maximum of ten minutes).

Long-term memory  Days after learning (maximum of two weeks).

First Generation College Student  A student, neither of whose parents has earned a four year college degree.

Computer experience  Having one year or more of computer classes or work.

College potential  Having test scores, grade point average, attitude and rank in class suggesting probable success in college.

Limitations

This study was conducted using subjects participating in the Texas Christian University and University of North Texas Upward Bound Programs. Upward Bound is a federally funded college preparatory program for economically disadvantaged youth. No attempt should be made to generalize results from this sample to other populations. A further limitation of this study is the use of a computer assisted instruction lesson that teaches vocabulary definitions. Therefore, no attempt should be made to generalize the results from this study to other academic subjects.
Materials

A computer assisted instruction software program was written using Apple SuperPilot, an authoring language commonly used by teachers. The lesson is a drill and practice and/or tutorial program that teaches vocabulary definitions. The lesson contains twenty words chosen from Schuster's list of seldom used words (Schuster 1982). Schuster's word list was made up of two hundred words which all had been above the median in terms of students' ability to memorize their definitions. These words are ones that are not too difficult to learn for the average high school student. A list of the words used in this study with their definitions follows:

Badchen  A professional jester
Benmost  Innermost
Cretaceous  Chalky
Cyanope  Blonde
Deictic  Showing or pointing out
Dimpsy  Dark or Dusky
Footle  Act or talk foolishly, to waste time
Gally  To frighten
Kiddier  A vegetable seller
Kittle  Tickle or perplex
Laches  Undue delay
Logian  A maxim or slogan
Meecher: Truant or thief
Podesta: A judge
Ranny: A mongrel calf
Runcation: Pulling weeds
Secant: Cutting line
Sepiment: A fence
Tushery: Poor writing style
Twibill: A two headed axe

The computer assisted instruction lesson runs on an Apple IIgs microcomputer with color capability and requires approximately twenty to twenty-five minutes to complete. The size of the letters are double video size for small characters. The text is double spaced. The achromatic system has a white border around the screen, a black background and white letters. The color system was identical in physical layout but had a dark blue border, a light blue background and purple letters. The screens on the following pages compose the lesson presentation.
Screen 1 - The word is presented to the student in the center of the screen. The word is in all-caps. Students must press return to go to the next screen.

The word is:

CYANOPE

PRESS RETURN
Screen 2 - The definition is presented to the student in the center of the screen. Students must press return to go to the next screen.

Definition:

A BLONDE.
Screen 3 - The definition is presented to the student in the center of the screen. Students must press return to go to the next screen.

The young cyanope was from Germany

PRESS RETURN
Screen 4 - A multiple-choice question with three short definitions is presented on this screen. Students answer the question. If the answer is correct the program continues to the next word. If incorrect, the student has one more chance to answer correctly.

Which of the following is the correct definition for cyanope?

A. a girl.
B. a foreign student
C. a blonde.

Answer:

PRESS RETURN
A panel of three educators who have expertise in and/or experience in computer assisted instruction reviewed the vocabulary software programs to evaluate them as a simple drill and practice or tutorial program designed to teach vocabulary word definitions. The form used by the reviewers to collect data on the computer assisted instructional programs was developed using general guidelines for software evaluation. This form is a revision of an earlier version which did not provide space for the panel members to rate both the color and achromatic versions. This was deemed necessary because of items 8 and 8a on the evaluation form. These two items which could vary for each of the versions individually, would have resulted in different scores for the programs (the achromatic version would have been rated zero on use of color). Item eight, use of color, and item nine, brightness for the achromatic version were important factors but different for each program. A copy of the evaluation rating form is provided in the Appendix.

Each of the three panelists reviewed both the color and achromatic versions of the computer assisted instructional program. During the review, each panelist completed a rating form for each version of the software program. An average score for both programs was computed for each panelist. A score for both programs was also computed using all three panelist's scores. The computer assisted instructional software programs received average scores of
2.58 and 2.50 for the achromatic and color versions respectively from the combined scores of all panelists. The top rating obtainable was 3.00 (Excellent). The ratings obtained by all panelists, individually, were between Above Average and Excellent. Data from the panelists is displayed in Chart One below. The first column for each panelist shows data for the achromatic version while the second column displays the data for the color version of the computer assisted instructional programs.

Chart One

Software Evaluation Rating
The numerical scale values are assigned subjective descriptors as follows: 0 = Poor; 1 = Average; 2 = Above Average; 3 = Excellent.

**Instrumentation**

The pretest, posttest and delayed posttest used in this study were printed paper and pencil tests. Each test consisted of twenty words divided into two groups of ten words each. Subjects matched the words with the correct definition chosen from a list of ten choices and one distractor for each word group. The tests were identical except for the word order which was changed for each instrument.

The **Computer Attitude Scale** was used to measure students' attitudes toward computer assisted instruction. The instrument was developed by Loyd and Gressard at the University of Virginia—Charlottesville (1984). The scale is a Likert instrument and measures anxiety or fear of computers, liking or enjoying working with computers and confidence in ability to use or learn about computers. The scale has forty items and subjects mark either strongly agree, slightly agree, slightly disagree, or strongly disagree for each statement. Positively and negatively worded statements are included for each of the four areas. The items were selected by a panel of judges from an original pool of seventy-eight items to represent each of
the four attitude domains; ten items were chosen for each of the four subscales (Loyd & Gressard 1984).

In a study conducted by Loyd and Gressard, the reliability coefficients of the subscales and the findings of the factor analysis suggest that the scores of the subscales are sufficiently stable to be used as separate scores (1984). They also found that the magnitudes of intercorrelations among the subscales of the large loadings on the initial factor analysis indicate that the subscales share a large amount of common variance and thus, the assumption that the total score does represent a general attitude toward working with computers.

The reliability coefficients are: .86, .91, .91, and .95 for the computer anxiety, computer liking, computer confidence and the usefulness subscales, respectively. The scale was a paper and pencil exercise which most students completed in approximately ten minutes. The survey is scored according to the following:

For questions 1, 3, 4, 6, 9, 11, 12, 14, 16, 17, 19, 22, 25, 27, 28, 30, 33, 35, 36 and 38, Strongly Agree = 4, Slightly Agree = 3, Slightly Disagree = 2 and Strongly Disagree = 1. For questions 2, 5, 7, 8, 10, 13, 15,18, 20, 21, 23, 24, 26, 29, 31, 32, 34, 37, 39 and 40, Strongly Agree = 1, Slightly Agree = 2, Slightly Disagree = 3, Strongly Disagree = 4. Four subscores are obtained by adding points for the following questions:
Anxiety: 1, 5, 9, 13, 17, 21, 25, 29, 33, 37
Confidence: 2, 6, 10, 14, 18, 22, 26, 30, 34, 38
Liking: 3, 7, 11, 15, 19, 23, 27, 31, 35, 39
Usefulness: 4, 8, 12, 16, 20, 24, 28, 32, 36, 40

Higher scores correspond to more positive attitudes; e.g., a higher anxiety score means less anxiety.

Subjects

The subjects in this study were ninth, tenth, eleventh and twelfth grade students enrolled in the Texas Christian University and University of North Texas Upward Bound Programs. Upward Bound is a college preparatory program for high school students of whom sixty-seven percent are low income and first generation college students. Students must have the potential for success in post secondary school as determined by grade point average, available test scores and teacher or counselor recommendations. The group consisted of forty-four females and twenty-seven males. There were twenty-one seniors, sixteen juniors, twenty-one sophomores and thirteen freshmen. The ethnic breakdown was twenty-four black, seventeen Hispanic, twenty-six Caucasian students and four others.

Students are accepted into the Upward Bound program after they have completed the eighth grade. They attend Saturday morning or week-night meetings during the academic school year. Students attend a schedule of classes which includes subjects such as Latin, computer education lab,
group dynamics, study skills and writing. The classroom activities last for approximately four hours each meeting. After-school tutoring and free computer lab time are available for the Texas Christian University students four days a week from three to six-thirty p.m. During the summer students attend a six week residential program on their respective campuses. The program is designed to provide enrichment as well as basic skills improvement in writing, mathematics, computer science, communication skills, physical education and study skills. It also provides counseling in personal relations, academics and career awareness. The profiles of all Upward Bound students are very similar. They are low-income students with the potential for success in college. They have committed themselves to extra work to obtain a goal of education beyond high school.

Research Design and Treatment

The design of this study of the effect of a color computer assisted instruction program versus an achromatic computer assisted instruction program was a variation of the pretest-posttest control group design described by Campbell and Stanley (1963). The independent variables were the color and achromatic computer assisted instruction software programs. The dependent variables were the posttest scores on the word definitions and the Computer Attitude Scale.
The study was conducted during a regular Upward Bound Saturday meeting on the Texas Christian University and University of North Texas campuses. The subjects, Upward Bound participants, normally attend classes several Saturdays during the academic school year. Data for the study was collected during one of the regular class periods. Students from the programs were randomly assigned to one of two experimental groups--achromatic screen or color screen computer assisted instruction program. The vocabulary pretest on the twenty words used in the computer assisted instruction lessons was administered to all subjects. The subjects also completed the pre-Computer Attitude Scale. After the pretests were completed, subjects were seated at the appropriate computer system for their assigned experimental group, color or achromatic. Subjects completed the program and were then administered the immediate posttest and the post-Computer Attitude Scale. A delayed posttest on the vocabulary words was administered two weeks after the immediate posttest.

Reporting of Data

Analysis of covariance was used to compare the mean scores between the color and achromatic computer assisted instruction groups. The covariates were the vocabulary pretest and the Computer Attitude Scale. The independent variables were the color and achromatic computer assisted instruction programs. The dependent variables were the
vocabulary posttests and the second Computer Attitude Scale. The level of significance below which the null hypothesis was rejected was set at the $p = .05$ level.
CHAPTER II

REVIEW OF LITERATURE

Light and Color

A clear distinction between light and the eye or vision has not always been understood (Overheim & Wagner 1982). It was not until the year 1000 A.D. that an Arab scholar, Alhazen, drew a clear distinction between light as a physical entity and the eye as a detector of light (Overheim & Wagner 1982). Very little progress in the understanding of light was made until this time. Light like any other form of matter is a physical entity with its own physical properties. Unlike sound and color, however, light exists whether anyone is around to see it or not. Light does have an effect on humans. These effects have been studied for many years and have evolved into studies of specific areas of the spectrum including both visible and non-visible radiation.

Light is the stimulus for color vision (Boynton 1979). Rays of light themselves are not colored. They do contain, however, a disposition to elicit color perception in an observer. Humans perceive color when the different wavelengths composing white light is selectively interfered with by matter (absorbed, reflected, refracted, scattered,
or diffracted) as it travels to our eyes (Christ 1987). The human eye can distinguish approximately three hundred-fifty thousand different colors or wavelengths of visible light (Foley 1984). "The perception of these colors is a subjective experience in which physiological and psychological factors have an important part." (Nassau 1980, 124). Nassau also notes that it seems reasonable to assume that perceived color is merely the eye's measure and the brain's interpretation of the dominant wavelength of frequency or energy of a light wave. Essentially, the perception of color is a mental process. Like sound, color is not an independent occurrence in nature that exists in and of itself.

Birren (1961, 271) states that "in the general 'gestalt' of seeing, it is not possible to separate the psychological factors from the physical and physiological factors." Castigan (1984) notes there is some evidence that the response to color is determined in the brain's reticular formation, a relay station for millions of the body's nerve impulses, and that the release of hormones or neurotransmitters may be triggered during the act of sight which in turn may influence moods and activities such as heart rate, blood pressure and breathing.

Castigan (1984) mentions an experiment performed at the American Institute for Biosocial Research in which the color pink decreased the strength levels of participants in a
strength test. Subjects taking part in the test were sent to a room where a hand-grip device was used to determine hand strength. Data were collected on each participant's strength level when squeezing the device. The following day, subjects returned to repeat the test. This time, subjects were sent to a room that had been painted pink. All subjects' strength level data showed declines in the pink room when compared to the previous day's data obtained in a white room. The color pink has also been used in prisons and juvenile delinquent homes because of its supposedly calming effects on these sometimes violent people.

Researchers have found that the "components" of light are necessary to our mental and physical well-being (Meer 1985). Some believe that blue-green light can lift the depression of persons suffering from Seasonal Affective Disorders (SAD) (Meer 1985). Babies born suffering from neonatal jaundice are bathed in blue light which they say breaks down toxic substances in the blood stream which is then washed out of the body (Meer 1985). One psychologist in Los Angeles goes so far as to use color shower imagery in an attempt to dramatically impact the health and well-being of patients (Meer 1985).

As noted earlier, the effects of light on humans has been studied for a relatively long time. Ben E. Graves (1985) provides a summary of the effects of light that have
been documented in scientific studies. According to Graves' studies, effects of light on humans that have been "well established" include vitamin D synthesis, calcium absorption rate and resistance to common illness. Some "not conclusively established" effects of light include visual acuity, hyperactivity, intellectual development and scholastic achievement. Graves also summarized the "well documented" effects that color has on humans. These include relaxation caused by cool colors such as blue and pink, increased activity caused by warm colors such as red, attentiveness/alertness caused by yellow/orange or red, aggression control caused by pink and strength variation caused by blue (increased) and pink (decreased).

It seems that some researchers believe that light and color not having an affect on humans would be more astounding than the opposite occurrence.

Color and Learning Studies

The fact that light can be broken down into its constituent colors by a prism is a well-known, elementary school science experiment. The rainbow made by passing white light through a prism displays colors ranging from red to blue. (Black is the absence of all color and exists only in our heads--there is no color black). Evidence supports the supposition that light can cause physical changes in our bodies. The individual colors that form light affect our bodies in many areas, including the mental processing we
call learning. As Birren (1961, 272) states, "there is little question that visible light and color influence and affect living things."

Dwyer's (1971) theoretical justification for the expectation that the addition of color to instructional materials should improve students' achievement is drawn from the "realism theories." Miller (1957) and other educational theorists of that era held the basic assumption that learning will be more complete as the number of cues in the learning situation increases. Color could act as an additional cue that aids learning. This concept is generally accepted as valid in today's educational dogma. Teachers and parents who are aware of effective study techniques tell their children to read the material, to write notes, to listen (possibly make tapes of notes), and to learn by actively participating in some related exercises. These study methods provide multiple cues as well as various types of cues. These study techniques do seem to assist students in learning material more effectively and efficiently.

The study of color as a variable in the learning process began as early as the 1940's. Cohen and Nelson (1966) noted a study by Vinacke (1942) which investigated the discrimination of color and form at levels of illumination below threshold. In another study, identified by Cohen, VanderMeer (1954) compared the relative
effectiveness of colored and black-and-white motion pictures in respect to learning achieved by high school students. His findings suggest that use of color does lead to some degree of reduction in the rate of forgetting. Bousfield, Easterbrook and Whitmarch (1957) tested subjects in a learning situation where words were augmented by non-colored and colored illustrations. Findings from these studies showed color to be a significant factor in the learning process under certain conditions. Colored pictures did improve immediate word retention over non-colored pictures and presentations that did not include pictures.

Dwyer (1968; 1969; 1970) also found color to be an important instructional variable for improving learning of certain tasks. In her study, which was one of the best designed studies using color as an instructional variable this researcher found, Dwyer attempted to determine whether color in visual illustrations used to complement oral instruction is an important pedagogical variable in improving achievement in five critical areas. The areas included a drawing, identification, terminology, comprehension and total knowledge. Eight types of visual illustrations were used to complement a taped oral presentation on the human heart. The presentations were: oral without visuals, simple black & white line illustrations, simple colored line illustrations, detailed black-and-white shaded drawings, detailed colored shaded
drawings, black-and-white model photographs, colored model photographs, realistic black-and-white heart photographs and realistic colored heart photographs. The study revealed that color treatments were more effective than black-and-white comparisons for all five of the areas. The simple color line presentation was found to be the most effective treatment for the total knowledge criteria. It should be noted, however that the oral presentations without visuals were just as effective as those with visuals for the terminology and comprehension criteria.

The Burke Marketing Research Study conducted in 1960 found that color commercials were more effective than the same commercial in black-and-white (Burke 1960). This difference may be due to the fact that efficient learning requires the learner to attend to the information being presented and that color evokes more attentive behavior than black-and-white. The Burke study revealed that color commercials received higher ratings and were viewed to their completion by a greater percentage of viewers. They also found greater as well as better recall of specific details from subjects who viewed the color version of the commercial.

Cohen and Nelson (1966) cited studies by Ibison (1951) in which the differential effects in the recall of textual materials associated with the inclusion of colored and uncolored illustrations produced no effects on recall.
Clifford and Calvin (1958) who found no significant difference in the use of color versus black-and-white in their experimentation using discriminative learning situations. Differences in performance associated with color among children in different grades were not found. Cohen and Nelson's (1966) study of colored versus non-colored incidental cues also resulted in no significant difference in learning between the two factors. Their work found no significant differences between color differences or between the use of different colors such as reactions to red or blue etc., and sex. Males and females did, however, show a significant difference in color and black-and-white presentations. They concluded that the sexes do not use this incidental cue, color, in the same way.

Dwyer (1971) identified several studies investigating the use of color in films (VanderMeer 1952; Zuckerman 1954; May & Lumsdaine 1958), television (Kanner and Rosenstein 1960, 1961), and textbooks (MacLean 1930; Ibison 1952). Findings in all of these studies did not suggest that the use of color in terms of increased student achievement is justified.

Physiological arousal or increased stimulation during learning is related to both short-term and long-term retention of learning material (Levonian 1968). This is true for both auditory and visual learning. This particular study of Levonian's had findings contrary to others in his
time period. The study supported the idea that it was the amount of arousal or stimulation that determined retention trends and not the type—auditory or visual.

Color perception requires a large part of the nervous system (Goodman 1986) and color sensation is more exciting to the nervous system than black-and-white (Katzman & Nyenhuis 1972). Katzman found some evidence indicating that color presentations are seen to be more active, interesting and emotional to the viewer. Again, the intensity of the arousal or stimulation appears to be the most important parameter (Baron 1961). Farley (1976) also argues that color is more physiologically arousing than black-and-white and thus, color presentations should lead to greater incidence of reminiscence relative to achromatic presentations. Farley's study sought to prove that although most data, in his era, did not support the contention that color use increased retention, the problem was not with color or black-and-white but short-term versus long-term retention testing. Most experiments previous to his did not test for reminiscence, an increase in retention over time, as opposed to forgetting over time. His study provided data that supported the use of color in educational materials to increase learning over time. Farley suggested further study using other materials since his study was limited to slide/tape presentations.
Dooley and Harkins (1970) have stated that color in visual communications does have an overall positive effect. Color in visual communication is either functional and/or attention-getting. The functional use of color involves using a coding system based on color to pass on information to learners. An example of the functional use of color in an illustration would be the use of red to designate oxygenated blood and blue to identify vessels carrying blood loaded with carbon dioxide back to the lungs to discard the CO₂ and pick up a fresh supply of oxygen. In Dooley's experiment, using color without a functional purpose, it was shown that color still increased the attention paid to colored charts (1970). Increased learning should occur when more attention is given to the material to be learned. Dooley's subjects using colored charts did score higher on an immediate posttest but the difference was not significant. According to Farley however, significant results might have been obtained had a delayed posttest been administered in addition to an immediate posttest.

Many other researchers suggest that the functional use of color enhances learning possibilities. Hater (1970) believes that the functional use of color leads to better learning by increasing the efficiency of organizing and coding information. According to Cahill and Carter (1976) color has been found to be the most effective coding dimension. The positive effects of color coding do,
however, decrease as the number of colors used in the coding scheme increases. Cahill and Carter suggest that a maximum of seven colors be used in the coding system—less if the screen data density is high. Elio and Reutener (1978) found that a color pattern hierarchy facilitated recall of blocked and randomly arranged words. Their results suggest that learners may use context (color) as both a cueing and differentiating factor in learning and as an organizational device for retrieval of the learned information.

Durrett (1982) contends that our understanding of information can also be significantly affected by color. Color material is generally processed faster than the same material in black-and-white (Durrett 1982). Chute (1979) says that color may add to the information density of a media presentation, but in so doing it may give individual learners more information than they can process. The human information processor could become overloaded and start to edit some of the incoming information. This researcher notes that the characters making up the words may be edited first because they are less stimulating to the nervous system than color.

Rudnick, Porter and Suydam summarized forty-seven research studies on the effects of color in instructional media as follows (Rudnick, Porter & Suydam 1973): (emphasis mine)
-The use of color frequently does not contribute to learning.
-Color may be useful when it is used to emphasize learning cues.
-Color can serve as a distractor from other cues when used indiscriminately.
-Learners generally prefer color.

According to Hativa and Teper (1988), current research has not yielded new evidence to contradict the above findings. They also provide elaborations and explanations of these four points provided by a more recent summary of studies of color in educational media. Highlights from their summary are provided below:

- The contribution of the general (superfluous addition) use of color to learning does not provide significantly better results than the non-use of color (Chute 1979).
- The use of color as a cueing or coding device generally facilitates student learning of concepts (Dwyer & Lamberski 1983).
- Color cues aid in the organization and structuring of material to be learned (Chute 1979).
- Color cues act as effective "attention getters" which is a prerequisite for information processing to take place (Hannafin 1985).
-Color used for coding may cause sensory overload and cause the student to attend to peripheral data that is not relevant (Chute 1979).

-Students prefer using color software because of its hypothesized influence on attention and motivation (Daniel & Tacker 1974).

-Color acting as an attention getting and attention maintaining factor may be significant for low aptitude students (Allen 1975; Hativa & Teper 1988).

One conclusive finding concerning the use of color is that increasing the number of different colors above a certain level used in a media presentation does confound learning when it is being used, functionally, as a cue (Kanner 1968). Lastly, and possibly as important as all the earlier mentioned factors, educational practitioners believe in the beneficial effects of color on student learning (Hativa & Teper 1988). This alone could have an effect on the color/computer assisted instruction connection in the area of learning.

Educational Media, Color and Learning

Rambally and Rambally (1987) note that although there is a substantial body of ergonomic and human factors, knowledge in well-established areas such as keyboard design, terminal interface design, et cetera, few guidelines are available for applying this knowledge to user interfaces of computer assisted instructional systems. Hativa and Teper
(1988) note that computers that came out in the early eighties without color capabilities (e.g. TRS 80's, and the Commodore PET) have almost disappeared from schools, whereas the sole microcomputer of the same generation which has survived in schools (Apple II family) does use color. The authors suggest that this may mean educators believe in the beneficial effects of color on student learning. Color generates a richer visual presentation which gains the attention of the students more than achromatic presentations.

Rambally offers recommendations based on research as well as suggestions based on his experiences in computer assisted instruction. Rambally and Rambally (1987) also recommend the use of color based on its functional use as a means of coding information. Using color codes reduces response time of users and requires fewer training exercises to become proficient in the use of software.

According to Tullis (1981) there is ample research to support using color as a coding function in screen displays. Tullis' study on the use of four different types of CRT displays found that color graphics displays were no more effective than achromatic graphics that used shape as a coding function. He did find, however, that subjects appear to view color as being pleasing or stimulating and that all subjects chose color graphics over the other three formats for daily use in their jobs (Tullis 1981). Tullis suggests
further research on the aesthetic effects of color to see whether it could have an effect on user acceptance of a computer system.

The choice of color over shape for processing is also verified in Birren's (1978a) study of children who were given blocks of various shapes and colors. The children were told to separate the blocks into groups. All of the children ignored the shape factor and separated the blocks based on color only.

Hativa and Teper (1988) carried out a study to determine the effects of color when used in computer guided teaching. This study used one large screen monitor instead of individual units and found that functional color produced significantly stronger effects than either non-functional color or achromatic versions of the same software. The use of non-functional color also proved to be better than achromatic versions, but not significantly so. The functional use of color was stronger for low-aptitude students than for high-aptitude ones. In fact, high-aptitude students scored lower on three of the four posttests. It may be that high-aptitude students see the extra sensory input as unnecessary. They may also be able to zero in on the important data (words), and edit the color data which is only incidental to the learning exercise.

Baldwin (1984) notes the fact that very little is said about the use of color as an emotive and persuasive
psychological force in the realm of computer use. Since
color is not well understood, he says, it is one of the most
difficult problems we face in an exacting field—computer
science. Screens for computers should be designed to allow
optimal performance by users. Allen (1975) recommends that
researchers continue to investigate the function of color
cues as an instructional variable because it would acquire
increased significance and would assist other researchers,
media designers and educators in improving instruction and
might reduce individual differences in learning.

Collis (1989) states that the consistency with which
color is used in educational software suggest there appears
to be a belief that color has a positive effect on possibly
motivation and probably learning. She also notes "that
surprisingly little has been done, specifically, on the use
of color in educational software." (Collis 1989, 6) Collis
recommends additional study and offers Hativa and Teper's
study (1988) as an excellent model in this area.

Attitude and Motivation

Considerable discussion about the possible effect of
color on motivation and/or attitude involving the computer
activity in this study has been provided. The issue of the
computer itself as a motivational factor or as a factor that
has an effect on attitude is also of importance. Several
studies have been conducted to determine the effect of
computer use on the user's attitude and motivation. Studies
have been identified that support both contentions: that computer use does improve motivation and attitude; that computer use does not have any significant effects on user's attitude and motivation.

Students' attitudes toward school and schoolwork is a very important factor in the learning process. Roblyer, Castine and King say that educators are and should be interested in the effects of computers on attitudes toward learning (1988). Students of all ages and grades like working on/with computers. Generally, they know more about computers and are more comfortable using them than teachers and other adults. Roblyer notes studies that have been carried out to determine whether students prefer computer-based methods of learning simply because a computer is involved or whether there is some other reason for this preference. Roblyer has also identified studies that focus on computer influence on attitudes toward school and subject matter. Increased motivation to learn could translate into greater desire to stay in school. He also states that, as Papert believed, the use of computers which emphasize students' control and creativity result in greater self-esteem and belief in their own abilities. Roblyer's, et al. (1988) analyses of eighteen studies on the use of computers in instruction revealed no preference for computers over other media by students. The study did show greater effects of computer use on attitudes toward themselves and toward
school learning. The researchers say there is very little agreement on the effect of computerized instruction on attitudes towards the new technological devices.

Seymour, Sullivan and Story (1987) conducted a study to determine the effects of using computers for what they described as a drill-and-practice science exercise on energy. (This researcher considers the program described a tutorial instead of drill-and-practice because it was teaching "new material"). Students were divided into two groups with one group reviewing the lesson and eight questions via a computer assisted instructional program, and the second group reviewing the same material and questions via a pencil-and-paper drill. The students completed a questionnaire when they finished the lesson. The questionnaire sought information on their attitudes toward mode of work (computer or pencil-and-paper), perceived difficulty of questions, mode preference for subsequent work, and interest in the subject of energy.

The study revealed there was no difference in how well students did on the two types of presentations. Students in the computer group did, however, rate the presentation as more interesting than the pencil-and-paper group. Almost all of the students said they preferred to do subsequent lessons on the computer. Another interesting note was that the students who used the computers considered the lesson easier than the paper group. They also thought that they
had done better on the quizzes than the paper group did. It should be noted that all of the 139 subjects in this experiment were familiar with computers so this exercise was not a novelty experience for them. Seymour says it is highly encouraging that the translation of a simple computer delivered exercise into a desire to study more about the subject content of the exercise is possible via computer technology.

Wilder et al. (1985) found that students' attitudes toward computers became more negative as they got older. It seems that this change is due to the same factors that cause an increase in the negative reaction to other school-related activities. It is the general school experiences that produce this change. Computers become part of the instructional process of the school and less of a novelty for fun and games. Computer literacy as well as computer programming courses are taught in the upper grades. Wilder says all of these factors lead to the disliking of computers in the upper grades.

In her study, Cambell (1987) studied the effects of time spent on computer assisted instruction on students' attitudes toward computers. Cambell notes Clement's (1981) statement that, in general, students' attitudes toward computer assisted instruction are positive and are due to reasons such as the material being self-paced, having immediate feedback, the objectivity of the computer and no
embarrassment from mistakes made during the lesson. Cambell's study was an effort to determine whether students' attitudes toward computers remained as positive as research and "thought at the time" suggested it was. Cambell assessed students' attitudes toward computers for three levels of ability after eight months of computer assisted instruction. She found that low ability students had a less positive attitude than high and average ability students after eight months of computer assisted instruction.

Cambell also found that student's attitudes toward computers became less positive over time. The less positive attitude became apparent between the fourth and eighth months of computer assisted instruction. Factors which influenced the change to a less positive attitude toward computer assisted instruction were downtime, computer inflexibility, eye-strain, physical discomforts and low quality courseware.

This researcher believes that some students may view computers as machines for remedial or developmental classes. Some schools take advantage of the computer's effectiveness in drill-and-practice and individualized teaching in their courses for students who are behind others in certain areas. The Job Training Program Act has provided hundreds of thousands of dollars over the past few years to set up these developmental labs for students who need assistance in basic skills and come from low-income families. These labs located in public schools are to be used only by low-income students.
who are a minimum of one grade level below their actual grade in reading and mathematics. This type of stigma attached to computer labs may be causing students to see them in a way with which they prefer not to be associated.

Gender and Computer Experience

It is generally believed that women/females are and never have been associated with computers to the extent that males have. This may be true now, but it has not always been the case. The Computer Research Board notes that only sixty of the five-hundred and seventy-seven computer science Ph.D. recipients in 1988-89 were female (Chronicle of Higher Education 1989). In an article on women, girls and computers, Marlaine Lockheed (1985) states that females have been associated with computers from the very beginning. Lockheed notes that Augusta Ada Lovelace was the world's first computer programmer: she wrote the instructions for Babbage's computing machine in the 1800's. She also notes that Adele Goldstine wrote the first programs for the ENIAC built in the 1940's. Grace Hopper was a central figure in the development of COBOL and was the first to use the term "bug" to reflect a problem in a program. Lockheed says in the publication Changes in the Occupational Structure of U. S. Jobs, it is noted that even as recently as the early 1960's, when there were only 2,000 computer operators in the entire industry, 65% of them were women. Strober and Arnold said that in 1980, 59% of the computer operators, 31% of the
computer programmers, and 22% of systems analysts were women; and in 1982, women earned 34% of the undergraduate degrees awarded in computer science (Strober & Arnold 1984).

Lockheed (1985) notes that the use of computers for different activities determines whether or not boys use them more than girls. She says that for programming and games boys do use computers more; for word processing girls use them more; and for classroom instruction, use of computers is about equal. Lockheed also makes another interesting observation: she says that the advent of the microcomputer and its introduction into homes and schools is the main factor which is stereotyping computers for children.

Wilder et al. (1985) also studied high school students and computer use. In one survey, Wilder found that some of our beliefs about females and computer experience did not coincide with her results. These findings included: thirty-five percent of the female and thirty percent of the males said they had a computer in the home; fifty percent of the females and forty-six percent of the males had taken a computer course in high school; both sexes had taken an average of one course. The only finding that coincided with educator's ideas was that males (75%) enrolled in computer programming courses more than females (59%).

Most research seems to support the fact that when girls do take part in computer courses, including programming, they do as well as boys. It has been and is very perplexing
to educators that although they are very careful not to show sex bias in their computer classes and purchase only software that is not sexist, nothing seems to change the fact that boys involve themselves more with computers than girls. This involvement includes courses in school as well as after school fun and games and even summer computer camps. According to Sanders (1984) not even good role modeling by computer teachers seems to be able to change girls attitudes toward computers. Sanders' and other researchers at The Computer Equity Training Project being conducted at the Women's Action Alliance in New York City identified a speculation list of reasons for sex discrepancy in computer use for middle school youth. The attitude and association factors included the following: computers are associated with math, a traditional male activity; computers are seen as machines; computers are unfeminine because mostly boys use them; few women in print and television media use them. Developmental and behavioral factors included these findings: girls at middle school age are very social and prefer people things to solitary activities; boys aggressively capture computer time which girls are reluctant to insist on for themselves; socially approved helplessness is acceptable behavior for girls at this age so it is all right for them to give up when things get rough; girls avoid competition with boys for fear of winning and appearing
unattractive to boys; and girls at this age have more things competing for their time than boys.

Lastly, parents are not helping the fight to remove sex bias from computer use. Parents see technical careers for their sons not their daughters and overtly or subconsciously guide them away from computer fields. More fathers than mothers use computers at home, creating negative role models for daughters. Sanders says there are many more possible speculations about why girls avoid computers (1984). These speculations that the Alliance has compiled have not been proven by research but they do seem logical. This researcher might add another speculation to the above. Females may avoid computers because they have the appearance of typewriters which are associated with clerical or secretarial work. This is a field with which many girls do not want to be associated in this day and time. They want to be doctors and lawyers and engineers, not secretaries and clerical staff.

Schubert and Bakke (1984) make an observation which I believe is worth mentioning here in its entirety.

"The obvious irony is that the computer is intrinsically non-discriminatory. It does not pass judgement on its users; it does not select those who instruct and learn from it; its language is symbolic; and it is not culturally or sex biased. It provides an opportunity for overcoming
any unfair practices to interested users; yet as
used in many schools, the computer is the object
of selective access that favors some populations
at the expense of others."

While carrying out a study on gender and computers with
elementary school students, Wilder (1985) identified what
she says was a most striking finding. In data from her
survey on attitudes toward computers, Wilder found there was
a decrease in liking of computers over time. Although it
was less of a decrease for males than females, this finding
was evident for both sexes. It was also noted that this
steady decline in liking for computers by males and females
began in the sixth grade.

Wilder et al. also found that any previous experience
with computers made students, male and female, feel more
comfortable. Girls did not feel more competent with
computers unless they had had a programming course. Males
felt more competent with exposure to any computer experience
or course. In the general discussion of the results from
her survey, Wilder notes that this data adds to the growing
body of evidence that boys and girls, men and women, react
differently to computers. It is important, she says, that
future study take place to provide important data for
enhancing our understanding of the varying ways in which the
sexes interact with an increasingly technological world.
The use of computers in instruction, the effect that color has on humans, one's experience and even one's sex are all factors which must be taken into consideration as we become a more advanced technological society. Also, computer assisted instruction programs should consider all of the factors which will improve performance. These factors include the use of color and perhaps even specific colors. It should also include access to and experience with computers by both sexes. The study of all these factors is important and will add to the body of knowledge required to provide students with the best computer assisted instructional hardware and software.
CHAPTER III

PROCEDURES

The procedures used in this study include quantitative measurements of vocabulary retention and attitudes of selected Upward Bound students toward color and achromatic computer assisted instructional software programs. The programs taught definitions of vocabulary words chosen from Schuster's list of rare and seldom used words. This chapter will describe the procedures used in this study.

Population

The population for this study was made up of selected Upward Bound students from urban and rural schools in north central Texas (Fort Worth and schools in/around Denton) who were participants in Upward Bound programs located on the campuses of Texas Christian University and the University of North Texas. The group consisted of forty-four females and twenty-seven males. There were twenty-one seniors, sixteen juniors, twenty-one sophomores and thirteen freshmen. The ethnic breakdown was twenty-four black, seventeen Hispanic, twenty-six Caucasian and four other students. Thirty-four subjects were randomly assigned to the monochrome version of the lesson and thirty-seven used the color version. Forty-four students were from small rural schools and twenty-seven
were from urban schools in a large metropolitan school district.

After a brief presentation about the study, students were invited to participate in the research activities. Students were offered an inducement to participate by the directors of the respective Upward Bound programs. The age range of the subjects was fifteen to eighteen with the average age being seventeen. All students had been previously exposed to computers in their high schools and/or in the Upward Bound programs. Their participation in this study using computers was not a novel experience for these subjects. As per eligibility criteria for Upward Bound, participants must have the potential for success in post secondary school. These students may or may not be, however, working up to their full potential as evidenced by grade point average and/or test scores. Upward Bound programs may serve only a small number of students who qualify for the program so acceptance into the program is considered an honor by most students. Applicants for participation in the program are recommended by teachers and counselors in local target schools. Available test scores, grade point averages and other personal data are used to select students who have the most need for Upward Bound services and who can benefit most from those services.
Materials

Materials needed for the study included a computer assisted instructional software program that would provide the subjects with a lesson and computers with the capability for controlling color or achromatic screen output.

Apple Super Pilot, an authoring language, was used by the researcher to write a computer assisted instructional software program. The language is easy, though time-consuming, to learn and has been widely used by classroom teachers to write their own computer lessons. Limited programming abilities are required. In fact, once the code has been written for the presentation of one set of information, i.e. a word and its definition, then it can be used as a skeleton for the rest of the program--the teacher need only change the specific data for each word.

The lesson that was written for this study could be classified as either drill-and-practice or tutorial but most probably it is a mixture of the two types. Drill-and-practice software simply provides practice exercises for students while tutorial software presents new material to be learned. There is considerable mingling of the two types in many computer assisted instructional programs. Twenty rare and seldom used, though easy to learn, words are presented one at a time by the computer assisted instruction program. Students control the pace of the program and most finish within twenty to twenty-five minutes. The first screen
presents the word. The second screen presents the
definition of the word. The third screen uses the word in a
short sentence. The fourth screen is a multiple-choice
question with three answers to choose from. After the
student has made his or her choice as to the correct answer
and has input the appropriate letter, the program checks the
student's answer and continues to the next word, if the
answer was correct, or asks the question a second time when
answer is incorrect. If the student answers the question
correctly the second time, the program continues to the next
word. If the student answers incorrectly the second time,
the program will show the definition of the word and then
continue to the next word.

The format for all screens, achromatic and color,
consisted of three distinct areas. The one half inch border
around the screen was one area and the background and
foreground made up the remaining two areas. A command to
"Press Return" appeared at the bottom of each screen, except
for the screen asking them to identify the correct
definition for a word. The "Press Return" command allowed
the student to have control over the pace of the program.
Initially, the plan was to write two versions of the
software lesson, one color and one achromatic. Apple IIe
computers were to be used and the software lesson itself
would have controlled the presence or absence of color on
the screens. Lines of code would have been added to the
color version of the program to instruct the computer to use specific colors or no colors in the screen displays. Apple IIGS (graphics & sound) computers became available for use in the study so it was necessary to write only one program. The screen output of the Apple IIGS computers can be set via the control panel to either color or achromatic format. Colors for background, foreground and borders can also be selected and set. Once more, the format can be locked so that the students cannot change the settings during the lesson. This was not possible using the IIe computers. Also, color reproduction in the IIGS computers is superior to that of the IIe machines. A computer lab set up with Apple IIGS computers was available at both Upward Bound Program sites. Each lab had sixteen computers that were used in the study.

Instrumentation

Instruments used in this study included the Computer Attitude Scale (CAS), a vocabulary pretest, a vocabulary posttest and a delayed vocabulary posttest. All instruments were administered by paper and pencil outside the computer laboratory. The CAS was used to measure students' attitudes toward computer assisted instruction. The instrument was developed by Loyd and Gressard at the University of Virginia--Charlottesville (1984). The scale has been widely used by researchers in numerous studies concerning the use of computers in an instructional setting. The scale is a
Likert instrument and measures anxiety or fear of computers, liking or enjoying working with computers and confidence in ability to use or learn about computers. The scale has forty items and subjects are instructed to mark either strongly agree, slightly agree, slightly disagree, or strongly disagree for each of the forty statements. The reliability coefficients are .86, .91, .91, and .95 for the computer anxiety, computer liking, computer confidence subscales and the usefulness, respectively. The instrument also had a place for subjects to enter their grade, gender, race, experience with computers and to list any computer courses they might have taken. Total scale scores were used for data analysis in this study because the reliability coefficient of the three subscales share a large amount of common variance and it is assumed the total scale score represents a general attitude toward computers. This procedure has been validated by Loyd and Gressard.

The paper and pencil vocabulary pretest, posttest and delayed posttest were all single page matching type instruments. Each test listed the twenty words on the left side of the page in two groups of ten. A blank line preceded each word and students were instructed to put the number of the correct definition in the blank preceding each word. Each group of ten words had eleven short definitions to the right of it, one of which served as a distractor. The definitions were numbered one through eleven. All three
of the vocabulary instruments were identical except for word and definition order.

**Procedures for Collection of Data**

On February 18 and February 25, 1989, Upward Bound students at the University of North Texas and Texas Christian University respectively, who were participating in the study met for an orientation to the morning's activities. An explanation of the research in which they were going to participate was provided to the group. The Statement to Subjects form (see Appendix) was read and the Use of Human Subjects form was distributed, completed and signed by the subjects. The Directors of the programs signed the forms as witness to student's signatures. Subjects were then administered the Computer Attitude Scale and the vocabulary pretest. Upon completion of these instruments, students were taken to the computer lab and randomly assigned to one of the two treatments, color or achromatic computer assisted instructional software program. After assignment to one of the treatments, students went to the appropriate computer and began to run the computer assisted instruction vocabulary lesson which was ready for execution. After subjects completed the computer assisted instruction lesson they went to an adjoining room where they were administered the immediate vocabulary posttest and the post-Computer Attitude Scale. Two weeks after the
completion of the treatment, all subjects were administered the delayed vocabulary posttest.

**Procedure for Analysis of Data**

Analysis of the data for this study consisted of using analysis of covariance to compare mean scores on the Computer Attitude Scale and the vocabulary tests for the two treatment groups. Data were obtained for seventy-one subjects. The pre- and post-Computer Attitude Scale instruments were hand-scored and a total score was obtained for each of the subjects. A summary of the subjects' personal data obtained on the CAS was also made. This information included gender, race, grade, computer experience and computer courses taken. After grading and recording vocabulary test scores, the analysis of covariance procedure was used to compare scores for the color and achromatic treatment groups and for male and female groups. Covariates were the vocabulary pretest and the first administration of the CAS. The independent variables were the two versions of the computer assisted instruction lesson--color and achromatic. The dependent variables were the vocabulary posttests and the second administration of the CAS. The level of significance below which the null hypothesis was rejected was at the p .05 level.

The Statistical Package for the Social Sciences, SPSS, version 3.0 for the IBM VM/CMS, was used to analyze the data obtained by this study. The analysis was run at the Texas
Christian University Computer Center. Analysis of Covariance was used to test each of the hypotheses.
CHAPTER IV

ANALYSIS OF DATA

The purpose of this study included the determination of the effects, if any, of using color in a computer assisted instructional software lesson on the short-term and long-term retention rates of vocabulary words by selected Upward Bound students. Differences between color and achromatic versions on the Computer Attitude Scale were also studied. Finally, an examination of short-term and long-term vocabulary retention as well as attitude toward computers based on gender and computer experience was made.

Results and Findings

Although there were some differences in the scores obtained on all factors measured in this study only two significant findings were obtained. Data collected for this study included Mean scores on the vocabulary pre-test, immediate vocabulary post-test, delayed vocabulary post-test, pre-Computer Attitude Scale and the post-Computer Attitude Scale. Data were collected for both treatment groups (color and achromatic). Mean scores were also computed for groups based on gender and computer experience. As noted previously, there were thirty-four subjects in the achromatic group and thirty-seven subjects in the color
group. Also, there were forty-four female and twenty-seven males taking part in the study from the two Upward Bound Programs one located at a private university in a large metropolitan area and the latter at a public university in a small city.

The Mean score and Standard Deviation for the pre-test are provided in Table 1. This table also contains Adjusted Mean scores for each treatment group for the immediate and delayed post-tests. These values were adjusted for effects of the Pre-test. See Table 1 below for all statistics.

Table 1

Vocabulary Pretest & Adjusted Immediate & Delayed Posttest
Means & Standard Deviations as a Function of Treatment Group

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>Adjusted Pretest</th>
<th>Adjusted Immediate Posttest</th>
<th>Adjusted Delayed Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achromatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>3.79</td>
<td>12.47*</td>
<td>7.1*</td>
</tr>
<tr>
<td>L</td>
<td>2.07</td>
<td>5.70</td>
<td>3.64</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>3.19</td>
<td>12.22*</td>
<td>7.98*</td>
</tr>
<tr>
<td>L</td>
<td>1.81</td>
<td>5.01</td>
<td>3.96</td>
</tr>
</tbody>
</table>

*Values are adjusted for effects of Pre-test
To obtain equal groups, random assignment was used to place subjects into either the color or achromatic treatment. A t-test was performed to provide data that assured no differences between the treatment groups. The results indicate that there was no difference between treatment groups on the Pre-Vocabulary test and that random assignment worked. Data for the t-test are presented in Table 2 below.

Table 2

Test of Difference Between Treatment Groups with the Pre-Vocabulary Test as the Dependent Measure

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achromatic</td>
<td>34</td>
<td>3.79</td>
<td>2.07</td>
</tr>
<tr>
<td>Color</td>
<td>37</td>
<td>3.19</td>
<td>1.81</td>
</tr>
</tbody>
</table>

\[ F(1.69) = 1.73, \ p < .19, \ MS_{e} = 3.76 \]

Analyses of Immediate Post-Test and Delayed Post-Test Scores

Hypothesis One states that subjects using the color computer assisted instruction program will not differ significantly in short-term vocabulary retention rate from subjects using the achromatic program. The hypothesis was tested using a One-way analysis of Covariance with treatment group (color vs. achromatic) as the between-groups factor, Immediate Post-test scores as the dependent measure and Pre-vocabulary as a covariate.
Results of the analysis reveal no significant difference between groups in consideration of short-term vocabulary retention. See Table 3.

Table 3

**ANCOVA Summary Table for Differences on Adjusted Immediate Posttest Scores as a Function of Treatment Group**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevocabulary</td>
<td>21.68</td>
<td>1</td>
<td>21.68</td>
<td>.75</td>
<td>.389</td>
</tr>
<tr>
<td>Main Effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>1.07</td>
<td>1</td>
<td>1.07</td>
<td>.04</td>
<td>.848</td>
</tr>
<tr>
<td>Error</td>
<td>1965.03</td>
<td>68</td>
<td>28.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1987.78</td>
<td>70</td>
<td>51.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results support Hypothesis One as measured by the Immediate Posttest. There was no difference between treatment groups on short-term retention of vocabulary definitions.

Hypothesis Two states that subjects using the color computer assisted instruction program will not differ significantly in long-term vocabulary retention rate from subjects using the achromatic program. Again, the hypothesis was tested using a One-way analysis of covariance
with treatment group (color vs. achromatic) as the between-groups factor, Delayed Post-test scores as the dependent measure and Pre-vocabulary as a covariate. Again, see Table 1 for statistics.

Results of this analysis reveal that there is no significant difference between treatment groups in terms of long-term retention as measured by the Delayed Posttest. See Table 4.

Table 4

**ANCOVA Summary Table for Differences on Adjusted Delayed Post-test Scores as a Function of Treatment Group**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-vocabulary</td>
<td>10.92</td>
<td>1</td>
<td>10.92</td>
<td>.75</td>
<td>.389</td>
</tr>
<tr>
<td>Main Effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>11.28</td>
<td>1</td>
<td>11.28</td>
<td>.77</td>
<td>.382</td>
</tr>
<tr>
<td>Error</td>
<td>989.95</td>
<td>68</td>
<td>14.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1012.15</td>
<td>70</td>
<td>36.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results support Hypothesis Two which states that there is no significant difference between treatment groups on long-term retention of the vocabulary words presented in the computer assisted instructional lesson.
Analysis of Effects of Treatment on Attitudes Toward Computers

Hypothesis Three states that there will be no significant difference in Mean scores on the Computer Attitude Scale for the color and achromatic treatment groups. The hypothesis was tested using a One-way analysis of covariance with the treatment group as the between-groups factor, the Post-Treatment Computer Attitude Scale as the dependent variable and the Pre-Treatment Computer Attitude Scale as a Covariate. See Table 5 for Means and Standard Deviations.

Table 5
Pre- and Post-treatment Means & Standard Deviations for CAS Scores as a Function of Treatment Group

<table>
<thead>
<tr>
<th>Group</th>
<th>CAS</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Adjusted Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achromatic</td>
<td>34</td>
<td>133.68</td>
<td>135.79</td>
<td>135.05</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>133.68</td>
<td>135.79</td>
<td>135.05</td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td>17.01</td>
<td>16.50</td>
<td>16.50</td>
</tr>
<tr>
<td>Color</td>
<td>37</td>
<td>132.16</td>
<td>135.24</td>
<td>135.99</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>132.16</td>
<td>135.24</td>
<td>135.99</td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td>17.18</td>
<td>19.60</td>
<td>19.60</td>
</tr>
</tbody>
</table>

*Note: CAS = Computer Attitude Survey.

*Values are adjusted for effects of Pretest
Although the Pre-Computer Attitude Scale was found to be a significant covariant, the analysis revealed no significant difference between the color and achromatic treatment groups on Attitudes Toward Computers as measured by the Post-Treatment Computer Attitude Scale. See Table 6 for all statistics.

Table 6

ANCOVA Summary Table for Differences Between Adjusted Post-CAS Scores as a Function of Treatment Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Computer Attitude Scale</td>
<td>19612.00</td>
<td>1</td>
<td>19612.00</td>
<td>402.86</td>
<td>.000</td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>15.70</td>
<td>1</td>
<td>15.70</td>
<td>.32</td>
<td>.572</td>
</tr>
<tr>
<td>Residual</td>
<td>3310.37</td>
<td>68</td>
<td>48.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22938.07</td>
<td>70</td>
<td>19676.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis Three was also supported by the analysis. There was no significant difference in attitude toward computers between the color and achromatic treatment groups.

An additional analysis using Computer Attitude Scale scores was performed to examine the potential effect of the
treatment manipulation on attitudes toward computers. The design for this analysis was a $2 \times 2$ repeated measures matrix. The between group factor was treatment groups (color or achromatic) and the repeated measure was the time of administration of the Computer Attitude Scale (pre-measure and post-manipulation). See Table 5 for cell statistics. Table 7 presents unadjusted differences for Main Effects of color versus achromatic versions of the lesson. Again, no differences were found until time of administration of the survey was taken into consideration.

Table 7

### ANCOVA Summary Table for Differences Between Pre- and Post-CAS Scores as a Function of Treatment Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between-groups Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>37.78</td>
<td>1</td>
<td>37.78</td>
<td>.05</td>
<td>.803</td>
</tr>
<tr>
<td>Error</td>
<td>41435.69</td>
<td>69</td>
<td>500.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis revealed a significant main effect for time of administration of the Computer Attitude Scale with the Post-Computer Attitude Scale scores being higher than the Pre-Computer Attitude Scale scores ($F(1, 69) = 238.43, p < .002, MS_e = 24.02$). See Table 8 for data. This result indicates that mere exposure to computers may be enough to improve
subjects' attitudes toward computers. No other significant differences were found in this analysis.

Table 8

**ANCOVA Summary Table for Differences Between Pre- and Post-CAS Scores as a Function of Time of CAS Administration**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-groups Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>239.43</td>
<td>1</td>
<td>239.43</td>
<td>9.97</td>
<td>.002*</td>
</tr>
<tr>
<td>Two Way Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment X Time</td>
<td>8.22</td>
<td>1</td>
<td>8.22</td>
<td>.34</td>
<td>.560</td>
</tr>
<tr>
<td>Error</td>
<td>1657.14</td>
<td>69</td>
<td>24.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In summary, the first analysis discussed in this section supported Hypothesis Three. There was no significant difference in attitude toward computers for the two treatment groups. Additionally, it was found that mere exposure to computers significantly improved subjects' attitudes towards these high-tech educational tools.

**Further Analyses of Immediate Vocabulary Pre-Test Scores as a Function of Treatment, Gender and Computer Experience**

Hypothesis Four states that there will be no significant difference in short-term retention rates, as measured by the Immediate Posttest, based on gender and computer experience. This hypothesis was tested using a Three-way analysis of covariance: treatment group (color or achromatic), gender (male or female) and computer experience.
(yes or no) were all between-groups factors. The dependent measure was the Immediate Vocabulary Posttest and the Vocabulary Pretest was the covariate. See Table 9 for statistics.

Table 9

**Adjusted Means & Standard Deviations for Immediate Posttest Vocabulary Scores as a Function of Treatment Group, Gender and Computer Experience**

<table>
<thead>
<tr>
<th>Group/Computer Experience</th>
<th>n</th>
<th>Pre-Vocabulary</th>
<th>Post-test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achromatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>9</td>
<td>3.67</td>
<td>11.69</td>
</tr>
<tr>
<td>M</td>
<td>2.00</td>
<td>4.89</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>4</td>
<td>2.25</td>
<td>12.96</td>
</tr>
<tr>
<td>M</td>
<td>1.71</td>
<td>2.59</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>10</td>
<td>3.70</td>
<td>12.70</td>
</tr>
<tr>
<td>M</td>
<td>1.57</td>
<td>3.74</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>4</td>
<td>2.25</td>
<td>11.21</td>
</tr>
<tr>
<td>M</td>
<td>3.30</td>
<td>7.39</td>
<td></td>
</tr>
<tr>
<td>Achromatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>13</td>
<td>4.05</td>
<td>13.35</td>
</tr>
<tr>
<td>M</td>
<td>2.08</td>
<td>7.11</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>8</td>
<td>3.00</td>
<td>11.55</td>
</tr>
<tr>
<td>M</td>
<td>1.69</td>
<td>5.71</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>12</td>
<td></td>
<td>table continues</td>
</tr>
</tbody>
</table>
Table 9 continued

<table>
<thead>
<tr>
<th>Group/Computer Experience</th>
<th>n</th>
<th>Pre-Vocabulary Adjusted Immediate Post-test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>2.67</td>
<td>12.29</td>
</tr>
<tr>
<td>SD</td>
<td>1.61</td>
<td>5.13</td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>11</td>
<td>3.64</td>
</tr>
<tr>
<td>M</td>
<td>3.64</td>
<td>11.83</td>
</tr>
<tr>
<td>SD</td>
<td>1.50</td>
<td>5.59</td>
</tr>
</tbody>
</table>

Results of the analysis of Hypothesis Four reveal no significant difference in Immediate Posttest scores as a function of treatment, gender and computer experience. These findings support Hypothesis Four. See Table 10 below.

Table 10

ANCOVA Summary Table for Adjusted Immediate Posttest Scores as a Function of Treatment Group, Gender and Computer Experience

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevocabulary</td>
<td>9.92</td>
<td>1</td>
<td>9.97</td>
<td>.32</td>
<td>.574</td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2.11</td>
<td>1</td>
<td>2.11</td>
<td>.07</td>
<td>.796</td>
</tr>
<tr>
<td>Gender</td>
<td>0.18</td>
<td>1</td>
<td>0.18</td>
<td>.01</td>
<td>.939</td>
</tr>
<tr>
<td>Computer Experience</td>
<td>5.33</td>
<td>1</td>
<td>5.33</td>
<td>.17</td>
<td>.682</td>
</tr>
<tr>
<td>2-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gender</td>
<td>.00</td>
<td>1</td>
<td>.00</td>
<td>.00</td>
<td>.993</td>
</tr>
<tr>
<td>Treat X ComExp</td>
<td>1.83</td>
<td>1</td>
<td>1.83</td>
<td>.05</td>
<td>.810</td>
</tr>
<tr>
<td>Gender X ComExp</td>
<td>3.79</td>
<td>1</td>
<td>3.79</td>
<td>.12</td>
<td>.729</td>
</tr>
<tr>
<td>3-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gen X Exper</td>
<td>14.94</td>
<td>1</td>
<td>14.94</td>
<td>.48</td>
<td>.492</td>
</tr>
<tr>
<td>Error</td>
<td>1935.28</td>
<td>62</td>
<td>31.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1973.43</td>
<td>70</td>
<td>69.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis of Delayed Vocabulary Post-Test Scores as a Function of Treatment Group, Gender and Computer Experience

Hypothesis Five states that there will be no significant difference in long-term retention rates, as measured by the Delayed Post-test, based on gender and computer experience. This hypothesis was tested using a Three-way analysis of covariance; Treatment group (color or achromatic), gender (male or female) and computer experience (yes or no) were all between-groups factors. The dependent measure was Delayed Vocabulary Post-test and the Vocabulary Pre-test was the covariate. Table 11 provides the statistics for this test.

Table 11
Adjusted Means & Standard Deviations for Delayed Post-test Scores as a Function of Treatment Group, Gender and Computer Experience

<table>
<thead>
<tr>
<th>Group/Adjusted Immediate</th>
<th>Computer Experience</th>
<th>n</th>
<th>Pre-Vocabulary</th>
<th>Post-test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Achromatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>9</td>
<td></td>
<td>3.67</td>
<td>6.02</td>
</tr>
<tr>
<td>M</td>
<td>2.00</td>
<td></td>
<td>4.29</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>4</td>
<td></td>
<td>2.25</td>
<td>8.96</td>
</tr>
<tr>
<td>M</td>
<td>1.71</td>
<td></td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>10</td>
<td></td>
<td>3.70</td>
<td>6.50</td>
</tr>
<tr>
<td>M</td>
<td>2.57</td>
<td></td>
<td>2.95</td>
<td></td>
</tr>
<tr>
<td>s2</td>
<td>2.95</td>
<td></td>
<td></td>
<td>table continues</td>
</tr>
</tbody>
</table>
The results of the analysis revealed a significant Treatment Group X Gender interaction. (F (1,62) = 56.33, p < .04, MS_ε = 13.20). See Table 12 below.
Table 12

ANCOVA Summary Table for Differences on Delayed Post-test Vocabulary Scores as a Function of Treatment Group, Gender and Computer Experience

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
<th>df of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevocabulary</td>
<td>10.02</td>
<td>1</td>
<td>10.02</td>
<td>.76</td>
<td>.387</td>
<td></td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>.10</td>
<td>1</td>
<td>.10</td>
<td>.01</td>
<td>.931</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>31.68</td>
<td>1</td>
<td>31.68</td>
<td>2.40</td>
<td>.126</td>
<td></td>
</tr>
<tr>
<td>Computer Exp.</td>
<td>9.03</td>
<td>1</td>
<td>9.03</td>
<td>.68</td>
<td>.411</td>
<td></td>
</tr>
<tr>
<td>2-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gender</td>
<td>56.33</td>
<td>1</td>
<td>56.33</td>
<td>4.27</td>
<td>.043*</td>
<td></td>
</tr>
<tr>
<td>Treat X ComExp</td>
<td>24.88</td>
<td>1</td>
<td>24.88</td>
<td>1.88</td>
<td>.175</td>
<td></td>
</tr>
<tr>
<td>Gender X ComExp</td>
<td>27.67</td>
<td>1</td>
<td>27.67</td>
<td>2.10</td>
<td>.153</td>
<td></td>
</tr>
<tr>
<td>3-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gen X Exper</td>
<td>15.53</td>
<td>1</td>
<td>15.53</td>
<td>1.16</td>
<td>.262</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>818.36</td>
<td>62</td>
<td>13.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>993.60</td>
<td>70</td>
<td>188.44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A significant difference on delayed post-vocabulary test scores was found for females using the color version of the software program over females using the black-and-white version. There was no significant difference on post-vocabulary test scores for males based on treatment group. A two-way Interaction between gender and treatment group does exist.

Figure 1 provides information showing the differences that were found on delayed Post-vocabulary test scores for
females using the color version of the computer assisted instructional lesson compared to males.

Figure 5

Scores on Delayed Post-Test as a Function of Treatment and Gender

An analysis of simple effects revealed a significant difference between Males and Females at the level of type of computer assisted instructional program used (color or achromatic). \( F(1,62) = 6.50, p < .025, \text{MS}_e = 13.20 \). Table 13 presents cell statistics for the treatment group X gender interaction. This finding suggests, in the context of this study, that females perform better in long-term retention of vocabulary definitions than males when using the color computer assisted instructional program \( (M_b = 9.15 \text{ and } 7.28 \text{ respectively}) \).
Table 13
Mean Scores and Standard Deviations on the Delayed Vocabulary PostTest With Type of Treatment and Gender

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.03</td>
<td>9.15</td>
</tr>
<tr>
<td>SD</td>
<td>3.14</td>
<td>4.01</td>
</tr>
<tr>
<td>Achromatic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.97</td>
<td>7.28</td>
</tr>
<tr>
<td>SD</td>
<td>3.97</td>
<td>3.50</td>
</tr>
</tbody>
</table>

The results of the analyses presented in this section suggest that the effect of the type of CAI programs (color or achromatic) may have differential effects with respect to gender.

Analysis of Post-CAS Scores as a Function of Treatment Group, Gender and Computer Experience

Hypothesis Six states that there will be no significant differences in Post-Computer Attitude Scale scores as a function of gender and computer experience. This hypothesis was tested using a Three-way analysis of covariance; treatment group (color or achromatic), gender (male or female) and computer experience (yes or no) were all between-groups factors. The dependent measure was Post-
Computer Attitude Scale and the Pre-Computer Attitude Scale was the covariate. Table 14 provides the cell statistics for this test.

Table 14  
**Adjusted Means & Standard Deviations for Post-CAS Scores as a Function of Treatment Group, Gender and Computer Experience**

<table>
<thead>
<tr>
<th>Group/Computer Experience</th>
<th>MALES</th>
<th>FEMALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted Post-Computer Experience</td>
<td>Precas</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td><strong>ACHROMATIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>138.33</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>7.58</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>149.75</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td><strong>COLOR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Experience-Yes</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>136.50</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>13.20</td>
<td></td>
</tr>
<tr>
<td>Computer Experience-No</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>133.00</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>19.11</td>
<td></td>
</tr>
</tbody>
</table>

*Table continues*
Results of this analysis revealed no significant differences in Post-Computer Attitude Scale scores as a function of treatment group, gender and computer experience. Table 15 below provides a summary of this analysis.

Table 15

*ANCOVA Summary Table for Differences on Post-CAS Scores as a Function of Treatment Group, Gender and Computer Experience*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PreCAS</td>
<td>17112.32</td>
<td>1</td>
<td>17112.32</td>
<td>362.79</td>
<td>.000</td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>56.74</td>
<td>1</td>
<td>56.74</td>
<td>1.20</td>
<td>.277</td>
</tr>
<tr>
<td>Gender</td>
<td>156.25</td>
<td>1</td>
<td>156.25</td>
<td>3.31</td>
<td>.074</td>
</tr>
<tr>
<td>Computer Exp.</td>
<td>43.02</td>
<td>1</td>
<td>43.02</td>
<td>.91</td>
<td>.343</td>
</tr>
<tr>
<td>2-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gender</td>
<td>55.61</td>
<td>1</td>
<td>55.61</td>
<td>1.18</td>
<td>.282</td>
</tr>
<tr>
<td>Treat X Computer Exp</td>
<td>87.61</td>
<td>1</td>
<td>87.61</td>
<td>1.86</td>
<td>.178</td>
</tr>
<tr>
<td>Gender X Computer Exp</td>
<td>13.42</td>
<td>1</td>
<td>13.42</td>
<td>.28</td>
<td>.596</td>
</tr>
<tr>
<td>3-Way Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat X Gen X Exper</td>
<td>32.03</td>
<td>1</td>
<td>32.03</td>
<td>.68</td>
<td>.413</td>
</tr>
<tr>
<td>Error</td>
<td>2924.48</td>
<td>62</td>
<td>47.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20481.48</td>
<td>70</td>
<td>17604.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These findings support this hypothesis of no difference.

Summary

The results of the preceding analyses revealed that:

1) There were no significant differences on short-term retention of vocabulary definition found between treatment groups.

2) There were no significant differences on long-term retention of vocabulary definitions found between treatment groups.

3) There were no significant differences in attitudes toward computers found between treatment groups.

Timing Effect

4) There were no significant differences on immediate posttest scores found between treatment groups as a function of gender and computer experience.

5) There was a significant difference found between treatment groups on delayed posttest scores as a function of gender and computer experience.

6) There were no significant differences on Post-CAI scores found between treatment groups as a function of gender and computer experience.

In summary, there were no significant differences found for Hypotheses One through Four or Hypothesis Six. There was, however, a significant difference found for
Hypothesis Five--differences based on sex as a function of color or achromatic instructional software program and the delayed vocabulary posttest. There was also an interesting finding concerning time of administration of the Computer Attitude Scale and attitude toward computers. It appears that the mere exposure to computers for a brief time improves attitudes toward working with these high-tech devices.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, DISCUSSION
AND RECOMMENDATIONS

Summary

The use of computers and computer assisted instruction in our schools has been, and continues to, increase at a very rapid rate. The number of computers in educational settings grew from one million, twenty thousand in 1987-88 to one million, five-hundred thousand in 1988-89 (Electronic Learning Survey 1988). Present estimates are that there are over two million computer units in grades K-12. Technological advances, improved instructional programming capabilities, artificial intelligence, and lower costs for more powerful machines have led to the purchase of a second wave of more advanced computers by school administrators. Industry advertisements tout the increased sophistication, power and color capabilities of their new computers, printers and other peripheral devices. Computer assisted instructional software developers are upgrading their programs to take advantage of these new capabilities. One area of computer technology which has seen tremendous advancement over the past three or four years is color reproduction. The latest computer models for major brands...
used in schools can produce millions of colors. Older monochrome computers are being replaced with these new color units.

Although studies of color and learning have been carried out in several other media used in instruction, few studies have been done to determine what effect using color computer software programs may have on learning when compared to achromatic software. The purpose of this study was to determine the effect(s) of color, if any, when used in computer assisted instructional software on the vocabulary retention rate of selected Upward Bound students. Factors included in the study were short-term and long-term retention, attitude toward computers and differences based on gender and computer experience.

The review of literature for this research project identified numerous studies on the use of computers in instructional settings. Several studies on the effect of color on learning were also found. The area of color and learning has been studied for several decades. The answer to the question of what effect color has on learning is still unanswered, as is the question of how effective is computer assisted instruction. Many studies can be found both supporting and refuting the claim that learning improves with the use of color or with the use of computers. Color is a highly motivating factor in learning. People, both students and teachers, prefer color. Physiological and
emotional reactions to color have been well documented over the past forty years. Computers are also motivating to student learners. The study of the combination of these two factors, the use of color and computers will increase the knowledge of learning and how it may be affected by these factors.

The subjects for this study were seventy-one selected Upward Bound students participating in the Texas Christian University and University of North Texas Upward Bound Programs. Students were administered a vocabulary pretest and the Computer Attitude Scale after which they completed a computer assisted instructional program teaching vocabulary word definitions. Some students used a color version and others used an achromatic version. Students were administered an immediate and delayed vocabulary posttest. The Computer Attitude Scale was also administered a second time immediately after completing the software program.

Findings

Hypothesis One stated that subjects using the color computer assisted instruction program would not differ significantly in short-term vocabulary retention rate from subjects using the achromatic program. The results indicated there was no significant difference between the mean scores of the color and achromatic groups in short-term vocabulary retention rate. This finding is in accord with other studies of the use of color in educational media and
materials. There are some findings, however, that do have contrary results for this hypothesis.

Hypothesis Two stated that subjects using the color computer assisted instruction program would not differ significantly in long-term vocabulary retention rate from subjects using the achromatic program. The results indicated there was no significant difference between the mean scores of the color and achromatic groups in long-term vocabulary retention rate. The majority of studies identified did not measure long-term retention and the color/achromatic factors. There was one study (Farley & Grant 1976) that did find significant differences for color use.

Hypothesis Three stated there would be no difference in the mean scores on the Computer Attitude Scale for the color versus the achromatic group. The results indicated there was no significant difference between the mean scores of the color and achromatic groups on the Computer Attitude Scale. Other studies found differing results on attitude and computer use. Only Hativa and Teper's (1988) study found differences, both functional and non-functional, for color programs over achromatic ones. The differences, though, were not significant for the non-functional use of color.

Additional analysis did reveal a significant main effect for Time of Administration of the Computer Attitude
Scale with the Post-Computer Attitude Scale scores being higher than the Pre-Computer Attitude Scale scores. The fact that students merely had the opportunity to work with computers resulted in a change in attitude toward computers.

Hypothesis Four stated there would be no significant difference in short-term retention posttest scores based on gender and computer experience. The results indicated there was no significant difference between the mean scores in this area when gender and computer experience were included. This is not an unexpected finding although one study was located which concluded that differences did occur because of the dissimilar ways in which males and females use color as a functional cue.

Hypothesis Five stated there would be no significant difference in long-term retention posttest scores based on gender and computer experience. Results indicated there was a significant difference between the mean scores in this area when gender and computer experience were included. Females using the color computer assisted instructional program did show a significant difference in long-term retention while girls using the achromatic version did not. Studies were found that showed significant differences, after identical treatments, in long-term memory when none were found in short-term memory. None of these studies included gender and color as possible factors that could make a difference.
Hypothesis Six stated there would be no significant difference on the Computer Attitude Scale Mean scores based on gender and computer experience. The results indicated there was no significant difference between the mean scores in this area when gender and computer experience were included.

Conclusions and Discussion

Available research on the effects of color on humans does not provide us with a black-and-white, yes-or-no answer to the question of, "What effect does color have on learning?" As previously noted, many studies substantiate the fact that humans are physically, emotionally and physiologically affected by color. Color, unlike light, is a subjective experience found only in animals having eyes with the capability of sensing it and the anatomical features and functions in their brains to interpret those sensory stimulations. Light exists whether there are eyes to see it or not. Color, on the other hand, must have eyes around to "see it" much as sound must have ears around to "hear it." If no eyes or ears existed then there would not be any color or sound. It seems as though nature has provided us with the ability to see color because it is important or advantageous to our existence or our evolutionary development.

Students prefer color computer assisted instruction software programs over achromatic ones much the same as they
prefer color films and movies over black-and-white. Studies show that color presentations increase the sensory experiences of students and provide additional cues and channels of input. Since both factors, increased motivation and higher sensory experiences, are also thought to increase ability to learn, it seems logical that color presentations would improve students' learning since they are affecting the body similarly. Although this study did not result in the same findings as other studies, that color does improve learning, there might have been unknown factors associated with computer assisted instruction which negated or canceled out the positive learning effects of color in the software presentations.

A "coupled pair" of these negating factors could be students' attitudes and motivation toward computers. As noted in several studies, attitude and motivation to work with computers are very high when students first begin to use them in the learning process. As Campbell (1987) found in her study, over a period of four to eight months, some students' attitude toward computers declined and so did their motivation to work with computers. It seems that the "new wears off" and the novelty of these high technology learning tools wanes. Computers become what some have feared they might--an electronic workbook used by teachers to take the place of teaching or a device to be used to isolate troublemakers or a special learning tool for
remedial students to spend time on. The computer may have lost some of its appeal to students and could actually be causing some of them to react negatively to computer assisted instruction. Any advantages resulting from the addition of color to the computer assisted instruction program might be overwhelmed by this change in attitude and motivation factors.

A second negating factor may be that students, because of their exposure to television for thousands of hours over their lifetime, may have become desensitized to any presentation made on a device similar to a television set. People, children included, might have developed the ability to shut out or ignore commercials or thirty-second news spots on television. Anything on the television that does not interest (motivate or excite) them can be easily tuned out. This is a normal capability of the human sensory system: our bodies must learn to filter out some of the incoming data via our senses. Unfortunately for teachers, ministers and computer assisted instruction, students can choose to selectively ignore instructional information presented by computers.

Our world is very different from that of twenty or thirty years ago. It is possible that students do not react to color in the same way people did before it became so prevalent in our environment. Television, books, magazines, outdoor advertising and clothing have all, to use an old
term, been colorized. The Turner Broadcasting Company has spent millions of dollars to convert old black-and-white movies into color versions. The reasoning behind this task being that young people will be more likely to watch old movies if they are in color. It is also possible that the increased use of color in our environment may have changed our body's physical and physiological reactions to any effects it may have once had. Overstimulation may lead to the ever increasing need for higher levels to cause any changes in our bodies. For the past four or five years men's and women's fashions have used a tremendous range of colors. Usually, these fads change to the opposite of what has been fashionable after a year or two. This has not been the case over the past few years. Instead of going back to drab colors, earthtones, etc., colors have become even more vibrant, i.e. the neon and fluorescent colors that almost blind you when you first see them. These colors have extended the fad of brightly colored apparel by increasing their color intensity to stimulate potential customers even more. Computer assisted instructional software may not be capable of providing high enough levels of color stimulation to make any differences in a user's reactions to it.

In this study, two shades of blue and purple were used in the color version of the computer assisted instruction lesson. Different results might have been obtained if other colors had been chosen for the study. Colors such as red,
which some say causes more physiological changes in humans, might have produced differences that were significant. Another option could have been to let the students choose the colors they wanted the CAI program to use. This might have increased their physiological reaction(s) due to the selection of their favorite colors.

The fact that every screen of the color version of the computer assisted instruction program was made up of the same color scheme and the same format may have had a desensitizing effect on the subjects. Hurick (1981) says studying a scene for too long can have negative effects on the observer. Fresh visual impressions are always superior. We get used to a continuous stimulation such as a flashing light or sound and become less aware of it over time. The continual blinking of a cursor on a computer screen may be annoying to a novice user but to an experienced computer user the blinking is given very little attention or thought. A lack of significant difference in the use of color versus achromatic versions of the computer assisted instruction program may be explained in the same way as the above mentioned cursor. The fact that every screen was identical except for the alphabetical characters used for each word (dark blue border, light blue background and purple characters as well as the positioning of all text in the same screen location) may have desensitized the subjects to the computer assisted instructional program thereby reducing
or negating completely any possible physical or physiological reactions to the colors.

Subjects were administered a paper and pencil pretest, posttest and delayed posttest. Jacoby and Hayman (1987) believes memory for a specific prior encounter with a word, seeing it for the first time on a computer screen, can be retrieved and can serve to aid its later identification. Also, Kolers & Roediger (1984) state that it is the actual processing or other operation used to identify a word that is seen as being preserved by memory. Thus, according to these authors, changing the visual details of a word between its presentation and test can reduce transfer by decreasing the similarity of the operations used to identify the word. This could mean that subjects learning words via a computer program may not transfer the computer memory processing of such words to a paper and pencil test as well as they would to a computer test.

The fact that the computer assisted instruction lesson was a static presentation may have offset any advantages of adding color. Research has provided some indication that color may make more of a difference in animated presentations than in static presentations. The slide-show-like presentation of the screens in this computer assisted instruction program might have been too static; thus, adding color would not have made any difference in the students' reactions to the lesson.
No significant differences in the use of the color and achromatic versions of the computer assisted instruction program were found based on sex. This may indicate that using the computer as a learning tool does not require a lot of interaction with the computer, other than providing single letter input. The assumed negative reaction of females to these high technology machines is not found. It also suggests there is no difference in male's and female's reaction(s) to color. Two things should be noted: one is that higher scores were found for the use of color by females on the long-term measure. Also, some research suggests that males and females do respond differently to color and black-and-white.

Recommendations

Learning is a complex process which some say we are just now beginning to understand. Based on the review of the literature, color appears to be an important factor in the learning environment. Human beings, and some non-human beings for that matter, prefer color and react to it in many physiological and psychological ways which we do not completely understand at this time. Any positive effects color may have on learning should be identified by continued research and then exploited to the maximum when and if it is found.

Computers do not seem to be just another fad in education. The use of computers in schools continues to
increase every year. If we are to make the most of these teaching machines, we should answer all questions about their potential no matter how unimportant they may seem to some educators. If color computer instructional software is more effective or if it is more pleasing for students to work with, then we should know it as fact. Continued research can guide us in the direction in which we should proceed by answering these questions.

Further study should be done to search out answers to some of the specific questions posed here. Suggestions for similar studies include one in which students are allowed to select the colors they want the instructional program to use. Some software has this capability and some computers, including the Apple IIGS, allow the user to set color parameters via control panels. If students could choose their favorite colors for the program, the instruction might be more stimulating to them and it could have an effect on their overall attitude toward computer use.

Studies similar to this one but using different colors, without student control or choice, may also provide different outcomes. Using different alternating colors for consecutive screens as well as varying the text layout from screen to screen should be studied to nullify any desensitizing effects caused by repetitive stimuli. It might also be interesting to do a study in which the lesson presentation lasted for a longer period of time. Most
students completed the lesson in about twenty minutes. It may be that it takes longer than twenty minutes for any effect caused by color to appear.

A study should be carried out that would exclude the paper and pencil pretest, posttest and delayed posttest. Students should be administered these tests in the same format as the vocabulary words in the original presentation. A computer version of these tests should be used instead of the paper and pencil versions. This would negate the possibility of loss of memory transfer when changing from one medium to another.

Payne's (1964) research seems to support the belief that visual acuity seems to best occur with a color figure seen against an achromatic background. If this study could be replicated and include the use of colored text on a black and/or white background, results may be obtained that are significant. It is interesting to note that many of today's music videos are being made in black-and-white, similar to an old movie, but with a limited number of items in the video being in color; i.e., a dress or a musical instrument. This provides for a very interesting effect which is being copied by many artists, advertising agencies and film producers.

Marschalek (1988) suggests that reaction to color and memory, together, are related to age. His study showed that the main effect of grade level for color memory processing
was significant. Also, there were more significant results between subjects in grades one and five than between subjects in grades three and five. A study should be made to determine whether the difference in age/grade is also found in secondary students. Using a larger number of subjects from each grade level would provide the opportunity to include this factor in further study of color and its effects on learning. There are many possible areas for further study involving the use of color in computer assisted instructional programs. We should continue to explore some of the questions raised by this study.
APPENDIX A

PRETEST
Pretest

badchen (5) 1. to act or talk foolishly, to waste time
benmost (4) 2. a vegetable seller
cretaceous (6) 3. blonde
cyanope (3) 4. innermost
diectic (7) 5. a professional jester
dimpsy (8) 6. chalky
footle (1) 7. showing or pointing out
gally (11) 8. dark or dusky
kiddier (2) 9. tickle or perplex
kittle (9) 10. reddish purple

laches (22) 11. to frighten
logian (14) 12. two headed ax
meecher (18) 13. a judge
podesta (13) 14. a maxim or slogan
ranny (15) 15. mongrel calf
runcation (19) 16. poor writing style
secant (21) 17. covered with blossoms
sepiment (20) 18. truant or thief
tushery (16) 19. pulling weeds
twibill (12) 20. a fence
twibill (12) 21. cutting line

undue delay

APPENDIX B

POSTTEST IMMEDIATE
Posttest Immediate

cyanope (10)  1. dark or dusky
benmost (6)   2. a vegetable seller
cretaceous (4) 3. reddish purple
badchen (5)   4. chalky
deictic (9)   5. a professional jester
dimpsy (1)   6. innermost
footle (8)   7. to frighten
gally (7)   8. to act or talk foolishly, to waste time
kiddier (2)  9. showing or pointing out
kittle (11)  10. blonde

logian (14)  12. undue delay
meecher (20) 13. a fence
laches (12)  14. a maxim or slogan
tushery (21) 15. pulling weeds
ranny (22)  16. cutting line
runcation (15) 17. covered with blossoms
secant (16)  18. a two headed ax
twibill (18)  19. a judge
podesta (19)  20. truant or thief
sepiment (13) 21. poor writing style

11. tickle or perplex
22. mongrol calf
APPENDIX C

POSTTEST DELAYED
Posttest Delayed

1. a maxim or slogan
2. tickle or perplex
3. to frighten
4. pulling weeds
5. a professional jester
6. innermost
7. reddish purple
8. to act or talk foolishly, to waste time
9. showing or pointing out
10. a fence
11. a vegetable seller

12. covered with blossoms
13. blonde
14. dark or dusky
15. chalky
16. cutting line
17. undue delay
18. a two headed ax
19. mongrol calf
20. truant or thief
21. poor writing style
22. a judge
APPENDIX D

SURVEY OF

COMPUTER ATTITUDE SCALE
SURVEY OF ATTITUDES TOWARD THE LEARNING ABOUT
AND WORKING WITH COMPUTERS
Brenda H. Loyd and Clarice P. Gressard
University of Virginia

The purpose of this survey is to gather information concerning people's attitudes toward the learning about and working with computers. It should take about five minutes to complete this survey. All responses are kept confidential. Please return the survey to your instructor when you are finished.

Please check the answer which applies to you.

1. Age: ( ) 15  ( ) 16  ( ) 17  ( ) 18  ( ) 19
2. Grade: ( ) 9  ( ) 10  ( ) 11  ( ) 12
3. Gender: ( ) Female  ( ) Male
4. Did you work with computers in the school you are attending?  
   ( ) yes  ( ) no
5. If you answered "yes" to question number four above, in how many classes per day did you work with computers?
   ( ) one class per day  ( ) three classes per day
   ( ) two classes per day  ( ) more than three classes per day

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**COMPUTER ATTITUDE SCALE**

Below are a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. Place a check mark in the parentheses under the label which is closest to your agreement or disagreement with the statements.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computers do not scare me at all.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>2. I'm no good with computers.</td>
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<td>( )</td>
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<tr>
<td>3. I would like working with computers.</td>
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<td>( )</td>
</tr>
<tr>
<td>4. I were use computers many ways in my life.</td>
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<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>5. Working with a computer would make me very nervous.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>6. Generally I would feel OK about trying a new problem on a computer.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>7. The challenge of solving problems with computers does not appeal to me.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>8. Learning about computers is a waste of time.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
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</tr>
<tr>
<td>9. I do not feel threatened when others talk about computers.</td>
<td>( )</td>
<td>( )</td>
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<tr>
<td>10. I don't think I would do advanced computer work.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>11. I think working with computers would be enjoyable and stimulating.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
12. Learning about computers is worthwhile.  
   Strongly Agree  Slightly Agree  Slightly Disagree  Strongly Disagree  
   ()  ()  ()  ()

13. I feel aggressive and hostile towards computers.  
   ()  ()  ()  ()

14. I am sure I could do work with computers.  
   ()  ()  ()  ()

15. Figuring out computer problems does not appeal to me.  
   ()  ()  ()  ()

16. I'll need a firm mastery of computers for my future work.  
   ()  ()  ()  ()

17. It wouldn't bother me at all to take computer courses.  
   ()  ()  ()  ()

18. I'm not the type to do well with computers.  
   ()  ()  ()  ()

19. 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.  
   ()  ()  ()  ()

20. I expect to have little use for computers in my daily life.  
   ()  ()  ()  ()

21. Computers make me feel uncomfortable.  
   ()  ()  ()  ()

22. I am sure I could learn a computer language.  
   ()  ()  ()  ()

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

24. I can't think of any way that I would use computers in my career.  
   ()  ()  ()  ()
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. I would feel at ease in a computer class.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>26. I think using a computer would be very hard for me.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>27. Once I start to work with the computer, I would find it hard to stop.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>28. Knowing how to work with computers were increase my job possibilities</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>29. I get a sinking feeling when I think of trying to use a computer.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>30. I could get good grades in computer courses.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>31. I were do as little work with computers as possible.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>32. Anything that a computer can be used for, I can do just as well some other way.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>33. I would feel comfortable working with a computer.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>34. I do not think I could handle a computer course.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>35. If a problem is left unsolved in a computer class, I would continue to think about it afterward.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>36. It is important to me to do well in computer classes.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>37. Computers make me feel uneasy and confused.</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Strongly Agree</td>
<td>Slightly Agree</td>
<td>Slightly Disagree</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>38. I have a lot of self-confidence when it comes to working with computers.</td>
<td>()</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>39. I do not enjoy talking with others about computers.</td>
<td>()</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>40. Working with computers will not be important to me in my life's work.</td>
<td>()</td>
<td>()</td>
<td>()</td>
</tr>
</tbody>
</table>

Name

Computer classes you have had

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---

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APPENDIX E

CAI SOFTWARE REVIEW FORM
CAI Software Review Form

This form is to be used to evaluate the vocabulary drill and practice program which you have agreed to review. The purpose of this program is to introduce secondary students to twenty of Schuster's little known and/or rare words. The words were selected for inclusion on Schuster's list according to 'average' students' ability to learn their meaning. The program was used in a study to determine the effect of using color in CAI software. The programs were simple drill and practice programs written using Apple SuperPilot. The programs were identical except for the color variable.

Thank you for your assistance.

Please circle the number that corresponds to your rating for each of the items below. 0 = Poor  1 = Average  2 = Above Average  3 = Excellent

<table>
<thead>
<tr>
<th>Achromatic Version</th>
<th>Color Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Screen design</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>2. Error handling</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>3. Content accuracy</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>4. Operation</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>5. Grammar/spelling</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>6. Clear statement of Objectives</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>7. Meets stated objective</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>8. Use of color</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>8a. Brightness</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>9. Readability</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>10. Overall impression</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>

Average Score | Average Score
APPENDIX F

USE OF HUMAN SUBJECTS
USE OF HUMAN SUBJECTS

Name of subject: ________________________________

1. I hereby give consent to CHARLES V. LATHAM to perform or supervise the following investigational procedure or treatment:

To test for the possible effects of using color in computer assisted instructional programs on vocabulary retention rate. I will work through the software program and will take appropriate tests and surveys as requested by the supervisor.

2. I have (seen, heard) a clear explanation and understand the nature and procedure or treatment; possible appropriate alternative procedures that would be advantageous to me (him, her); and the attendant discomforts or risks involved and the possibility of complications which might arise. I have (seen, heard) a clear explanation and understand the benefits to be expected. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my (his, her) status. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in Paragraph one above.

Signed: ______________________ Date: ______________

Subject

Signed: ______________________

Witness

If subject not responsible:

Signed: ______________________ Relationship _____________

Person Responsible
APPENDIX G

STATEMENT TO SUBJECTS
STATEMENT TO SUBJECTS

You have a copy of a drill and practice software program that teaches rare or seldom used vocabulary words. The program presents a word and its definition followed by a sentence that uses the word. The last screen is a multiple-choice question over the word just presented.

The program will take about twenty to thirty minutes to run. You will be given a pretest on the words before working the program. You will also take a posttest after completion of the program. An attitude scale will be administered after the posttest. Two weeks after this you will take a delayed posttest.

There should be no difference in this software program than others you have used in this class this semester. You will be introduced to several words which are seldom used but are interesting. You could look these words up in a dictionary yourself but this is an easier way to learn new words.

You may choose to not participate in this study without any consequences. This is a voluntary activity. No individual data will be used in this study. You may obtain copies of your scores if you so desire.

If you have any questions, please ask them before we begin the procedure.
BIBLIOGRAPHY


