A STUDY OF THE EFFECTS OF GENDER AND DIFFERENT INSTRUCTIONAL MEDIA (COMPUTER-ASSISTED INSTRUCTION TUTORIALS VS. TEXTBOOK) ON STUDENT ATTITUDES AND ACHIEVEMENT IN A TEAM-TAUGHT INTEGRATED SCIENCE CLASS

by

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ABSTRACT

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ON STUDENT ATTITUDES AND ACHIEVEMENT
IN A TEAM-TAUGHT INTEGRATED SCIENCE CLASS

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The purpose of this study was to determine the effect of different instructional media (computer-assisted instruction (CAI) tutorial vs. traditional textbook) on student attitudes toward science and computers and achievement scores in a team-taught integrated science course, ENS 1001, "The Whole Earth Course," which was offered at Florida Institute of Technology during the Fall 2000 term. The effect of gender on student attitudes toward science and computers and achievement scores was also investigated.

This study employed a randomized pretest - posttest control group experimental research design with a sample of 30 students (12 males and 18 females). Students had registered for weekly lab sessions that accompanied the course and had been randomly assigned to the treatment or control group. The treatment group used a CAI tutorial for completing homework assignments and the control group used the required textbook for completing homework assignments. The Attitude toward Science and Computers Questionnaire and Achievement Test were the two instruments administered during this study to measure students' attitudes and achievement score changes.

A multivariate analysis of covariance (MANCOVA), using hierarchical multiple regression / correlation (MRC), was employed to determine:
1) treatment versus control group attitude and achievement differences; and
2) male versus female attitude and achievement differences. The differences between the treatment group's and control group's homework averages were determined by t test analyses.

The overall MANCOVA model was found to be significant at $p < .05$. Examining research factor set independent variables separately resulted in gender being the only variable that significantly contributed in explaining the variability in a dependent variable, attitudes toward science and computers. T test analyses of the homework averages showed no significant differences. Contradictory to the findings of this study, anecdotal information from personal communication, course evaluations, and homework assignments indicated favorable attitudes and higher achievement scores for a majority of the students in the treatment group.

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Dedication

I have been blessed with many opportunities to follow my dreams and to visit places I have always dreamed of seeing. All the while, I continued my education, not only in school, but also in life's experiences. I have learned a lot from the people I love, and from the people whom I have met along the way. I admire so many of them and can only hope to accomplish half of what they have achieved. I dedicate this to them: my friends, my family, my Dad, and Chad because I would not be where I am and I would not be who I am without them. Thank you. I love you!!

CHAPTER 1

INTRODUCTION

Background Information

It is important to understand how the use of computer tutorials differs in this generation from past ones, because people today interact with computers almost everyday. With the increased popularity of computers in the today's society, it is almost inevitable that computers and computer tutorials will become indispensable in the classrooms of tomorrow. The integration of CAI systems into classrooms will continue to increase.

From a constructivist point of view, information based on personal experiences should be constructed and processed in meaningful, effective ways (Ormrod, 1998). This includes methodologies such as discovery learning, divergent thinking, and open-ended problem solving (Goldin, 1990). Also, constructivist learning theory states that information acquired in the classroom should be accurate and complete so that students' prior misconceptions can be resolved before students connect new information with fragmented and incomplete information (Fosnot, 1989). This was one motivating factor for the present research study, to have the computer tutorial complete information that the professors did not discuss during the classroom lecture. It was believed that using the tutorial would also be a more effective way for students to learn the required material, as compared to using the textbook. Students are more commonly using computers in conjunction with their laboratory sessions, homework, and as a supplement to classroom material. Because of this, it was believed students would be more interested in employing the computer tutorial to interactively learn new material. Thus, using the computer tutorial could have a positive effect on students' learning, which, in turn, can prove to be an effective way for students to process classroom information.

Many studies have been conducted on the effects of computer-assisted tutorials (Duncan, 1991; Nosek et al., 1993; Tjaden & Martin, 1995), yet studies focusing on an integrated science class are scarce since this concept has only recently arisen within the educational realm. Moreover, studies on the effects of integrated science computer tutorials at the post secondary level are limited. Vanderveer (1997), in an unpublished master's thesis, studied ninth graders' attitude toward integrated science in Brevard County Schools. This study revealed that students who enrolled in an integrated science class showed an improvement in attitude toward science compared with students who were enrolled in traditional discipline-based courses. However, this was only when students had a positive attitude toward science prior to instruction. Kulik, Kulik, and Cohen (1980) conducted a meta-analysis on classroom-based comparisons of computer-based instruction (CBI) and conventional teaching. Their study suggested that CBI resulted in a significant gain (.5 standard deviation) in student learning than traditional means of instruction.

Many studies have investigated gender and its effect on students' attitudes toward computers and computer tutorials (Shashaani, 1994; Comber, Colley, Hargreaves, & Dorn, 1997). Studies have shown that males are more interactive with computers and have a more positive attitude toward computers than females (Levin & Gordon, 1989). Males are typically more interested in video and computer games, whereas females normally take a passive role regarding computers. Robertson et al. (1995) reported motivational differences between boys and girls that seem to be the cause of gender related issues, that is, girls are interested in computers only when its for practical uses. It is apparent that most computer games are designed with the male gender in mind since the majority of games include car chases, battle scenarios, and physical contact sports such as football or wrestling. It is for this reason that gender should be considered in any study that is regarding computers, especially computer tutorials.

With the increase of recent technology, people are constantly exposed to computers in everyday situations – school, work, and personal communication. In addition, younger people of both sexes are expected to understand computers now that computers are an integral part of our everyday culture and they typically enjoy using computers (Robertson et al., 1995). Personal ownership of computers has increased with the integration of computers into the work force as well as school settings. Also, the cost of computers has steadily declined, causing people to be more willing to purchase a computer. With the increase of computer ownership and usage, most people are improving their computer skills, which has caused anxiety toward computers to diminish. This has, in turn, caused the overall attitudes toward computers to become more favorable.

The effect of computer-assisted instruction tutorials on students' achievement scores and attitudes toward science and computers, compared to achievement scores and attitudes of students who use the required textbook, can indicate to educators which type of instructional method has a greater effect on students' understanding of and motivation for learning science. It is also important to have an understanding of how gender affects students' attitudes toward science and computers as well as its effect on achievement scores. With research studies indicating that males have a more favorable attitude toward computers (Whitley, 1997; Robertson et al., 1995), it is only appropriate that computer tutorials be designed to be equally appealing to both males and females. Effective instructional media can facilitate an increase in achievement and interest in science from students. The need for innovative instructional teaching methods is prevalent in all levels of education. This study investigated the impact of CAI homework versus traditional textbook with college students in an interdisciplinary science course.

Background and Rationale

With the initiation of the National Aeronautics and Space Administration's (NASA) Mission to Planet Earth (recently renamed Earth Science Enterprise (ESE)), Florida Institute of Technology was chosen to participate in a nationwide effort to increase awareness of integrated Earth science though their Earth System Science Education (ESSE) program. In 1997, Florida Institute of Technology implemented a new course, "The Whole Earth Course," for incoming freshmen. This course used a team teaching approach to an integrated science curriculum instead of the traditional disciplinary science curriculum (Eardley & Maul, 1998, Supp10). Six professors from three Florida Institute of Technology colleges and schools taught the course. They participated in the development and administration of a syllabus that introduced six integrated modules of the Earth system: cosmosphere (Earth's near-space environment), geosphere (the solid earth), hydrosphere (realms of water), atmosphere (our gaseous envelope), biosphere (the living Earth), and anthroposphere (influences of humankind). The purposes of this integrated-science class were to introduce interdisciplinary science education, to increase student awareness of integrated systems, and to promote integrated critical thinking skills. The purpose of this research study was to determine if students who were enrolled in "The Whole Earth Course," would show an increase in student attitudes toward science and computers and achievement when using a computer-assisted instruction tutorial for homework assignments than students who use the required textbook for homework assignments. This study also investigated the influence of gender on attitudes toward science and computers and achievement scores.

The required textbook and supplementary study guide was Skinner and Porter's The Blue Planet: An Introduction to Earth System Science, copyright by John Wiley and Sons, Inc., 1995. During the inaugural year of "The Whole Earth Course," students were required to complete homework assignments from the textbook's supplementary workbook. With homework assigned from the textbook and study guide, it was assumed students had read the book in order to answer the questions. However, the answers were listed in the back of the study guide. Students were observed copying the answers verbatim out of the workbook immediately prior to class. Students' test scores were not reflective of their homework scores, averaging much lower than homework scores. Also, the quiz scores were much lower than the homework scores. Thus, it was decided that the test and quiz scores did not properly represent the high scores received on the homework.

After in-depth discussions with the ESSE faculty, I decided to create a computer-assisted instruction (CAI) tutorial based on the required textbook that would be used at the beginning of the following year. With the growing popularity of computers in today's society, I felt it would be useful to develop and integrate a computer software tutorial into The Whole Earth Course so that students would be more interested and involved in their learning. The goal of this tutorial was to teach students about Earth System Science and its six integrated modules. Although each module was unique, the modules were interconnected to create a holistic view of "The Whole Earth." Before students first used the tutorial in Fall 1999, students who were enrolled in The Whole Earth Course in Fall 1997 and Fall 1998 were asked to evaluate the tutorial. This preliminary study allowed me to make changes to the present research study design as well as to the computer tutorial. After reviewing the tutorial, students said they wished they had had the computer tutorial while they were taking the class. They stated the tutorial was much easier to follow and comprehend than the textbook. After making suggested corrections, the computer-assisted instruction tutorial, "The Blue Planet," was employed in a pilot study in Fall 1999 to assist student learning with this Earth System Science concept. Students used the computer tutorial in answering their homework assignments. At the end of semester, students stated they felt the tutorial was learner friendly, compared to their textbook, and extremely helpful in understanding this new integrated Earth system science concept. However, one problem encountered with the implementation of the computer tutorial was improper computer hardware. Many of the computers had to be upgraded in order for the tutorial to run properly. Other problems included student absenteeism when quizzes were administered and students not turning in their homework assignments. Observations from Fall 1999 were used to describe the initial assessment of the CAI tutorial. Also, changes to the present research study design and computer tutorial were made based on the Fall 1999 pilot study. This research study was implemented in Fall 2000.

Research Questions

This study, which involved students in The Whole Earth Course, investigated the following research questions:

1) Will students in "The Whole Earth Course" at Florida Institute of Technology who use a computer-assisted instruction tutorial to complete homework show an increase in positive attitudes toward science and computers compared to students who do not use a computer-assisted instruction tutorial?

2) Will students in "The Whole Earth Course" at Florida Institute of Technology who use a computer-assisted instruction tutorial to complete homework show an increase in achievement scores compared to achievement scores of students who complete homework using the required textbook?
3) Will there be a difference between the males' and females' scores on the attitude questionnaire posttest?
4) Will there be a difference between males' and females' achievement scores on the achievement posttest?
5) Will students using CAI programs yield higher homework averages than students using the traditional textbook?

Null Hypotheses

The null hypotheses for this study that correspond to the research questions were as follows:

1) There will be no significant difference between treatment and control groups' science and computer post-attitudes.
2) There will be no significant difference between treatment and control groups' post-achievement scores.
3) There will be no significant difference between males' and females' scores on the attitude questionnaire posttest.

4) There will be no significant difference between males' and females' achievement scores on the achievement posttest.

5) There will be no significant difference in homework averages between the two groups using the different instructional media – CAI and traditional textbook.

Definition of Terms

The *integrated science curriculum* is operationally defined as a team-taught course that incorporates or integrates concepts from each of the traditional science curricula in order for students to have a holistic viewpoint of the Earth. The *Whole Earth Course* is defined as an integrated science class that is uniquely team-taught by 6 professors from three different colleges at Florida Institute of Technology. A *computer-assisted instruction tutorial (CAI)* is operationally defined as "the interaction of a learner with a computer in a direct instructional role" (Lockard, Abrams, & Many, 1997, p. 190). *Attitude toward science* is defined as the students' interests and perceptions of science as they pertain to realistic problems. Attitude toward science was measured using science attitude questionnaires with a Likert-type scale, administered before the implementation of the computer tutorial and at the end of the semester. This questionnaire is based on Vanderveer's (1997) Science Questionnaire and is modified to include students' viewpoints on the use of computers in today's society.

Achievement is defined as the students' increase in scores on a comprehensive achievement pretest and posttest, in between which the treatment was given. Achievement was measured by comparing the raw scores of each group on the achievement pretest and posttest.

Purpose

The purpose of this study was to determine if students who were enrolled in a team-taught integrated science class, "The Whole Earth Course," would show an increase in achievement scores and attitude toward science and computers when using a computer-assisted instruction tutorial for homework assignments compared with students using the required textbook for homework assignments. In addition, this study examined if there were gender differences affecting achievement scores or attitudes toward science and computers.

Significance of the Study

This study built on the research studies previously discussed. I applied the CAI program toward integrated science, in which there is a dearth of research presently. I expanded on Vanderveer's (1997) study by looking at students' attitude toward integrated science when a computer tutorial was utilized. Vanderveer's research, which investigated ninth-graders' achievement scores, was elaborated by measuring achievement scores in an integrated science class at the post secondary level. The findings of this research are of importance to the professors involved with

The Whole Earth Course. The structure of future courses could use a computer tutorial as an alternate homework delivery system. Also, the tutorial could be used as a study guide for quizzes and exams. Using a computer tutorial as a study aide was found to be at least as effective as using the traditional textbook. As found in this study, males showed a significantly better attitude toward science and computers than did females. This parallels findings of previous studies, suggesting that perhaps computer tutorials have been designed to appeal to males thus influencing their overall attitudes toward computers. From the findings of this research, it can be suggested that future computer tutorials should be intended and designed for both males and females.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Computer Tutorials

In the Classroom

Computer tutorials were first used in the classroom during the 1960's. However, the use of computer-assisted instruction (CAI) programs in the classroom has only become popular within the past 10–15 years. Three major factors have contributed to the popularity of computer tutorials in the education of today's students. First, computer tutorials provide students with opportunities to develop skills in logic (Crosby & Iding, 1997). Second, tutorials aid students in problem–solving using higher order thinking skills (Singh, Ahluwalia, & Verma, 1991). These two reasons are especially prevalent in the education of gifted students (Lin, Podell, & Tournaki-Rein, 1991). Third, computer tutorials have unlimited potential for individualized interaction (Hickey, 1995). Most software is currently categorized according to one's age, which indicates one's grade level. Teachers can determine a student's learning level and thereby ensure the appropriate software is being used for that student's learning ability. Students can work at their own pace using the computer tutorial since it was specifically selected by their teachers to match their learning level.

These three features are key reasons tutorials have become increasingly integrated into today's classrooms (Hickey, 1995, p.48).

The use of computer tutorials in classrooms has increased because of the advantageous features of microcomputers. Tutorials are flexible because they can be used with any subject being taught such as, foreign languages (Child, 1998, p. 390), chemistry (Hwang, Chen, & Tseng, 1995, p. 9), physics (Crosby & Iding, 1997, p. 127), or mathematics (Singh, Ahluwalia, & Verma, 1991, p. 212; Tilidetzke, 1992, p. 53). Tutorials are motivating because students are encouraged to take control of their own learning throughout the software program, deciding which direction they want to take or which questions they want to answer. For many students a computer tutorial is an effective and interesting method to help them understand and learn new material. Students have been learning new material interactively because computer tutorials have integrated sound, text, graphics and video (Askov & Bixler, 1996, p. 24), compared to a two-dimensional textbook with text and pictures only.

As briefly mentioned above, computer tutorials are capable of delivering instruction that can be customized to meet the needs of individual students. This can strengthen a student's learning ability, as well as increase the student's motivation and interest in learning new subject material. All of these factors combined have caused computer tutorials to become valuable to teachers and in classroom settings.

Nosek et al. (1993) suggest that, at the college level, the integration of CAI programs will aid in decreasing the number of large group lectures, which are now mostly traditional instruction. The decrease enhances informal interaction between students and faculty into small groups for review sessions. Informal interaction in smaller groups creates a more pleasing, active learning environment. Also, problem solving and independent learning skills are enhanced due to the personal interaction between the students and faculty (Nosek et al., 1993, p.129). Thus, the efficiency of learning is improved because the motivation and interest in learning are increased.

In summary, computer-assisted instruction tutorials are computer software programs designed to assist and enhance student comprehension and learning of subject material, as well as aid lecturers in the instructional delivery of subjects. CAI tutorials can strengthen students' learning ability if properly administered and integrated into the subject material being presented. Students can effectively and interactively learn new material when a CAI program is used. Thus, it is believed CAI programs can be practical and interesting methods for students to understand and learn material. Also, with this increased learning ability, students could achieve higher performance on quizzes and exams.

Effectiveness of Computer Tutorials

Research studies of the effectiveness of CAI focus on three main treatment group possibilities: traditional instruction versus CAI instruction; traditional instruction combined with CAI; and traditional instruction versus CAI instruction combined with a supplemental textbook. There are two main methods to measure CAI effectiveness on student learning. The first is to administer Likert–type scale questionnaires assessing students' attitudes toward the CAI program as well as their opinions of the effectiveness of the CAI program. The second method is to give the students pretests prior to the treatment application and posttests following the treatment. The difference in scores indicates CAI effectiveness on student learning.

In order for CAI programs to be effective for student learning and achievement, certain requirements must be met. First, students need to be put in control of their own learning. This maximizes the motivation and interest of students thus increasing their learning ability. Second, hardware requirements should be minimized, so as not to intimidate students. Students should not feel threatened in their learning environment; they should feel comfortable when using the computer. Third, subject material should incorporate high quality text and illustrations in order to enhance student learning. Fourth, the CAI program should be fully integrated into the course so that it can be used as part of the normal instruction. A CAI application should be formally introduced to the students to ensure proper utilization. Last and most importantly, the validity of the content material should be tested in order to ensure that appropriate subject material is being used for the topic being taught.

Duncan (1991) investigated the effect of CAI used as a supplement to course content in a research design course. She stated that the CAI program was selected based upon the desired objectives of the course. Test performance was used to measure CAI effectiveness. Results indicated that students scored significantly higher ($p < .001$) on exams when lecture and text materials were supplemented with CAI. Duncan suggests that the CAI was effective in meeting the objectives.

Tjaden and Martin (1995) examined the learning effects of CAI combined with traditional lecture, versus traditional lecture by itself. Students were enrolled in a freshman level, computer science course in which they were assigned to one of two groups. Both groups received the same traditional lecture from the same professor. Examples were given to the control group by the professor aided by transparencies during the lecture. The examples were presented to the treatment group using the computer tutorial, without teacher intervention. Pretests indicated similar prior knowledge of the subject area by both groups. Posttests demonstrated no significant difference between the two groups in the amount of learning that occurred. However, time spent on the different delivery methods of the examples varied greatly. The professor spent more time actually presenting the examples to the control group than was spent by the treatment group to comprehend the examples presented on the computer. The professor commented there was not enough time to cover all the subject material because he had to stop often in the middle of a lecture. Students indicated that they preferred the examples being presented with the use of the CAI tutorial to those of the professor. Even though no significant performance difference was observed in this study, the results demonstrate the students' positive attitude toward using CAI programs compared to traditional lecture. Tjaden and Martin (1995) suggest that relying on the computer instead of the instructor for the delivery of subject material was considered by the students to be a more interesting instructional environment.

Several reasons are suggested as to why an increase in student learning is typically observed in experiments that include traditional instruction combined with CAI instruction as well as traditional instruction versus CAI supplemented with a textbook. First, the CAI program reinforces concepts students have learned in their traditional classroom lecture (Crosby & Iding, 1997). Second, in viewing the CAI program, students are spending more time studying thus learning the subject material (Bishop-Clark & Donohue, 1998-99). Last, by having students use CAI applications, more time is made available for teachers to focus on students' questions and to thoroughly discuss subject topics in the classroom (Tilidetzke, 1992). This explains the final outcome of increased effectiveness and achievement on exams. Students enhance their learning ability by supplementing already known information learned in traditional instruction with CAI programs.

Kulik, Kulik, and Cohen (1980) examined 59 articles in a meta-analytic study on computer-based instruction (CBI), in which the CBI was used as both a supplement to classroom instruction and lecture replacement, versus traditional lecture. Results showed that CBI yielded significant gains (0.5 standard deviations) in learning over the traditional instruction. However, Clark (1985) re-analyzed this meta-analysis and concluded that the initial findings were incorrect because some of the research studies associated with the meta-analysis lacked internal validity due to confounding variables. Indeed, Clark stated that CBI had the same effect on learning as the traditional teaching methods. However, Clark added that more research needed to be conducted to detect CBI efficiency.

It must be noted that the importance and integration of computers in school systems has dramatically increased since both of these studies were undertaken. This research study investigated the significance of computers today on student achievement and attitude toward science.

Advantages of Computer Tutorials

Educators have realized the beneficial qualities of CAI and its contribution to the effectiveness of teaching. CAI has been increasingly integrated into classrooms in order to supplement or assist in the instruction of subject material. One major advantage of CAI is that it can be used with students of different ages or abilities (Hickey, 1995, p. 48). Another beneficial quality is that CAI can be customized to meet the needs of individual students (Copper, 1991, p. 68). Accompanying customization is the fact that teachers can track student responses and their progress in their acquisition of skills throughout the program and adjust accordingly, if needed.

Immediate and individualized feedback is an advantage to CAI (Reglin, 1989/1990, p. 47). Students are more inclined to be interested in learning subject material if they are not self-conscious about what their peers might think of their responses, thus maintaining their status among their peers (Reglin, 1989/1990). Individualized feedback also allows freedom from embarrassment or disapproval by peers or teachers as might happen if a question was answered incorrectly during a traditional lecture. Immediate feedback enables students to be aware of their progress instantaneously instead of having to wait for a teacher to grade papers or exams. This enables students, as well as teachers, to diagnose sources of errors quickly. Also, immediate feedback often gives detailed explanations to incorrect responses. This aspect of CAI privacy enhances student comprehension because students often are embarrassed to ask questions during lecture if they do not understand the subject material (Reglin, 1989/1990).

Immediate and individualized feedback promotes two more advantages of CAI, self-paced learning and independent learning, through active involvement with the subject material within the CAI. Students are in control of the learning resource actively, including decision-making choices within the CAI regarding direction (unidirectional or branching) that promotes independent curiosity and exploration (Reglin, 1989/1990). Because students are in control of their own learning, students can proceed at a pace with which they are comfortable. This is unlike a traditional lecture where the teacher must continue at a pace that may not be appropriate for everyone's learning level. Self-paced learning and independent learning enhance students' motivation and interest because they are in control of their learning. Students have the freedom to delve into different aspects of the subject material being discussed at their own pace and to investigate information, which interests them.

Disadvantages of Computer Tutorials

Although there are several advantages to using computer tutorials, there are also disadvantages that need to be addressed that include limited CAI applications, hardware and software requirements, and difficulty levels of tutorials.

Nosek et al. (1994) reported that CAI applications were limited for various subjects. However, they stated that the subject variety of CAI tutorials was quickly growing with the integration of computers into everyday culture. They also claimed that computer tutorials were sometimes not completely integrated into courses and thus caused the subject material to be disjointed from the subject material within the computer tutorials. Bishop-Clark and Donohue (1994) suggested that teachers should formally introduce their students to the computer tutorial application being used to minimize computer anxiety as well as maximize the students' computer awareness. It is reasonable to infer students need some form of step-by-step introduction to the computer as well as the computer tutorial, even if it is minimal, if it is assumed that many professors may not know what their students' prior computer knowledge is (Tilidetzke, 1992).

Nosek et al. (1994) suggested that the hardware requirements for a tutorial be minimized so those students with little computer experience would not be intimidated. This corresponds to appropriate computer software as well. Baldwin, Johnson, and Hill (1994) stated that the poor quality of graphics of computer tutorials caused first year baccalaureate nursing students much frustration. This caused the students to have negative attitudes toward the computer tutorial since they felt it was less useful and less stimulating due to the faulty graphics. The students preferred more faculty demonstration and contact for learning their subject material rather than the computer tutorial.

Another issue of computer tutorials is the actual subject material. The subject material should be tested prior to student usage (Nosek et al., 1994). This ensures that the tutorial subject material is appropriate for the particular course. This also allows the professor to check the detail of the subject material and the length of the tutorial (Tilidetzke, 1992). In checking the subject material, the professor can also make sure that the difficulty level of the tutorial and the tasks within the application is equal to the students computer knowledge and cognitive skills (Czaja & Sharit, 1998).

Although there are disadvantages to computer tutorials, the benefits of using computers and tutorials outweigh the negative issues. With the increase of computer technology in our society, it seems inevitable that the quality of the computer tutorial will surpass our expectations. Also, the quantity of computer tutorials is quickly expanding as well with the integration of computers into the school systems. While there may still be shortcomings to computer tutorials, it only seems natural that the use of computer tutorials within the classroom will increasingly continue.

Computers and Gender

Several research studies have consistently shown that males have a more positive attitude toward computers than females. This attitude is typically caused by different factors including prior computer experience, computer ownership, amount of computer usage, computer anxiety and computer software biases.

Shashaani (1994) conducted a study of 902 males and 828 females in secondary schools. The research findings indicate that the gender differences in computer experience were directly related to students' attitudes toward computers. Specifically, males had more positive attitudes than females. The author reported that females used the computer within the school setting for one hour or less per week. However, males used the school computers for five hours or more per week. With the increased computer usage, males had more confidence in their ability to work with computers, causing males to have more favorable attitudes toward computers. Shashaani reported, however, that frequent computer usage overall caused both males and females interest in learning about computers to increase.

In a study of 384 adults, Czaja and Sharit (1998) found that the level of comfort with computer technology increased with computer experience. Many research studies show females to have negative attitudes toward computers as compared to males. However, their findings indicated women had a greater increase in comfort with computers than males thus contradicting the notion that women have more negative attitudes toward computers than men. The authors suggested also that the increase in positive attitudes were a direct result of computer experience.

Robertson et al. (1995) conducted a study of first year students in an English secondary school, with a sample of approximately 62 students. Like the findings of Shashaani, Robertson et al. (1995) reported that males have more computer experience and typically own computers, causing them to have more positive attitudes than females toward computers. However, their research findings showed no difference in computer anxiety between males and females. This result refutes the suggestion that females are more anxious toward computers than males. The authors stated that this equality was perhaps due to the increase of computer experience among younger people.

Comber et al. (1997) investigated the effects of age, gender and computer experience of 278 secondary students. The results indicated that the majority of students who owned computers or had access to them at home were males. Males also used computers more frequently than females. The authors reported that overall, males had a more positive attitude toward computers than females, which was supported by the fact that males had greater experience with computers than females.

Levin and Gordon (1989) examined the effects of gender and computer experience on students' attitudes toward computers. The sample consisted of 222 Israeli students in grades 8 through 10. The findings suggested computer ownership caused students to have more favorable attitudes toward computers. Also, males had more positive attitudes toward computers than females. However, the authors stated that males and females who owned computers showed similar perceptions toward computers than did students who did not own computers, commenting that computers were more "enjoyable," "important," and "easier." The results indicated that computer experience had more of an effect on students' attitudes toward computers than gender.

Whitley (1997) conducted a meta-analysis that investigated the gender differences in computer-related attitudes. He reported that males had higher computer self-efficacy than females. It was stated that computer games and educational software were designed to be more appealing toward males than females, ultimately causing males to have more positive attitudes toward computers.

Teh and Fraser (1995) investigated gender differences in the achievement and attitudes of students who were involved in computer-assisted instruction and traditional expository teaching. The analysis indicated that males had higher, yet non-significant achievement results (.5 standard deviation) than females in the CAI group, but males and females had similar achievement results in the traditional teaching group. The authors stated that the overall attitude was not affected by gender differences. Because of the discrepancy in the findings, they suggested that computer software should be designed for both male and female users.

Younger generations are being exposed increasingly to computers in our society and their computer skills are excelling rapidly. It is obvious that the younger generation is the future of our advancing computer technology. Caftori (1994) stated that software applications should be designed to appeal equally to males and females. With gender biases in computer software applications removed, males, and especially females, would be more motivated in purchasing computers, using computers more frequently, and increasing their computer experience. With these factors combined, males' and females' anxiety toward computers could be diminished while their attitudes toward computers could be greatly enhanced.

CHAPTER 3

METHODS

Research Design and Power Analysis

This study employed a randomized pretest-posttest control group experimental research design. As described by Fraenkel and Wallen (1996), this research design had two groups of subjects that were randomly assigned to an evening lab session depending on the course section for which they were registered. Both subject groups were measured twice with a science attitude scale questionnaire and achievement pretest given at the beginning of the semester and the same questionnaire and achievement test given at the end of the semester as a posttest. The questionnaire and test were given to the students simultaneously. Group equivalency was confirmed using a t test analysis between control and treatment groups on each pretest score. No statistically significant differences were found on both measures (Science Attitude: $t = -.185$, $p > .05$; Achievement: $t = 1.243$, $p > .05$), which indicates that both groups were equivalent on the pretest measure, which was also used as the posttest.

Students enrolled in "The Whole Earth Course" were the subjects for this study. This was a sample of convenience because students in the research study had registered for this particular class. Students had a choice of two different evening lab sessions for which to register. In order to achieve equal group numbers in each lab, registration for each session was limited to 15 students. When the research study began, the treatment was randomly assigned to one of the lab session groups based on a random numbers table. The group using the instructional media was determined by which lab session they were assigned.

An appropriate sample size for this study was determined a priori by a power analysis with an alpha level of .05. A 90% chance of finding a treatment effect was desired and power was set at .90, which means beta equaled .10. The treatment effect to be detected with the determined power was chosen as a large effect size (.50). The rationale for the large effect size was that since the class was only in its fourth year and still in its experimental stages, any treatment effect could be of importance. Also, based on the past years' enrollment numbers, a small sample was anticipated. Therefore the best possibility of finding any treatment effect was using a large effect size. Using these values, a sample population of 29 students was calculated to be the minimum number of students needed (Cohen & Cohen, 1983). More students were included than the suggested sample size to account for mortality. The research study was conducted in Fall 2000.

Population and Subjects

The target population of this study was students attending Florida private universities with a student enrollment less than 6,000, who were enrolled in an integrated science class. Generalization of the results to all southeastern private university students was desired. However, actual extension of the results to this population was questionable since the research sampling design was non-random. The accessible population of this study was students enrolled in The Whole Earth Course at Florida Institute of Technology during Fall 2000. All students enrolled in The Whole Earth Course were the research subjects. This sample was chosen on the basis of convenience of the researcher's close proximity to the university and involvement in The Whole Earth Course.

Treatment

The treatment in this study was a computer tutorial that was designed for a new type of science curriculum that was based on NASA's "Earth System Science Education" program. This program consisted of a team-taught integrated Earth systems approach designed for university level students. Students who were enrolled in one of the two sections of "The Whole Earth Course" completed six homework assignments using a computer tutorial instead of their required textbook. Students in the other section completed the same six homework assignments using the traditional textbook. There were a few differences between the tutorial and the textbook. First, the tutorial was more interactive. Students had total learner control, being able to move anywhere within the tutorial. Also, there were questions asked throughout the tutorial for the student to answer and receive immediate feedback, unlike a 2-dimensional textbook.

However, a common link between the computer tutorial and the textbook was that the students had to finish their homework during scheduled evening lab sessions. The homework lab sessions during which the students completed homework were offered on Tuesday or Thursday. The student's registration determined which night he/she attended the homework session. Each session was 80 minutes long. Every time a student attended the lab, he/she was required to sign in and the total time spent in the lab was recorded for each of the students.

An undergraduate student who had been enrolled in The Whole Earth Course in its inaugural year proctored these sessions. The proctor ensured that students used only the instructional medium they were supposed to by being present, taking attendance, giving them their homework assignments, and observing them during the lab sessions. The proctor was instructed not to assist the students with any questions related to the content of homework questions. The students were encouraged to use e-mail or discuss any questions they might have with the professors or myself. Students who used the computers could ask any questions they might have pertaining to computer usage, but not the subject material. Students were monitored while completing their homework to ensure they were reading the material and not sharing their homework answers with other students. The students were not allowed to take uncompleted homework assignments outside the lab. Rather, they had to complete the homework within the lab sessions. All homework answers and assignments were collected at the end of each lab session and redistributed to the students at the beginning of the next lab session.

Instruments

To measure students' attitude toward science and computers, the instrument used in this study was a 36-item Likert–type science attitude questionnaire (see Appendix A). This questionnaire was designed to determine students' attitudes toward science as well as computers. This set of questions was based on Vanderveer's (1997) Science Questionnaire and was revised to include students' attitude toward computers because this research was focused on the effects of computer-assisted instruction tutorials. The face and content validity of the questionnaire was confirmed by a panel of eight professors involved with The Whole Earth Course: Dr. George Maul, Dr. Michael Witiw, Dr. Robert Fronk, Dr. John Windsor, Dr. Iver Duedall, Dr. Mark Moldwin, Dr. Hamid Rassoul, and Ms. Sarah Frias-

Torres. The six professors involved with the Fall 2000 class reviewed the questionnaire. It was determined the questionnaire did not need to be revised. A Flesch Reading Ease coefficient for this questionnaire was determined to be 70.5 by Microsoft Word. With a desired score of approximately 60 to 70 for standard documents, this coefficient indicates it was easy to understand the questionnaire. A Cronbach's alpha reliability coefficient of $r = .87$ was determined for the science attitude questionnaire. A Cronbach's alpha reliability coefficient is designed to measure the internal consistency of a unidimensional questionnaire, with a coefficient of 1.00 being the highest desired score.

A science exam tested students' achievement scores (see Appendix A). This instrument consisted of multiple-choice questions that had been selected from previous exams and the study guide. The achievement test yielded a total of 30 questions, with a total of five questions representing each module taught throughout the course. The face and content validity of the test were reviewed and revised by a panel of seven professors involved with The Whole Earth Course: Dr. George Maul, Dr. Michael Witiw, Dr. Hamid Rassoul, Dr. Robert Fronk, Dr. John Windsor, Ms. Sarah Frias-Torres and Dr. Iver Duedall. A Flesch Reading Ease coefficient was determined to be 60.2 by Microsoft Word. The SPSS computer program was utilized to calculate the Kuder-Richardson 20 formula for reliability of internal consistency. The reliability coefficient for the test was r = .79, with a coefficient of 1.00 as the maximum possible coefficient that can be obtained.

Procedures

The tutorial included seven different modules of information - the introduction section and the six modules. The introductory module included the directions, goals, objectives, concept of the systems approach, and the Whole Earth Menu. From the Menu, the student could navigate to any of the six modules. The specific objectives of this program were stated so that upon finishing this tutorial, the student was able to identify each of the six spheres, identify key characteristics of each sphere, and identify how the spheres were integrated to form "The Whole Earth."

The research design involved using a course in which the students were registered for one of two lab sessions. Group 1, which met on Tuesday nights, used the computer tutorial to complete homework assignments (treatment group), while Group 2, which met on Thursday nights, used the textbook to complete homework assignments (control group). All students completed an attitude toward science and computers questionnaire and a science achievement test prior to initial instruction. The same questionnaire and test were administered at the end of the semester. The anticipated test taking time was approximately 50 minutes, although most students finished within 35 minutes.

All students attended the same class sessions. The structure of the class was such that the students were given a quiz based on textbook material at the beginning every class. The format of the quizzes was standardized throughout the course, so that each quiz was worth 10 points and contained multiple choice questions, true-false questions, and short answer questions. After the first quiz of each module, the groups had homework assignments to complete either using the textbook or the computer tutorial. The questions used for both homework assignments were identical, in most cases. A total of three quizzes were administered during each module. At the end of two modules, both groups were simultaneously given an exam. This pattern was followed throughout the semester for a total of six modules and three exams. It was important to have numerous recorded scores so students had several ways improve their final grade in the class. The planned statistical analyses allowed examination of each group's mean achievement scores on the homework assignments as long as the achievement section of the analysis was significant.

A MANCOVA (multivariate analysis of variance) analysis is an extension of an ANOVA (analysis of variance) model and was employed to test this data for several reasons. First, there were two dependent variables, achievement in science and attitude toward science and computers. The MANCOVA model allowed the intercorrelations among the dependent variables to be examined. Second, this analysis allowed the effects from the attitude toward science and computers questionnaire and achievement test (covariates) to be factored out. Third, the MANCOVA analysis also determined the adjusted group means, which allowed the treatment effect to be seen without the influence of the covariates. Fourth, MANCOVA models control for excessive inflation of experimentwise Type I and Type II error rates (Haase & Ellis, 1987). A Type I error is the probability of rejecting the null hypothesis when in reality a treatment yielded no effect which can result in making a false report of a treatment effect. A Type II error is defined as the action of failing to reject the null hypothesis when it is really false. This research design allowed the testing of the effect of a computer-assisted instruction tutorial on achievement and attitudes of students in an integrated science course. The achievement scores of each group were tested for significance using the MANCOVA model.

If the MANCOVA analysis showed statistical significance, a follow-up test was warranted. The most frequently used post-hoc test is the protected univariate F test (Haase & Ellis, 1987). The advantage of using this test was that it prevents inflated Type I errors. However, the disadvantage of this test was that it ignores the interrelations of the dependent variables, which is one of the very reasons for employing the MANCOVA model. Upon executing a separate correlation analysis, the correlation of the achievement and attitude posttests was $r = .36$, which was considered to be a relatively low correlation (Sokal & Rohlf, 1995). A post-hoc test was not employed since the intercorrelations of the dependent variables was determined using an analysis other than the univariate F test.

Description of Dependent and Independent Variables

Table 1 shows the categorizing of the dependent and independent variables and their entry order based on the chosen statistical analysis. Two dependent variables were involved in the statistical analysis as well as three sets of independent variables. The independent variables were categorized into three different sets. The first two independent variables, the covariates, were the attitude toward science and achievement in science pretests (Set A). The second set (Set B) included the research factors: group membership (either experimental or control group) and gender (male or female). The third set (Set C) consisted of the interactions between the variables within Set A and Set B. This interaction was the product between the covariate and research factor sets. There were a total of four independent variables within Set C. The attitude and achievement posttests were the dependent variables (Set D).

Table 1

MANCOVA variable set descriptions and statistical model entry order

Variable Set	Entry Order	Variable Name
		Independent Variables
A (Covariates)	First	X_1 - Attitude pretest
		X_2 - Achievement pretest
B (Research Factors)	Second	X_3 - Group membership
		X_4 – Gender
C (Interactions)	Third	$X_5 – X_1X_3$
(Product of Set A X Set B)		$X_6 – X_1X_4$
		$X_7 – X_2X_3$
		$X_8 – X_2X_4$
		Dependent Variables
D (Outcomes)	First	Y_1 – Attitude posttest
	Second	Y_2 – Achievement posttest

Threats to Internal Validity

The major threats to internal validity in this study included: 1) mortality, maturation and history threats due to the time period (four months) between the administration of the Science Questionnaire pretest; 2) data collector bias: I was personally involved with grading the students' quizzes, homework, and exams; 3) data collector characteristics: possibly distorting the data so the outcomes were fitted to support the hypotheses; 4) location: the class was conducted in a separate room from where the homework lab sessions were held; 5) implementation effect: students may have had a preference for using the textbook for homework assignments instead of the computer, possibly causing students to have negative attitudes toward using the computer tutorial; and 6) testing: any improvement in posttest scores could have resulted from the use of the pretest. The randomized pretest-posttest control group research design controlled for several threats to internal validity including subject characteristics (such as age), mortality, history, and maturation. An overview of controlling the internal validity threats follows.

Even though the research study lasted four months, mortality, maturation and history could have posed possible threats to internal validity. Loss of subjects was expected because this was a freshman level course. Students withdrawing from the course could happen easily. Thirty-two students enrolled for the class and only two withdrew from the class. This left the class size larger than the needed sample size of 29 as calculated by the power analysis. Asking the students their age at the present time on the pretest and posttest controlled for maturation and subject characteristics. This allowed each student to be placed into a certain age group that showed how many students had had a birthday during the semester. The changing number of students within each age group was consistent with the amount of students who had had birthdays. Observing school and local newspapers for major events that might have been related to the subject material alleviated the history threat. For example, if students were learning about space flight and during this time there was a space shuttle launch, this could have potentially influenced students' understanding or interest in the subject material. With the current topics in the newspapers being reviewed for similar lecture topics, events were recorded in the researcher's log. These events were then examined for possibly having an influence on students' learning. For example, the discussion at the beginning of the semester was about hurricanes, yet there were not any hurricanes during the semester that could have influenced the students' attitudes. Upon reviewing class notes and recorded events, it was determined that there were not any special or extraordinary events that occurred that would have influenced the students' learning.

The threat of data collector bias existed because I was personally involved with this class as a teaching assistant. To resolve this, all students were observed in the same manner during the class period. A proctor supervised the evening classes in order to control for data collector bias in the experiment itself. The proctor was present to assist students with hardware and software problems, not with homework assignments.

In order to control for data collector characteristics, I was the only person collecting data throughout the entire study. Even though there was a proctor for the labs, she was not collecting or analyzing any of the data. This was a team-taught class with six professors lecturing; however, they were not responsible for grading any of the quizzes, homework assignments, or exams. I graded all assignments (except the term paper, which was not included in the overall achievement scores) in order to control for multiple teachers' grading inconsistencies and expectations. Also, by being in charge of the grading for a course taught by six professors, as well as the sole data collector, experimenter bias as well as instructor bias was controlled.

To control for location, the room in which the research study was conducted was held constant for all subjects. The lectures were given in one room, while the computer labs and homework labs were offered in another room. Both rooms remained the same throughout the study.

Students utilized a computer tutorial during this lab session to complete homework questions. However, it was possible that some students may have been intimidated by a computer and felt more comfortable using their textbook for completing their homework assignments. The proctor informed me that some students had problems with spreadsheets for doing mathematical calculations. However, she said that after she explained the spreadsheet functions there were not any student misunderstandings. She stated that the students were very comfortable with using the computers, especially Microsoft Word, for typing their homework assignments. Also, because the lab sessions were offered outside of the classroom and in the evening, students may have felt this was an inconvenience for them to attend. To accommodate this possibility, the lab sessions were printed in the Fall Semester 2000 Class Schedule. In this manner, students were aware of the evening lab sessions upon registering for the course.

To control for implementation effect, the proctor was instructed to observe the groups during their lab sessions in order to see that the research methods were being administered as instructed. During class periods, I observed the students and professors to ensure consistency within the planned implementation. Examples are such conventions as not accepting unexcused late homework or allowing people who were tardy to retake a quiz.

In order to control for the testing effect, an appropriate statistical analysis design was chosen. The MANCOVA statistical model was employed to factor out the effects of the pretest, leaving only the attitude and achievement posttest scores to be analyzed for statistical significance.

CHAPTER 4

RESULTS

This chapter is separated into three different sections. The first section consists of the descriptive statistics obtained from the Science Achievement Test and Attitude toward Science and Computers Questionnaire pretest and posttest. The second section contains the inferential statistics completed by examining the null hypotheses of this study mentioned in Chapter 1. The third section consists of supplemental information obtained from additional univariate analyses.

Descriptive Statistics

Demographics

The Science Achievement Test and Attitude toward Science and Computers Questionnaire contained a demographics section at the beginning of the questionnaire. The two questions addressed only gender and age. As can been seen in Table 2, a total of fifteen students were enrolled in each group. The treatment group had seven males and eight females; the control group had five males and ten females. The majority of students were within the 18 years old category.

Table 2

Summary of Student Demographics (N = 30): Group Membership and Gender

Group	Gender		Age				
			17	18	19	20	21+
Treatment	Males:	7	0	5	0	1	1
	Females:	8	0	4	0	2	2
Control	Males:	5	2	1	1	0	1
	Females	10	0	9	1	0	0

Science Attitude Questionnaire

Table 3 summarizes the results for the science attitude pretest and posttest. The combined group (N = 30) had a mean score on both the science attitude pretest and the posttest of 130, with a maximum score of 180. When divided into group membership categories, the mean scores for the control group (N = 15) were 131 for the pretest and 130 for the posttest. The mean scores for the treatment group (N = 15) were 130 for both the pretest and posttest. No statistically significant differences were found to exist between the control group's or treatment group's pre- and posttest attitude scores (Control: $t = .391$, $p > .05$; Treatment: $t = .495$, $p > .05$).

When the control group was divided by gender, the mean score of the pretest and posttest for the males (N = 5) was 136 and 137, respectively. The females' (N = 10) mean score for the pretest was 128. The mean score for the females' posttest was 127. The treatment group's males (N = 7) mean score for the pretest was 132 and the posttest was 134. The females' (N = 8) mean score for the pretest was 128 and the posttest was 127. In short, males showed a more positive attitude toward science and computers than females. Also, males in the control group had a more favorable attitude than the males in the treatment group.

Table 3

Results of the Science Attitude Questionnaire by Group Membership and Gender

		Pretest			Posttest		
Group	Gender	Mean	SD	N	Mean	SD	N
Combined	All	130	14	30	130	7.3	30
Combined	Male	134	18	12	135	7.7	12
Combined	Female	128	9.3	18	127	6.9	18
Control	All	131	8.3	15	130	7.3	15
Control	Male	136	8.1	5	137	4.3	5
Control	Female	128	7.4	10	127	5.8	10
Treatment	All	130	18.0	15	130	9.5	15
Treatment	Male	132	23.6	7	134	9.6	7
Treatment	Female	128	11.8	8	127	8.5	8

Note: Scores reported as raw data based on a total possible score of 180.

The pre- and posttest mean scores and standard deviations for each item on the Attitude toward Science and Computers Questionnaire are summarized in Appendix B.

Achievement Test

The achievement test contained 30 multiple-choice general integrated science questions, which were scored one point each. Table 4 summarizes the results for the achievement pretest and posttest. The overall group pretest achievement mean was 15.6 (with a maximum of 30), and the posttest mean was 19.8. After separating the data by group membership, the mean scores for the control group ($N = 15$) were 15.0 for the pretest and 19.0 for the posttest. The pretest mean score for the treatment group ($N = 15$) was 16. The posttest mean score for the treatment group was 21. No statistically significant differences were found to exist between the control group's or treatment group's pre- and posttest scores (Control: $t = .018$, $p > .05$; Treatment: $t = 9.23 \times 10^{-6}$, $p > .05$).

Dividing the control group by gender resulted in pretest and posttest mean scores for the males ($N = 5$) of 16.0 and 23.0, respectively. The females' ($N = 10$) pretest and posttest mean scores were 14.4 and 16.7, respectively. The pretest mean score for the males ($N = 7$) in the treatment group was 16. The males' posttest mean score was 21. The females' ($N = 8$) pretest and posttest mean scores were 16 and 20.5. Overall, males had higher achievement scores than females. The achievement scores for the males of the treatment group were similar to that of the control group. However, females in the treatment group had a higher increase in achievement scores than the females in the control group.

Table 4

Results of the Achievement Test by Group Membership and Gender

			Pretest			Posttest	
Group	Gender	Mean	SD	N	Mean	SD	N
Combined	All	15.6	2.4	30	19.8	4.7	30
Combined	Male	16.6	2.5	12	22.0	3.8	12
Combined	Female	15.1	2.2	18	18.4	4.9	18
Control	All	15.0	2.5	15	19.0	6.0	15
Control	Male	16.0	2.8	5	23.0	4.2	5
Control	Female	14.4	2.2	10	16.7	5.8	10
Treatment	All	16.0	2.2	15	21.0	2.8	15
Treatment	Male	16.0	2.5	7	21.0	3.5	7
Treatment	Female	16.0	2.1	8	20.5	2.1	8

Note: Scores reported as raw data based on a total possible score of 30.

Inferential Statistics

MANCOVA Overview

This research study contained multiple dependent and independent variables that included a set of covariates. As a result, the inferential statistical analysis involved using the multivariate general linear model, which is a generalization of the traditional univariate general linear model (e.g., ANOVA and ANCOVA), but simultaneously deals with more than one dependent variable (Cohen, 1988). A multivariate analysis of covariance (MANCOVA) controls for excessive inflation of experimentwise Type I and Type II error rates that result from univariate analyses for each dependent variable. The MANCOVA model also takes into account the intercorrelations among the dependent variables that are examined. MANCOVA is a special case of analysis of partial variance (APV), that involves quantitative dependent and covariate variables, and a research factor set that describes group membership, which is nominal. For the purposes of this research, a MANCOVA analysis was employed.

In this study, functional sets were used to represent both dependent and independent variables (Cohen & Cohen, 1983). The independent variables (IVs) were organized into the three IV sets (Sets A, B, and C). Set A was the covariate set and included the pre-science attitude scores (X_1) and pre-achievement scores (X_2). Set B was the research factor set and included group membership (X_3) and gender (X_4). Finally, Set C was the interaction set, which included the product of Set A and Set B variables. The dependent variables (DVs) – attitude posttest (Y_1) and achievement posttest (Y_2) – were organized into a single DV set (Set D), Set membership was summarized in Chapter 3, Table 1.

Use of a Pretest

The rationale for using a pretest in the research design was twofold. First, an objective of using a pretest is to assess change over a period of time. The second reason for using a pretest, as recommended by Frankel and Wallen (1996) is for verifying group equivalency that is based on random assignment. As stated in Chapter 3, a t test analysis on pretest scores showed no statistical significant difference between the control and treatment groups (Science Attitude: $t = -.185$, $p > .05$; Achievement: $t = 1.243$, $p > .05$), thus indicating that the groups are equivalent. There are, however, certain drawbacks in using a pretest in terms of a threat to internal validity. A testing threat, as described by Fraenkel and Wallen (1996), is the possibility that improvements or changes in dependent variables are caused when students are exposed to pretests or when an interaction occurs between a pretest and an intervention. The use of a pretest may sometimes create a "practice effect" since students typically are exposed to the same questionnaire or test questions prior to instruction as well as after instruction. Pretesting can also cause students to be more attentive to what may be going to happen which can make students more sensitive and responsive to the treatment. This increased awareness may affect the way students respond to a posttest, with possibilities of influencing the results on posttest scores. Because the science attitude questionnaire and achievement pretest were likely to account for variance in the posttest measures, they were treated as covariates so that their effects could be partialled out from both sets D and B.

Missing Data

In the current study, data were originally collected from 30 students on the Attitude toward Science and Computers Questionnaire and Achievement pretest. After the treatment period, the same number of students took the posttest. All students answered every item. This demonstrates there were no missing data among subjects involving the pretest and posttest. However, there were missing data within the individual homework scores as a result of students not turning in their homework assignments. Of the six homework assignments examined for this study, the treatment group (N = 15) had one value each missing for two different assignments. The control group (N = 15) had one value each missing for three different homework assignments. The missing data needed to be accounted for so that the homework averages of the two groups could be compared as stated in the fifth research question, Chapter 1. In order to account for the missing data, each group's mean for the particular homework assignments with missing values was calculated and then was substituted for the missing data point.

t Test Analyses for Homework Assignments

Caution should be taken regarding to the use of t tests on difference scores as a unit of analysis (Cohen & Cohen, 1983), yet t test analyses are essential when attempting to evaluate change over time. Table 5 shows the results of t test analyses on the group means for the six homework assignments. While there were small mean differences in homework averages between the two groups, the differences were not large enough to be statistically significant.

Table 5

Group Mean Results According to Homework Assignment

Assignment	Section	Treatment Mean	Control Mean	*t* value
Homework 1	Anthroposphere	77.27	76.93	.451
Homework 2	Cosmosphere	87.81	87.85	.493
Homework 3	Geosphere	85.23	85.14	.483
Homework 4	Hydrosphere	89.70	87.48	.177
Homework 5	Atmosphere	85.43	87.98	.180
Homework 6	Biosphere	81.96	79.47	.243
Group Averages	-	84.57	84.14	.438

Note: (1) N = 30; $t_{critical}$ value = 2.074, $p > .05$

Homogeneity of Regression

In any analysis of covariates (ANCOVA or MANCOVA), there is an underlying assumption that the relationship between the covariates and dependent sets (Sets A and D, respectively) is the same for all values of the research factor set (Set B), which is coded nominally. This implies that "the regressions of the variables in Set D on the Set A variables be the same for all combinations of Set B values" (Cohen, 1998, p. 493). This is known as homogeneity of regression and is assessed by investigating the interaction between Sets A and B, which is Set C (A X B). If this interaction set, A X B, is significant, then the homogeneity of regression assumption would be violated, thus indicating that the MANCOVA was not valid. The unique contribution to y-variance made by the interaction set was examined and found not to be statistically significant thus validating the MANCOVA model.

To test the homogeneity of regression assumption, a hierarchical multiple regression/correlation (MRC) analysis was conducted for each dependent variable. Each dependent variable was regressed hierarchically with the independent variable entry order of Set A (covariates), Set B (research factors), and Set C (A X B) (refer to Table 1). The independent variables (IV) were coded in the following manner: group membership (control = 0, treatment = 1) and gender (males = 0, females = 1). Table 6 shows the results of the separate hierarchical MRC analyses.

Table 6

Hierarchical Cumulative R^2 Analysis of the Homogeneity of Regression Assumption in the MANCOVA Model

IV Set Added	Cum R^2	I	df	F
	Y_1 = Post Attitude			
Set A	.201	-	-	-
Set B	.418	.217	2, 25	4.66*
Set C (A x B)	.499	.081	4, 21	.849
	Y_2 = Post Achievement			
Set A	.315	-	-	-
Set B	.362	.047	2, 25	0.92
Set C (A x B)	.421	.059	4, 21	.535

Note: (1) N = 30; I = Increment in R^2; *$p < .05$; (2) Set A = Covariates (Attitude and Achievement pretest scores); (3) Set B = Research Factors (group membership and gender)

As can be seen in Table 6, the interaction variables were entered into the regression model in the presence of Sets A and B. The incremental increase (I) in explained model variance (R^2) due to the addition of the interaction variables (A X B) was found to be not significant, with $F_{critical}$ values of .849 for Y_1 (post attitude) and .535 for Y_2 (post achievement). Because the interaction sets were not significant, the homogeneity of regression assumption was satisfied thus validating the MANCOVA model.

Table 6 also shows that within the analysis of Y_1, the explained model variance due to the addition of Set B in the presence of Set A resulted in a statistically significant incremental increase of .217. This indicates that Set B contributed an additional 21.7% to the measure of post attitude (Y_1) variance.

Testing the Valid MANCOVA Model

The significance of the model was tested after the overall MANCOVA model was determined to be valid. Table 7 shows the results of the overall MANCOVA analysis. Set A included the two covariates, which included the Pre-Attitude and Pre-Achievement variables. Set B contained the research factor variables, which were group membership and gender. As can be seen in Table 7, the achievement pretest within the covariate set (Set A) and gender within the research factors set (Set B) were both statistically significant. Because at least one variable in the MANCOVA model is significant, the overall MANCOVA model is significant. Furthermore, both Set A and Set B are considered to be significant because at least one variable within each set was found to be significant. Since significance was found in the overall MANCOVA model, further data analyses regarding the dependent variables were conducted.

Table 7

Multivariate Analysis of Covariance for the Two Dependent Variables Y_1 = Attitude Posttest and Y_2 = Achievement Posttest

Source of Variance	Wilk's Lambda	df	F	p
Set A (Covariates)				
X_1 = Pre-Attitude	.836	2, 24	2.35	0.117
X_2 = Pre-Achievement	.720	2, 24	4.67	0.019*
Set B (Research Factors)				
X_3 = Group Membership	.979	2, 24	0.25	0.779
X_4 = Gender	.728	2, 24	4.48	0.022*

Note: (1) N = 30; *$p < .05$

Null Hypotheses

As previously stated, the overall MANCOVA model was significant. This allowed examination of all research factors (group membership and gender) for each dependent variable from the perspective of removing the covariate influences. Recall that when investigating the data in terms of the null hypotheses, alpha and power were set a priori at .05 and .90, respectively.

Null Hypothesis 1

There will be no significant difference between treatment and control groups' science and computer post-attitudes.

(1) Ho: μ Attitudes $_{(treatment)}$ = μ Attitudes $_{(control)}$

The mean differences in science and computer attitudes between the two groups (Table 3) were not large enough to be statistically significant. A Wilk's Lambda, which was calculated for group membership differences within the MANCOVA analysis (Table 7), was .979 with a multivariate F of .25, which was not significant at $p < .05$. Null Hypothesis 1 failed to be rejected.

Null Hypothesis 2

There will be no significant difference between treatment and control groups' post-achievement scores.

Ho: μ Achievement $_{(treatment)}$ = μ Achievement $_{(control)}$

Although there were small mean differences between the two groups' achievement scores (Table 4), the differences were not large enough to be considered statistically significant. As previously stated, a Wilk's Lambda for group membership differences (Table 7) was found to be not significant. Null Hypothesis 2 failed to be rejected.

Null Hypothesis 3

There will be no significant difference between males' and females' scores on the attitude questionnaire posttest.

Ho: μ Males-Attitude = μ Females-Attitude

The differences between males' and females' attitudes toward science and computers (Table 3) were statistically significant. As can be seen in Table 7, the MANCOVA analysis for gender differences resulted in a Wilk's Lambda of .728 with a multivariate F of 4.49, which was found to be statistically significant at $p < .05$. Null Hypothesis 3 was rejected.

Null Hypothesis 4

There will be no significant difference between males' and females' achievement scores on the achievement posttest.

Ho: μ Males-Achievement = μ Females-Achievement

There were small mean differences in achievement scores between the males and females (Table 4). However, the differences were not large enough to be statistically significant. The overall MANCOVA analysis results for achievement was not significant (Tables 6 and 7). Null Hypothesis 4 failed to be rejected.

Null Hypothesis 5

There will be no significant difference in homework averages between the two different instructional media – CAI and traditional textbook groups.

Ho: μ Homework Averages $_{(treatment)}$ = μ Homework Averages $_{(control)}$

There were small mean differences in homework averages between the two groups (Table 5). The differences were not large enough to be found statistically significant as can be seen in the results of t test analyses in Table 5. Null Hypothesis 5 failed to be rejected.

The results obtained from the 30 students who participated in this research study indicated statistically significant differences between males' and females' attitudes toward science and computers. However, the results indicated no statistically significant differences between control and treatment groups' achievement in an integrated science course and attitudes toward science and computers.

Supplemental Information

Because there was no statistical difference regarding achievement with the other measures, I was not permitted to further statistically examine this particular data. I was still interested in removing the effects of the covariates across the board so additional secondary univariate ANCOVA analyses were conducted. A discussion regarding the research hypotheses relative to the MANCOVA results is provided. The results described here have limited generalizability, yet are included to assist subsequent related research.

Separate Overall Model Analyses

Separate univariate multiple regression analyses were performed for each dependent variable. As can be seen in Table 8, when each DV was regressed separately on the set of independent variables, only one of the two DVs was statistically significant. More specifically,

- When attitude scores (Y_1) were regressed on the covariate set (Set A) and the research factor set (Set B), a univariate F of 4.66 resulted. This was significant at $p < .05$.
- When achievement scores (Y_2) were regressed on the covariate set (Set A) and the research factor set (Set B), a univariate F of 0.92 resulted. This was not significant at $p < .05$.

The independent variables, when examined collectively, make a significant contribution (at $p < .05$) in explaining variability in attitude, but do not make any significant contributions in explaining the variability in achievement. Furthermore, the collective contribution of pre-attitude and pre-achievement (covariate set), group membership, and gender was not significant for achievement but was significant for attitude.

Table 8

Overall Model Results for Follow-up Univariate Multiple Regression Analysis

DV	Y_i	$R^2_{Yi\text{-}AB}$	df	F
Post Attitude	1	.418	2, 25	4.66*
Post Achievement	2	.362	2, 25	0.92

Note: (1) *$p < .05$; (2) A = Covariate set (X_1 and X_2); (3) B = Research Factor set (X_3 and X_4)

Univariate ANCOVA Analyses

Two separate univariate ANCOVA analyses were performed without regard to the interaction set, because it had been previously determined not to be significant. It should be emphasized again that these analyses were conducted to help subsequent associated research. The results are limited due to inflated alpha levels and concerns of power (Cohen & Cohen, 1983). An inflated alpha level implies that the probability of any observed difference due to chance or random effects and not a treatment effect is greatly increased. Because the relationship between the independent variables and their collective influence on the dependent variables is not considered with these models, these results should be interpreted carefully.

Examining the Influence of Each Independent Variable

Table 9 shows the results of a univariate multiple regression analysis in which Y_1 (post-attitude) was regressed on the covariate set (X_1 and X_2) and on each independent variable in the research factor set. When group membership (X_3) was added to the model in the presence of the covariates, X_3 uniquely contributed 0.1% in explaining Y_1-variance, which was not statistically significant. However, gender contributed an additional 21.6% in explaining the variability in attitude scores, which was statistically significant.

Table 9

Univariate Multiple Regression Analysis for Y_1 = Post Attitude

Variables In Model	Variables Entering Model (X_i)	R^2	$I = sr_i^2$	df	F
X_1, X_2 (Covariates)	X_3 (Group Membership)	.202	.001	1, 26	0.03
	X_4 (Gender)	.418	.216	1, 26	9.63*

Note: (1) N = 30; *p < .05; (2) $F_{critical(1,26)} = 4.23$

Table 10 shows the results of a univariate multiple regression analysis in which Y_2 (post-achievement) was regressed on the covariate set (X_1 and X_2) and on each independent variable in the research factor set. When group membership (X_3) was added to the model in the presence of the covariates, X_3 contributed 1.3% in explaining Y_2-variance, which was not statistically significant. Gender (X_4) uniquely contributed an additional 3.4% of explained variability in achievement scores, which was not statistically significant.

Table 10

Univariate Multiple Regression Analysis for Y_2 = Post Achievement

Variables In Model	Variables Entering Model (X_i)	R^2	$I=sr_i^2$	df	F
X_1, X_2 (Covariates)	X_3 (Group Membership)	.328	.013	1, 26	.503
	X_4 (Gender)	.362	.034	1, 26	1.39

Note: (1) N = 30; *p < .05; (2) $F_{critical(1,26)}$ = 4.23

When separate ANCOVA analyses were conducted without regard to the interaction set, only gender was found to significantly contribute to explaining the variability of the dependent variables, specifically attitude scores.

Adjusted Group Mean Scores

The mean scores of the attitude posttest were adjusted in order to factor out the influence of the covariates (Set A). To do this, the gender model in the presence of the covariates was determined and is represented by the following regression equation:

$$Y'_1 = .192\,X_1 - .572\,X_2 - 8.375\,X_4 + 119.13$$

Calculating the adjusted group mean first required determination of the adjusted intercept (A') using the following equation:

$$A' = (B_1)(M_1) + (B_2)(M_2) + A$$

When the attitude and achievement group mean values are substituted into the equation, we get

$$A' = (.192)\ (130.4) + (-.572)\ (15.6) + 119.13$$

Therefore,

$$A' = 135$$

In order to compute the adjusted group means, X_4 was replaced by 0 (males) and then by 1 (females) in this equation. This resulted in a male group mean of 135 and a female group mean of 126.6. This indicates that when the effects of the covariates are factored out, the adjusted attitude posttest score for males was 135 and 126.6 for females. A comparison of the mean scores and adjusted mean scores are provided in Table 11. Males showed a small increase over females in overall more positive attitudes toward science and computers. Also, males started with and continued to have more positive attitudes than females through the entire study.

Table 11

Adjusted Mean Calculations for Attitude Posttest According to Gender

Gender	Mean Pre-attitude	Mean Post-attitude	Adjusted Mean Post-attitude	N
Male	133.75	135.25	135	12
Female	128.17	126.56	126.6	18

Note: Scores reported as raw data based on a total possible score of 180.

The mean scores of the achievement posttest were adjusted to factor out the influence of the covariates (Set A). To do this, the gender model in the presence of the covariates was determined and is represented by the following regression equation:

$$Y'_1 = .094\ X_1 + .882\ X_2 - 1.872\ X_4 - 5.589$$

Calculating the adjusted group mean first required determination of the adjusted intercept (A') using the following equation:

$$A' = (B_1)(M_1) + (B_2)(M_2) + A$$

When the attitude and achievement group mean values are substituted into the equation, we get

$$A' = (.094)\ (130.4) + (.882)\ (15.6) - 5.589$$

Therefore,

$$A' = 26.02$$

In order to compute the adjusted means, X_4 was replaced by 0 (males) and then by 1 (females) in this equation. This resulted in a male group mean of 26.02 and a female group mean of 24.15. This indicates that when the effects of the covariates are factored out, the adjusted achievement posttest score for males was 26.02 and 24.15 for females. A comparison of the mean scores and adjusted mean scores are provided in Table 12. Consistent with the overall results of this research, males showed a small increase over females in overall achievement scores.

Table 12

Adjusted Mean Calculations for Achievement Posttest According to Gender

Gender	Mean Pre-achievement	Mean Post-achievement	Adjusted Mean Post-achievement	N
Male	16.33	22.0	26.02	12
Female	15.11	18.38	24.15	18

Note: Scores reported as raw data based on a total possible score of 30.

In summary, the rejection of Null Hypothesis 3 was based on finding a statistically significant difference in males' and females' attitude scores (i.e., pre and post). This difference reflects a pre-to-post change in scores between males and females. The interpretations and implications of this result, as well as this study's inability to detect any other treatment effects, are discussed in Chapter 5.

CHAPTER 5

DISCUSSION

Summary of Study

The purpose of this study was to determine the effect of different instructional media (computer-assisted instruction tutorial (CAI) vs. traditional textbook) on student attitudes toward science and computers and achievement scores in a team-taught integrated science course. The effect of gender on student attitudes toward science and computers and achievement scores was also investigated. "The Whole Earth Course," ENS 1001, was offered at Florida Institute of Technology during the Fall 2000 term. Students in this course were the sample because I had been a teaching assistant for the course for the past three years. I was familiar with the content material, the professors involved in the course, and how the course was conducted.

This study employed a randomized pretest-posttest control group experimental research design that consisted of 30 students (12 males and 18 females). Students had registered for weekly lab sessions that accompanied the course and had been randomly assigned as either a treatment or control group. The treatment group used a CAI tutorial for completing their homework assignments while the control group used the required textbook for completing homework assignments.

The Attitude toward Science and Computers Questionnaire and Achievement Test were the two instruments administered during this study as both a pretest and a posttest. The first instrument was a 36-item Likert-type questionnaire that measured student attitudes toward science and computers. The second instrument was an achievement test that consisted of 30 multiple-choice general science questions. The professors involved with The Whole Earth Course confirmed the face and content validity of both instruments. The internal consistency for reliability was also confirmed for both instruments through statistical analyses. A multivariate analysis of covariance (MANCOVA), using hierarchical multiple regression / correlation (MRC), was employed for data analysis.

Summary of Findings

Pre- and posttest data for the Attitude toward Science and Computers Questionnaire and Achievement Test were collected by me at the beginning of the semester prior to instruction and again at the end of the semester. I also collected the homework assignments at the beginning of class on pre-determined due dates.

Descriptive statistical results showed small mean differences between the treatment and control groups' attitudes toward science and computers and achievement scores. Post-attitudes scores indicated that neither treatment nor control groups could be classified overall as having a more positive or more negative attitude. When groups were divided by gender, results indicated that males could be classified as having a more positive attitude toward science and computers than females (males' posttest mean = 135; females' posttest mean = 127). Post-achievement scores for the treatment group were slightly higher than the control group (treatment group posttest mean = 21.0; control group posttest mean = 19.0). However, when the groups are divided by gender, males in the control group had greater achievement scores than the males in the treatment group (control group posttest mean = 23; treatment group posttest mean = 21.0). Females in the treatment group, however, had higher achievement scores than females in the control group (treatment group posttest mean = 20.5; control group posttest mean = 16.7).

The overall MANCOVA model used to test the significance of the collective influences of the independent variables and on the two dependent variables simultaneously was found to be significant. Results obtained from the MANCOVA analysis indicated that gender significantly contributed to explaining the variability in students' attitudes toward science and computers. Furthermore, when univariate ANCOVA analyses were performed, gender was the only research factor that, when examined collectively or separately, made a significant contribution in explaining the variability in post-attitudes toward science and computers.

It was hypothesized that after using a computer-assisted instruction (CAI) tutorial for completing homework assignments, the treatment group would have a more positive attitude toward science and computers and have greater gains in achievement scores and homework averages than the control group. It was also hypothesized that males would have a more positive attitude toward science and computers and that males would also have greater gains in achievement scores than females. The statistical results yielded from this study supported only one of my hypotheses - males' attitudes toward science and computers being more positive than females. Table 13 shows a summary of the results of the five hypotheses that were tested in this study.

Table 13

Summary of Hypothesis Tests Results

	Null Hypotheses	Decision
Ho :	μ Attitudes (treatment) = μ Attitudes (control)	Fail to Reject
Ho :	μ Achievement (treatment) = μ Achievement (control)	Fail to Reject
Ho :	μ Males – Attitude = μ Females - Attitude	Reject
Ho :	μ Males – Achievement = μ Females - Achievement	Fail to Reject
Ho :	μ Homework Averages (treatment) = μ Homework Averages (control)	Fail to Reject

Study Limitations

When one or more alternative hypotheses can explain the outcomes of a research study, the study is described as lacking internal validity (Frankel & Wallen, 1996). There were several limitations to internal validity, which could be used to account for the results of this study. One factor that could limit the generalizability of the results included my role in the class as a teaching assistant and as the researcher. I designed both the achievement and science attitude questionnaire, even though others reviewed it and offered comments. Even though I was the researcher, I graded all of the assignments, which included the quizzes, homework, and exams.

In reviewing the results of this research study, several limitations of the research study itself must be considered before generalizability. The sample size consisted of only 30 students. A larger sample size is typically desired, but is this small due simply to the size of the class as well as the university's small population.

There were also certain issues that could have caused statistical limitations to interpreting data. First, the groups may not have been equivalent in size. To control for size differences, the number of students allowed to register per lab session was limited to 15 students. A total of 15 students were enrolled in each lab session. However, results of this study are limited because the sample size was relatively small. Second, students had a choice of registering for a Tuesday or Thursday lab session. This choice may have caused there to be a difference in student body composition with the scheduling of different classes as well as students' social lives. Upon examination of the student composition within each lab, it was determined that the majority of the students were of the same age and class level.

The physical setting in which the CAI tutorial interaction took place was a limitation because the computer lab had only 16 computers. This not only limited the number of students that could be enrolled within each lab period, but also caused there to be limited working space for students' books or notebooks. Students were often observed as using their laps or books as a desktop. Since there were only 30 students enrolled in the class, computer availability was not a pertinent issue. However, if more students had enrolled, the limited number of computers would definitely have caused conflict of having to accommodate a larger class size per lab session.

The number of days that students could use the computer facility was limited to one night a week, with the lab period being only 80 minutes long. Some students, especially international students, had difficulty finishing their homework assignments within the allotted time. Since the lab time was limited, the consequences of a longer period of exposure to the CAI cannot be determined.

The computer tutorial had been specially designed for the textbook that was required for this class. The tutorial may not be appropriate for another integrated science class that does not use that particular textbook. One last issue that must be addressed is the number of professors involved in this team-taught course. Although most students in their final course evaluation commented they had particularly enjoyed the involvement and expertise of the different professors, some people might criticize six professors teaching one class. With several professors, the class may be regarded as a "turn-teaching" course rather than a "team-teaching" course. Also, some critics may question how all the subject material could have been thoroughly covered with only three lecture sessions per professor.

Conclusions and Inferences

As stated in Chapter 4, the overall MANCOVA was found to be significant which indicates there was a statistical difference between the collective influences of the independent variables and the two dependent variables. This section consists of separate discussions for each research question that may provide some explanations for the results that were obtained.

Research Question 1:

Will students in "The Whole Earth Course" at Florida Institute of Technology who use a computer-assisted instruction tutorial to complete homework show an increase in positive attitudes toward science and computers compared to students who do not use a computer-assisted instruction tutorial?

The results of the overall MANCOVA analysis (Table 7, p. 59), with respect to attitude, revealed a Wilk's Lambda (λ) of .979, which has a corresponding $R^2 = 1 - \lambda = .021$, for group membership (treatment or control). This indicates that in a model that already contained the covariates, group membership accounted for only 2.1% of the variance, which was not significant, $p > .05$.

Because the MANCOVA model was found to be significant, follow-up hierarchical univariate analyses were performed. When posttest attitude scores were individually regressed on both the covariate set and research factor set, the unique contribution that the research factor set made toward the post-attitude variance was $R^2 = .418$ (Table 8, p. 64). This indicates that the collective contribution of the two independent variables toward explaining the variability in post-attitudes was 41.8%, which was significant at $p < .05$.

Because the research factor set was significant, the unique contribution of group membership toward post-attitude variability was examined. The results showed that in a model that already contained the covariates (X_1 = Pre-Attitude; X_2 = Pre-Achievement), group membership contributed .1% (Table 9, p. 65) in explaining posttest-attitudes toward science and computers (Y_1) variance. This result, however, was found to be not significant ($p > .05$). Null Hypothesis 1 failed to be rejected. The answer to Research Question 1 was that there was no difference between the attitudes of students who used a CAI tutorial to complete homework and the attitudes of students who did not use the tutorial to complete homework.

Several students in the treatment group commented to me throughout the semester how much they enjoyed the computer tutorial, indicating that they thought it was more user friendly than the textbook. They also indicated that the tutorial was easier to read than the textbook. Also, some students stated on their end-of-course evaluations that "labs were good and informative, not long and boring" and that they "liked the quantitative aspects of imagining situations."

Another point worth noting is the negative comments stated by students. Some students in the treatment as well as the control group indicated they would rather do homework at their convenience, instead of within the lab setting. Also, some students on the mid-term course evaluations commented that "more time for the homework lab" was needed. Nonetheless, students throughout the semester generally had more positive comments about the lab sessions than negative comments. Thus, it was to my surprise that Null Hypothesis 1 was not rejected based on students' positive feedback on end-of-course evaluations, as well as their feedback through personal communication.

There are several plausible explanations for this result. First, as the semester progressed, students might have grown tired of attending a weekly evening lab session. It is possible that students would have preferred to attend other social activities or work in homework groups rather than individually completing their homework assignments in a controlled environment. On different occasions students were observed leaving the lab early without finishing their homework, often commenting that they had other engagements (including going out with friends and watching television shows). Second, because there was a time constraint on lab availability students may have felt pressured to complete their homework thus rushing to finish their homework even if it was not their best work. Students were sometimes observed turning in uncompleted homework simply because they wanted to leave. Third, this class was a prerequisite for incoming freshmen of Environmental Science, Oceanography, and Meteorology. The course was also offered as an elective for other students. It is possible that because certain students were required to take the course, they may not have been as interested in the course subject material as compared to those students that chose the course as an elective. Finally, it is possible that students discussed amongst themselves the details of each lab thus causing them to be more aware of one group using the tutorial versus the textbook. Students may have had a personal preference for using one or the other, but had no choice to which lab group they were assigned because the treatment and control groups were randomly assigned. I believe this to be possible because several students inquired if they could use the tutorial instead of the textbook (and vice versa), since some of their friends used that instructional media for completing their homework.

Research Question 2:

Will students in "The Whole Earth Course" at Florida Institute of Technology who use a computer-assisted instruction tutorial to complete homework show an increase in achievement scores compared to achievement scores of students who complete homework using the required textbook?

The results of the overall MANCOVA analysis (Table 7, p. 59), with respect to achievement, revealed a Wilk's Lambda (λ) of .979, which has a corresponding $R^2 = 1 - \lambda = .021$, for group membership (treatment or control). This indicates that in a model that already contained the covariates, group membership accounted for only 2.1% of the variance, which was not significant, $p > .05$. Because the MANCOVA model was found to be significant, follow-up hierarchical univariate analyses were performed. When posttest achievement test scores were individually regressed on both the covariate set and research factor set, the unique contribution that the research factor set made toward the post-achievement variance was $R^2 = .362$ (Table 8, p. 64). This indicates that the collective contribution of the two independent variables toward explaining the variability in post-achievement scores was 36.2%, which was not significant, $p > .05$.

Because the research factor set was significant, the unique contribution of group membership toward the variability in post-achievement scores was examined. The results showed that in a model that already contained the covariates (X_1= Pre-Attitude; X_2 = Pre-Achievement), group membership contributed 1.3% (Table 10, p. 66) in explaining the variability in post-achievement test scores (Y_2). This result, however, was found to be not significant for $p > .05$. Null Hypothesis 2 failed to be rejected. Therefore the answer to Research Question 2 was that there was no difference between the achievement scores of students who used a CAI tutorial to complete homework and the achievement scores of students who did not use the tutorial to complete homework.

There are several explanations as to why there was no difference between the two groups' achievement scores. On mid-term evaluations, it was stated "homework makes you learn the class because homework is done in class." Students had a two-week time period during which they were to complete a homework assignment in weekly evening lab sessions. During this time period, each group only had access to the lab for two, 80-minute sessions. It is possible that if the treatment group had been able to use the tutorial more often then there might have been a significant difference. However, lab availability and utilization were controlled for the specifics of the research design. Second, it appeared to me that many students in the control group, because they used their textbook for completing their homework, used their laps quite often as a desk since the computer took the majority of the desktop space. Students in the treatment group also used their laps as a desktop. It is a plausible explanation that this issue of inadequate desk space and being uncomfortable caused students in both groups to rush through their homework answers, perhaps not always assuring their answers were correct. Third, it was observed that students in the treatment group had a tendency to socialize more than the students in the control group. It is possible that this caused these students to have less time devoted for answering homework questions, thus causing them to hurry through the assignment. Homework answers for the treatment group often were shorter and contained less information, which could have been a result of the CAI tutorial being a simplified version of the textbook. However, these shorter answers may have caused students to have points deducted on their homework assignments based on the point value of a question. Fourth, it is plausible that the treatment group was simply scanning the tutorial's text for homework answers and not taking full advantage of the computer tutorial's beneficial and educational qualities. Finally, the heightened effects of the tutorial may have been nullified because the daily quizzes were based on required reading assignments from the students' textbooks. Therefore, the treatment group was exposed to both instructional media types that were used in the research study.

Research Question 3:

Will there be a difference between the males' and females' scores on the attitude questionnaire posttest?

The results of the overall MANCOVA analysis (Table 7, p. 59), with respect to attitude, revealed a Wilk's Lambda (λ) of .728, which has a corresponding $R^2 = 1 - \lambda = .272$, for gender (male or female). This indicates that in a model that already contained the covariates, gender accounted for 27.2% of the variance, which was significant at $p < .05$. Because the MANCOVA model was found to be significant, follow-up hierarchical univariate analyses were performed. When posttest attitude scores were individually regressed on both the covariate set and research factor set, the unique contribution that the research factor set made toward the post-attitude variance was $R^2 = .418$ (Table 8, p. 64). This indicates that the collective contribution of the two independent variables toward explaining the variability in posttest-attitudes was 41.8%, which was significant at $p < .05$.

Because the research factor set was significant, the unique contribution of gender toward post-attitude variability was examined. The results showed that in a model that already contained the covariates (X_1 = Pre-Attitude; X_2 = Pre-Achievement), gender contributed 21.6% (Table 9, p. 65) in explaining posttest-attitudes toward science and computers (Y_1) variance. This result was found to be significant for $p < .05$. These results allowed Null Hypothesis 3 to be rejected, therefore the answer to Research Question 3 was that there was a difference between the attitudes of students who used a CAI tutorial to complete homework and the attitudes of students who did not use the tutorial to complete homework.

As past studies have shown, males typically have more favorable attitudes toward science and computers than females (Levin & Gordon, 1989; Whitley, 1997; Robertson et al, 1995), so this result is not surprising. There are several possible explanations as to why males had a more favorable attitude toward science and computers than females in this study.

First, the course was team-taught by six professors, five of which were males. Even though each professor only taught a total of three classes, they typically attended and participated in every class. This increased presence of male professors could have influenced students' attitudes. In conjunction with this explanation is the suggestion that perhaps the females in the class were disappointed with there only being one female professor among the professors in this study causing their attitudes to be less favorable. Second, Florida Institute of Technology (FIT) is a school that is recognized for its high standards in engineering and computer science. It is plausible that the males involved in the course already had positive attitudes toward science and computers coming into the course, based on the assumption that they chose to attend FIT to learn about science or computers. Third, the presence of a female proctor for lab may have influenced students' attitudes. The proctor was instructed not to assist students with homework answers; rather she was there to observe the students. On several occasions students asked for her help regarding answers – whether the answer was correct or not, where the location of an answer was in the textbook or tutorial, and even if the answer was too short or too long. She had been instructed to direct all questions to the teaching assistant, as that was not her role within the lab sessions. This lack of assistance may have negatively influenced students' attitudes, particularly females, since the proctor was a female who may have been viewed as unwilling to help another female. Finally, the Attitude toward Science and Computers Questionnaire was personally developed and was determined to have face and content validity. However, the questionnaire was never reviewed with the issue of gender preference in mind. This may have caused some of the questions to be more appealing to males rather than females. The same is true of the CAI tutorial. The tutorial was inspected and validated by the professors involved with the class, which at the time of reviewing included six males. Again, the subject of gender equality within the tutorial was never addressed. It is possible that the design of the tutorial appealed more to males than females.

Research Question 4:

Will there be a difference between males' and females' achievement scores on the achievement posttest?

The results of the overall MANCOVA analysis (Table 7, p. 59), with respect to achievement, revealed a Wilk's Lambda (λ) of .728, which has a corresponding $R^2 = 1 - \lambda = .272$, for gender (male or female). This indicates that in a model that already contained the covariates, gender accounted for 27.2% of the variance, which was significant at $p < .05$. Because the MANCOVA model was found to be significant, follow-up hierarchical univariate analyses were performed. When achievement posttest scores were individually regressed on both the covariate set and research factor set, the unique contribution that the research factor set made toward the post-achievement test scores variance was $R^2 = .362$ (Table 8, p. 64). This indicates that the collective contribution of the two independent variables in explaining the variability in post-achievement test scores was 36.2%, which was not significant at $p < .05$.

Because the research factor set was significant, the unique contribution of gender toward the variability in post-achievement scores was examined. The results showed that in a model that already contained the covariates (X_1 = Pre-Attitude; X_2 = Pre-Achievement), gender contributed 3.4% (Table 10, p. 66) in explaining post-achievement test scores (Y_2) variance. This result, however, was found to be not significant at $p > .05$. Null Hypothesis 4 failed to be rejected, thus the answer to Research Question 4 was that there was no difference between the attitudes of students who used a CAI tutorial to complete homework and the attitudes of students who did not use the tutorial to complete homework.

As indicated earlier, there was no significant difference observed between the treatment and control groups' achievement scores. Thus, this answer to Research Question 4 is in context with the findings of this research study. There are several plausible explanations as to why there was no significant difference found between males' and females' achievement scores. First, students were allowed to register for either of the lab sessions. This resulted in the number of females being higher than males in each lab. In fact, the control group only had five males compared to 10 females. Therefore it is difficult to determine the equality of the groups based on the differing numbers of males and females in the lab groups. Second, my role as both the researcher and the teaching assistant could have influenced the results of this study. I not only designed the instruments utilized as the pre- and posttests, but also I compiled all assignments, which included the quizzes, homework, and exams. As the researcher, my desire to find any treatment effect could have influenced the design of these assignments. Moreover, grading of the assignments also may have been influenced as my role as the researcher wanting to find an effect. Third, the tutorial itself was not designed with gender equality in mind; rather it was designed with the intent of an educational and instructional delivery system. Fourth, it is plausible that the variation of each professor's (both male and female) teaching style either positively or negatively affected a student's desire to learn and achieve in the course. Last, even with my role as teaching assistant, the fact that five of the seven members who participated in this course were male most likely had an effect on the students in regards to achievement scores.

Research Question 5:

Will students using CAI programs yield higher homework averages than students using the traditional textbook?

While there were small mean differences in the two groups' homework averages (Table 5, p. 55), t test analyses showed no statistically significant differences between the groups. Hence, Null Hypothesis 5 failed to be rejected. The answer to Research Question 5 was that there was no difference between homework averages of students who used a CAI tutorial and students who used the traditional textbook.

As discussed earlier, some students had commented on mid-course evaluations that the lab sessions helped them to enjoy homework assignments and helped further their understanding of the material. However, some students stated on end-of-course evaluations that the homework assignments were too long and labs were purposeless. Yet, even though students were observed socializing during lab sessions instead of working on their assignments, students were continuously engaged in working on their homework. This causes one to question the integrity of students stating that labs were meaningless.

Interpretation of these comments suggest that some students enjoyed the instructional media they used to complete homework assignments, while other students were simply annoyed by having to attend an evening lab session even though they had knowledge of the lab when registering for the course. Most of the treatment group's homework averages were slightly higher than the control group's homework averages, yet were not significantly different. A plausible explanation is that the treatment group simply did not have enough exposure to the CAI tutorial to cause an observable significant effect in the groups' homework averages. Groups met only one night a week for a lab session of 80 minutes. Another explanation for non-significant mean differences could be the fact that the tutorial was a simplified version of the textbook, enabling the treatment group to formulate less verbose answers that did not fully cover the homework questions. It was observed during grading homework assignments that the homework answers for the treatment group were often much shorter and less detailed than those of the control group. Third, the treatment group used both types of instructional media because the daily quizzes were based on required readings that were assigned from the textbook. This may have caused students in the treatment group to focus less on the information within the tutorial since they had previously read the same information in their textbook. Last, because there were six different professors involved in team teaching this course it is plausible that each professor had his or her own style of teaching. It is likely that while a student enjoyed one professor, another student may have had negative opinions about that same professor. This may have caused a student's interest in that particular sphere to be enhanced or decreased, affecting his or her desire to learn that subject material.

Implications

Implications for Prior Research

The findings of this research study are consistent with that of previous studies. The results of this study support the findings of Tjaden and Martin (1995), in which they found there to be no significant learning differences between groups when CAI, combined with traditional lecture, was compared with traditional lecture by itself. Although the authors did not give a suggestion as to why this result occurred, it is proposed that for this study that the treatment group did not spend enough time using the computer tutorial for a significant treatment effect to be observed.

Clark (1985), in a re-analysis of Kulik, Kulik, and Cohen's (1980) meta-analysis, found that CAI had the same effect on learning as traditional teaching methods. This study supports Clark's (1985) findings such that there was no significant difference between the treatment and control groups' achievement scores. As previously mentioned, it is believed that an effect was not found because the treatment group did not have enough exposure to the CAI tutorial, as well as the fact that they were also using their textbook for studying for quizzes and exams. The effect of CAI programs should be further investigated in a more controlled environment so that the treatment group accesses the tutorial more than the textbook.

The present study also appears to support the suggestion of Baldwin, Johnson, and Hill (1994) that poor quality of graphics of tutorials causes much frustration. During the present study, students had commented on course evaluations about the small size of the tutorial's screen, which made it difficult to read some pages. This was a direct result of the advance in computer technology because the tutorial was first designed on a computer with a smaller screen size.

This study's conclusions were consistent with the findings of Shashaani (1994) regarding students' attitudes toward computers. Males were found to have more positive attitudes than females in both studies. Similarly, the findings of this study also support the results found by Comber et al. (1997) as well as Levin and Gordon (1989) in which it is reported that males had a more positive attitude toward computers than females. Shashaani (1994), Comber et al. (1997), and Levin and Gordon (1989) all state that attitudes are directly related to computer usage, indicating that frequent computer usage caused students' attitudes to improve. This implication has been consistently suggested throughout the findings of the present study, stating that perhaps if the treatment group had used the computer tutorial more frequently, there would have been a significant difference between the treatment and control groups' attitude and achievement scores.

It is important to point out that the findings of this study are not entirely consistent with that of previous studies. Duncan (1991) found that students' test performance improved when lecture and text materials were supplemented with CAI. However, results of this study do not support the findings of Duncan's (1991) study. It is possible that the CAI in this study was not utilized enough for the treatment group to benefit from the instructional effects of the tutorial. It is also possible that the treatment group viewed the tutorial as a simplified version of the textbook, thus causing them to quickly scan through the tutorial's subject material looking for answers to homework questions instead of taking advantage of the educational benefits of the tutorial.

Tjaden and Martin (1995) observed that students had a more positive attitude when CAI was utilized without a professor present for instruction. The results of the current study do not support the findings of their study. It is possible that the incoming freshmen who participated in the current study felt more comfortable having a professor deliver subject material instead of a computer tutorial, even though Tjaden and Martin (1995) stated that students considered using the computer as a delivery system to be a more interesting instructional environment than relying on professors for the delivery of subject material.

The conclusions of this study are inconsistent with the findings of Czaja and Sharit (1998) regarding females' attitudes. Their results indicated that females had a more positive attitude toward computers than males. The authors stated that this finding was a direct result of computer experience. Again, it is suggested for the present study that, if students had had more exposure to the computer tutoria, there would have been an increase in student attitudes.

Implications for Educational Practice

In terms of educational practice, studies investigating team-teaching as well as integrated science should continue. These explorative studies could furnish information about the types of instructional delivery that students, as well as professors, prefer. These studies could also give insight to the effect of these different teaching aspects on student attitudes and achievement. Throughout the entire course, students were constantly praising how the different spheres were continuously integrated in the course. They also enjoyed the fact that an instructor who was an expert in that field taught each individual sphere.

Given that gender differences resulted in males having a more positive attitude toward science and computers, this finding can suggest that it could prove beneficial to have female instructors join this course. In doing so, the ratio of male to female professors would be more equally balanced, thus possibly improving the overall attitudes of the female students.

In summary, it is possible that the computer tutorial in conjunction with the textbook may have enhanced student learning. However, it is possible that a significant treatment effect was not evident due to the limited amount of computer tutorial usage. It is evident that the computer tutorial needs to be utilized more frequently in order to have an impact on student learning. It should also be common practice to have the tutorial be fully integrated into the classroom setting so that it can be used as an instructional aide. This would allow all students in a classroom to benefit from the educational qualities that are presented by a CAI tutorial.

Recommendations for Research

This section is divided into different discussions of recommendations for research. The first examines recommendations relevant to the study limitations so that future research studies (i.e. extension or replication studies) can improve on the significance. The second section focuses on suggested issues, which stemmed from this research study that should be investigated in future research studies. The third section addresses recommendations for practice and application in the classroom, which are based on details and findings of this research study.

Recommendations for Future Research Relative to Study Limitations

This study was designed to examine the effect of different instructional media on gender and students' attitudes and achievement scores in a team-taught integrated science class. The results of the research study indicated that gender in relation to student attitude was the only significant variable. It is because of this lack of overall significance that study limitations are important to address.

The sample for this study was undergraduate students enrolled The Whole Earth Course at Florida Institute of Technology (FIT) during Fall 2000. FIT is a small institution that has a reputation as being a technologically based university. Because the instructional media delivery system did not change the gender issues in this study, it is recommended that future studies should have a larger equivalent group of females and males. Thus, it is recommended that the study be replicated at a larger collegiate school. A larger school would have a greater student body population, possibly increasing the number of students enrolled for the course. With a larger sample, gender balance within in the course may be improved.

Second, it is recommended that students have more opportunities to access the computer lab as well as have longer lab sessions. This would increase the availability of the computer tutorial as well as increase their exposure to the CAI tutorial, which may in turn cause an observable effect in attitude and achievement. Also, the room in which the lab is held should have ample space for students to utilize for their books and notebooks.

The instruments used in this study to measure attitude and achievement should be revised and validated with gender equality as a key factor in the design. Also, additional questions that address students' previous computer experience, including experience with computer tutorials and home computer ownership should be incorporated into the questionnaire. Previous science experience should also be included in the questionnaire. This will allow the researcher to determine the level of computer and science experience a student has coming into the course.

For this study, my role was as both the researcher and the teaching assistant for the course. It is recommended that future researchers not have this double role. Yet, the situation proved to be beneficial to the current research design, being able to have control over all aspects of the assignments and grading. However, this increased my personal interaction with the students perhaps causing some bias in leniency or grading.

The tutorial was personally developed based on the required textbook for the course. The tutorial was initially developed two years before the current study occurred. During this time period, computer screen sizes as well as their speed increased, thus causing the tutorial to be outdated. It is recommended that the tutorial be revised so that it is updated to meet modern computer standards. The issue of gender equality should also be addressed and incorporated into the revising the tutorial so that it is equally appealing to males and females.

Last, this course was team-taught by six professors. It is possible that this teaching approach influenced students' attitudes and achievement scores. It is recommended that future studies investigate the effect of the different instructors and their individualistic teaching styles on students' attitudes and achievement scores. On the other hand, it is also recommended that perhaps only one professor teach the course so that the effect of different teachers is eradicated.

These recommendations, although not included in the current design, lend plausible explanations as to why a larger effect was not observed. With these recommendations incorporated into similar future research designs, the likelihood that the researcher will find a significant treatment effect is possible.

Recommendations for Future Research Relative to Implications

Upon examination of the results of this study, several questions emerged that should be investigated in future research studies.

First, it is suggested that students' cognitive learning styles be examined. In other words, a student's learning mode preference could be measured and examined for a student's strengths and weaknesses in learning. Also, learning mode preference could be examined in conjunction with CAI preference. This further analysis could indicate if students prefer a computer tutorial for learning subject material. It could also indicate which learning style is complemented with a tutorial so that the tutorial would be of an effective instructional tool.

Second, this study required a proctor for the lab sessions because my role as both the researcher and teaching assistant would have caused additional bias had I been the proctor. Students may have been disappointed to discover their teaching assistant was not present during their homework lab sessions. It is suggested that future studies investigate the effect of a proctor, whether male or female, on students' attitudes because the role of the proctor was to monitor students' behavior and progress in the lab.

Third, it is recommended that statistical analyses be expanded to investigate the achievement scores of all assignments, including quizzes examinations, and homework, because the treatment group used both forms of instructional media for learning in this study. It is also suggested, though, that future studies have the treatment group solely use the computer tutorial for learning instead of having access to both forms of instructional media. This would enable the true effect of the computer tutorial on student attitudes and achievement scores to be isolated. Also, if the sample population size were large enough, it would be an ideal research study design to have three separate sections of students participating in the study. One group would have only traditional lecture and textbook for learning. The second group would have the lecture plus the computer tutorial as the instructional media. The third group would have traditional lecture and textbook combined with the computer tutorial. This would allow the different types of instructional media to be examined and compared in different combinations.

Fourth, it is recommended that the presentation of CAI tutorial be modified to meet current computer hardware system requirements. Also, it is suggested that interactive video be incorporated into the computer tutorial. These modifications to the computer tutorial would update it to current standards to which students are accustomed. The tutorial should be modified so that there are more examples of the integration of the spheres.

Finally is the issue of team teaching. Should the course continue to follow this instructional mode of team-teaching, there are some important recommendations for investigation, as well as for improvement. First, the concept of team-teaching needs to be clearly defined within the group of professors. It is understandable that each teacher involved in this course has his or her own impression of teaching, including team-teaching. Because of the differing teaching techniques, some students may respond better to one professor over another. This is one research aspect that warrants further investigation. Also, it is possible that some of the students, as well as some professors, respond better to the team-teaching style compared to individual teaching. This preference of team-teaching versus individual teaching is another aspect that should also be further investigated. It is recommended that the teachers involved in the course have a similar definition of team teaching so that the teaching delivery method is maintained throughout the course.

In addition to defining team-teaching, structural changes to the team-taught course should also be addressed. Comments from the course evaluations indicated that students felt displaced during the transition from one professor to another. A student's anxiety tended to increase with the introduction of a new professor and his/her teaching style and expectations. The issue of student anxiety and its effect on student attitudes warrants further investigation. Students' anxiety levels could be decreased with a more structured outline of grading expectations amongst the professors. With the changing of a professor, the style and composition of the assignments typically changed as well. For example, while one professor may have chosen to put all multiple-choice or true-false questions on a quiz, exam, or homework assignment, another professor may have chosen to use all short answer or essay questions. Students commented that once they grew accustomed to one instructor's style of teaching and understood their grading process, it was time to switch to the next instructor. The changing of professors should be performed in a manner so that the students are reassured that the new professor's expectations and teaching style will remain consistent with the previous instructor.

Recommendations for Practice

The following recommendations for practice and application in the classroom are based on the details and findings of this study that resulted during and after the study was completed.

First, based on the lack of significant differences in achievement scores, it is recommended that lab session availability as well as the structure should be changed. The lab sessions themselves should be moved to an earlier time in the day so that students are not required to attend an evening lab when they appear to be tired and less attentive.

More lab sessions should also be available for the students to attend so that they can increase their time using the computer tutorial. In doing this, though, the amount of credits earned for this course may need to be increased from 3 to 4. The increase of course credits could allow instructors to incorporate field trips and actual lab experiments into the required lab sessions. This idea has been suggested by students on their course evaluations and has been discussed by the professors. The structure of the actual lab should be changed so students are devoting more attention to their homework assignments instead of socializing. Perhaps adding a participation grade within the lab session would assist this issue.

Given the minimal significant differences observed in student attitudes and achievement, it is recommended that students be separated into two completely different class sections for treatment and control groups. This aspect is possible if future studies have a larger sample size. This will help to control students in both groups from discussing the aspects of the differing lab sessions. It will control the extent to which the treatment group uses their textbook as well as the amount of time spent using the computer tutorial.

Based on the fact that the computer tutorial did not appear to have an effect on students' attitudes or achievement scores, it is recommended that the following questions regarding the computer tutorial be investigated. First, is it possible that CAI works better in topic areas as compared to integrated areas? How can the computer tutorial be improved to fully integrate the spheres so that the segmenting of individual topics is eliminated? Should there be a broader range of topics presented on the computer tutorial? How in depth should discussions and details of subject material be on the tutorial? Perhaps each sphere discussion should include one or more topics that contain several levels of difficulty so that a student continuously feels challenged? The professors involved in the course, the students enrolled in the course, and the framework of the course itself can benefit from these questions being examined.

Given that the instructional media delivery system did not change the gender issues in this study, it is recommended that additional female instructors be recruited to teach this class, so that the ratio of male to female professors is equal. Also, it is recommended that this study be replicated with a larger sample to make males and females more equally represented. This may further facilitate the issue of gender equality within the course.

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APPENDIX A

INSTRUMENTS AND ACHIEVEMENT KEY

NAME ____________________

Science Questionnaire

Please listen to your teacher's instructions before you complete this questionnaire. The answers you give on this survey will not affect your grade in this or any other class.

1. My gender is
   a) male b) female

2. My age is
   a) 17 b) 18 c) 19 d) 20 e) 21 +

Use this scale to answer the survey questions:
a) I strongly agree
b) I agree
c) I am undecided or don't know
d) I disagree
e) I strongly disagree

3. Science is indispensable to society.

4. There are many job opportunities in science.

5. Our society values science more than it should.

6. Science does not address social problems such as poverty, crime, and drugs.

7. Studying science will help me in my career.

8. Scientists are out of touch with the real world.

9. What I learn in science class is not important outside of school.

10. Studying science only helps students who are in a university.

11. I would enjoy a career in science.

12. Jobs involving science usually require a Ph.D. degree.

13. Science is a way of looking at the world.

14. Science involves learning lots of facts and figures.

15. Science creates more problems than it solves.

16. Science is a way of life, not just a job people do.

(Please turn to the back for questions 17 through 36)

Use this scale to answer the survey questions:
a) I strongly agree
b) I agree
c) I am undecided or don't know
d) I disagree
e) I strongly disagree

17. Science helps make the world a better place to live.

18. Careers in science are exciting.

19. Science is all around us every day.

20. Math and science are closely related subjects.

21. What I learn in science classes is not important in my other classes.

22. Computers are indispensable to society.

23. There are many job opportunities in computer science.

24. Our society values computers more than it should.

25. Studying computer science will help me in my career.

26. Computer specialists are out of touch with the real world.

27. I would enjoy a career that involves working with a computer.

28. Jobs involving computers usually require a Ph.D. degree.

29. Computers create more problems than they solve.

30. Computers help make the world a better place to live.

31. Careers in computer science are exciting.

32. Everyone should be computer literate.

33. I would enjoy using a computer tutorial for learning about science.

34. I would rather learn about science from a computer than a textbook.

35. I enjoy using computers for doing my class work.

36. I would rather do homework assignments using a computer than a textbook.

ACHIEVEMENT TEST

Please circle the letter corresponding to the best answer. Please be sure to answer all questions, even if you do not know an answer.

1. Kepler recognized that the shape of the planetary orbits is
   a. circular
   b. irregular
   c. elliptical
   d. retrograde egg-shape

2. According to Kepler's law of equal areas
   a. each planet sweeps matter from an equal area of space
   b. each planet's orbit is an ellipse with the Sun at one focal point
   c. the closer a planet comes to the Sun, the faster it moves along its orbit
   d. the closer a planet comes to the Sun, the more slowly it moves along its orbit

3. The sky is divided into 88 distinctive star patterns called
   a. the zodiac
   b. constellations
   c. star clusters
   d. galaxies

4. The part of the Sun that emits the light which reaches the Earth is the
   a. core
   b. radiative layer
   c. photosphere
   d. chromosphere

5. Sunspots and solar prominences are thought to be caused by the Sun's
   a. magnetism and differential rotation
   b. extreme temperature and pressure
   c. rotation and blackbody radiation
   d. blackbody radiation and gamma-ray flux

6. What type of waves cause earthquakes?
   a. Isostatic
   b. anomaly
   c. Richter
   d. seismic

7. The main gas erupted by volcanoes is
   a. carbon dioxide (CO_2)
   b. sulfur dioxide (SO_2)
   c. nitrogen (N_2)
   d. water vapor (H_20)

8. New continental crust is produced chiefly at
   a. mid-ocean ridges
   b. convergent plate margins
   c. transform faults
   d. hot spots

9. A Himalayan- or Alpine plate boundary would be
   a. divergent, with continental crust on both sides
   b. transform, with continental crust on at least one side
   c. convergent, with continental crust against oceanic crust
   d. convergent, with continental crust on both sides

10. The preferred explanation for the cause of most earthquakes is which theory?
   a. isostatic rebound
   b. elastic rebound
   c. volcanic explosion
   d. body-wave

11. Approximately what percent of the earth's surface is ocean?
   a. 30
   b. 60
   c. 70
   d. 80

12. Surface ocean currents are broad, slow drifts of surface water set into motion by
   a. the Coriolis effect
   b. Ekman transport
   c. prevailing surface winds
   d. tidal forces

13. The Coriolis effect causes the paths of surface ocean currents in the northern hemisphere to veer
   a. right
   b. left
   c. north
   d. south

14. Many of the world ocean's great fisheries are located in
   a. areas of high water evaporation
   b. areas of coastal upwelling
   c. areas of coastal downwelling
   d. warm surface currents

15. A fjord is a(n)
    a. lake developed in a cirque
    b. pre-glacial valley
    c. glacial valley that extends to the sea
    d. Scandinavian glacial ridge

16. Air pressure is measured with a device called a
    a. Bergeron column
    b. gravimeter
    c. Torricelli
    d. Barometer

17. The last glacial maximum occurred
    a. during the Little Ice Age
    b. about 20,000 years ago
    c. during the 1810-1819 decade, the coldest decade in Europe since the seventeenth century
    d. during the Holocene Epoch

18. Winds that result from a balance between pressure-gradient flow and the Coriolis deflection are called
    a. geostrophic winds
    b. Hadley cells
    c. Ferrell cells
    d. convergent and divergent flow

19. The ratio of air's water vapor content to its total capacity at a given temperature is the
    a. dew point temperature
    b. absolute humidity
    c. relative humidity
    d. vapor pressure

20. High pressure systems are typically associated with
    a. convergent surface winds
    b. wet, stormy weather conditions
    c. dry, clear weather conditions
    d. higher wind speeds than lows

21. Organisms that can live exclusively on energy obtained from nonliving, inorganic sources are
    a. heterotrophic
    b. autotrophic
    c. herbivorous
    d. omnivorous

22. The first level of the biological spectrum capable of supporting life is the:
    a. population
    b. community
    c. ecosystem
    d. biosphere

23. The pathways of energy (food) transfer from one type of organism to another within an ecosystem make up a(n)
    a. food web
    b. trophic level
    c. food chain
    d. ecosphere

24. The main process by which organisms synthesize large, complex organic molecules is
    a. crystallization
    b. metabolism
    c. biosynthesis
    d. polymerization

25. The hypothesis that life originated elsewhere in the Universe and then was spread to the Earth is called
    a. biosynthesis
    b. panspermia
    c. symbiosis
    d. chemosynthesis

26. Which of the following is a non-renewable energy resource?
    a. solar energy
    b. nuclear
    c. wind
    d. hydroelectric

27. The ozone hole forms in the stratosphere over
    a. Asia
    b. Africa
    c. Australia
    d. Antarctica

28. Fine-grained lake sediment in which pollen and other organic materials have been trapped becomes
    a. coal
    b. tar sand
    c. lignite
    d. oil shale

29. By the year 2030, it has been estimated that for most of the world winter and summer temperature will increase by about 1-3°C and 2-3°C, respectively. This will lead to:
    a. wetter winters and drier summers for the most part
    b. drier winters and wetter summers for the most part
    c. no change in the winter but drier in the summer
    d. wetter in the winter but drier everywhere in the summer

30. Globally, current CO_2 production per capita is 1 ton of Carbon (as CO_2). By the year 2050, the per capita carbon production is likely to be:
    a. 1 (no change)
    b. 1.5
    c. 3
    d. 6

ACHIEVEMENT TEST KEY

Please circle the letter corresponding to the best answer. Please be sure to answer all questions, even if you do not know an answer.

1. Kepler recognized that the shape of the planetary orbits is
   a. circular
   b. irregular
   c. elliptical
   d. retrograde egg-shape

2. According to Kepler's law of equal areas
   a. each planet sweeps matter from an equal area of space
   b. each planet's orbit is an ellipse with the Sun at one focal point
   c. the closer a planet comes to the Sun, the faster it moves along its orbit
   d. the closer a planet comes to the Sun, the more slowly it moves along its orbit

3. The sky is divided into 88 distinctive star patterns called
   a. the zodiac
   b. constellations
   c. star clusters
   d. galaxies

4. The part of the Sun that emits the light which reaches the Earth is the
   a. core
   b. radiative layer
   c. photosphere
   d. chromosphere

5. Sunspots and solar prominences are thought to be caused by the Sun's
   a. magnetism and differential rotation
   b. extreme temperature and pressure
   c. rotation and blackbody radiation
   d. blackbody radiation and gamma-ray flux

6. What type of waves cause earthquakes?
   a. Isostatic
   b. anomaly
   c. Richter
   d. seismic

7. The main gas erupted by volcanoes is
   a. carbon dioxide (CO_2)
   b. sulfur dioxide (SO_2)
   c. nitrogen (N_2)
   d. water vapor (H_20)

8. New continental crust is produced chiefly at
   a. mid-ocean ridges
   b. convergent plate margins
   c. transform faults
   d. hot spots

9. A Himalayan- or Alpine plate boundary would be
   a. divergent, with continental crust on both sides
   b. transform, with continental crust on at least one side
   c. convergent, with continental crust against oceanic crust
   d. convergent, with continental crust on both sides

10. The preferred explanation for the cause of most earthquakes is which theory?
   a. isostatic rebound
   b. elastic rebound
   c. volcanic explosion
   d. body-wave

11. Approximately what percent of the earth's surface is ocean?
   a. 30
   b. 60
   c. 70
   d. 80

12. Surface ocean currents are broad, slow drifts of surface water set into motion by
   a. the Coriolis effect
   b. Ekman transport
   c. prevailing surface winds
   d. tidal forces

13. The Coriolis effect causes the paths of surface ocean currents in the northern hemisphere to veer
   a. right
   b. left
   c. north
   d. south

14. Many of the world ocean's great fisheries are located in
   a. areas of high water evaporation
   b. areas of coastal upwelling
   c. areas of coastal downwelling
   d. warm surface currents

15. A fjord is a(n)
    a. lake developed in a cirque
    b. pre-glacial valley
    c. glacial valley that extends to the sea
    d. Scandinavian glacial ridge

16. Air pressure is measured with a device called a
    a. Bergeron column
    b. gravimeter
    c. Torricelli
    d. Barometer

17. The last glacial maximum occurred
    a. during the Little Ice Age
    b. about 20,000 years ago
    c. during the 1810-1819 decade, the coldest decade in Europe since the seventeenth century
    d. during the Holocene Epoch

18. Winds that result from a balance between pressure-gradient flow and the Coriolis deflection are called
    a. geostrophic winds
    b. Hadley cells
    c. Ferrell cells
    d. convergent and divergent flow

19. The ratio of air's water vapor content to its total capacity at a given temperature is the
    a. dew point temperature
    b. absolute humidity
    c. relative humidity
    d. vapor pressure

20. High pressure systems are typically associated with
    a. convergent surface winds
    b. wet, stormy weather conditions
    c. dry, clear weather conditions
    d. higher wind speeds than lows

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   b. **1.5**
   c. 3
   d. 6

APPENDIX B

RAW DATA

Homework Assignment Averages for Treatment Group Students 1-15

Anthropoosphere Homework	Cosmosphere Homework	Geosphere Homework	Hydrosphere Homework	Atmosphere Homework	Biosphere Homework
77.5	86.8	86.8	93.6	93.6	82.5
78.5	80.9	93.8	91.0	91.0	91.3
74.5	90.8	81.9	87.2	91.0	87.5
73.0	78.9	83.3	84.6	82.1	65.0
82.0	87.5	81.9	93.6	85.9	0.0
87.5	97.4	90.3	94.9	98.7	93.8
76.5	90.8	88.9	93.6	83.3	80.0
66.5	90.8	91.0	85.9	67.9	72.5
68.0	79.6	84.7	84.6	73.1	82.5
82.0	71.1	77.8	93.6	83.3	85.0
68.5	90.1	0.0	82.7	79.5	67.5
80.0	93.4	80.6	92.3	86.5	88.1
89.5	93.4	94.4	100.0	97.4	92.5
73.5	90.1	81.3	79.5	76.9	76.9
81.5	95.4	81.9	88.5	91.0	87.5

Homework Assignment Averages for Control Group Students 1-15

Anthropoosphere Homework	Cosmosphere Homework	Geosphere Homework	Hydrosphere Homework	Atmosphere Homework	Biosphere Homework
85.0	86.2	87.5	89.7	83.3	81.3
75.0	96.1	72.2	89.7	91.0	86.9
77.0	94.1	92.4	88.5	92.3	82.5
82.5	92.1	70.8	67.9	75.6	48.8
74.5	91.4	0.0	74.4	0.0	0.0
84.0	87.5	97.9	87.2	78.2	81.3
71.0	92.1	79.9	90.4	94.9	83.1
91.0	96.1	92.4	87.2	93.6	86.9
73.0	88.8	90.3	85.9	88.5	78.8
80.0	86.8	82.6	92.3	91.0	85.0
84.0	86.2	86.8	89.7	92.3	86.9
79.5	88.2	87.5	93.6	92.3	80.6
60.5	77.6	82.6	93.6	89.7	81.9
67.0	69.1	84.7	87.2	82.1	64.4
70.0	85.5	89.6	94.9	92.3	89.4
76.9	87.9	79.8	87.5	82.5	74.5

Note: Raw data based on a total 100 points

Final Data Set Used for MANCOVA Analyses

Y1 Post Att	Y2 Post Ach	X1 Pre Att	X2 Pre Ach	X3 Group	X4 Gender
113	21	144	18	treatment	female
139	24	129	16	treatment	male
134	18	125	12	treatment	female
126	18	120	15	treatment	female
147	18	142	14	treatment	male
122	24	126	16	treatment	female
125	20	134	16	treatment	female
121	16	135	13	treatment	male
125	20	108	16	treatment	female
142	23	151	15	treatment	male
124	19	81	20	treatment	male
129	24	147	18	treatment	male
136	25	139	18	treatment	male
125	20	126	19	treatment	female
142	23	142	16	treatment	female
134	18	130	15	control	female
130	21	132	15	control	female
119	24	115	15	control	female
133	16	126	14	control	male
126	5	133	13	control	female
138	26	142	17	control	male
126	18	127	11	control	female
130	18	136	15	control	female
132	25	129	19	control	male
141	22	144	13	control	male
141	26	140	19	control	male
131	23	135	15	control	female
125	16	117	18	control	female
115	10	124	16	control	female
130	14	133	11	control	female

Notes:

1) Y1 = Raw data based on a total of 180 points
2) Y2 = Raw data based on a total of 30 points
3) X1 = Raw data based on a total of 180 points
4) X2 = Raw data based on a total of 30 points

Attitude Pretest Raw Data for Treatment Group Students 1-15 - Questions 1-18

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
4	1	5	5	4	5	5	5	5	5	5	4	5	4	4	5	5	5
5	4	5	5	4	3	5	5	4	4	5	3	4	4	1	4	5	4
4	2	2	5	3	4	5	4	5	5	4	3	3	4	2	3	4	5
4	4	1	4	3	4	5	3	4	4	4	2	4	4	2	3	4	4
5	4	5	5	2	3	5	5	5	5	5	3	5	4	5	5	5	5
4	2	4	4	4	4	5	5	5	5	5	2	5	4	2	5	4	5
4	4	5	5	3	5	5	5	5	5	5	4	4	4	2	3	4	5
5	4	3	5	4	1	5	4	5	5	5	4	5	4	2	5	5	5
4	4	1	3	5	3	5	5	4	5	5	1	5	5	1	3	3	5
5	2	5	5	4	5	5	5	5	5	5	4	4	5	1	4	5	5
5	4	3	2	3	2	2	2	2	2	2	2	2	2	4	3	3	2
5	1	5	5	5	5	5	5	5	5	5	5	4	2	1	4	5	5
5	4	5	5	4	5	5	5	5	5	4	4	5	3	2	4	4	4
4	1	2	4	4	2	5	4	5	5	4	4	4	2	2	4	4	5
4	4	5	5	4	4	5	5	4	4	5	3	5	4	3	4	4	4

Attitude Pretest Raw Data for Treatment Group Students 1-15 - Questions 19-36

Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36
5	4	5	4	5	4	2	4	2	5	2	5	1	5	5	4	4	2
4	4	4	5	4	2	4	4	3	3	2	5	3	4	4	3	4	2
5	4	5	2	4	2	4	4	4	4	1	4	4	3	4	2	4	4
4	5	4	2	4	4	4	3	4	4	3	3	4	4	4	2	4	3
5	5	5	2	5	5	4	1	3	5	5	3	3	3	4	4	4	4
5	4	4	2	5	5	4	3	1	5	2	2	2	4	2	1	4	3
5	5	4	3	5	3	4	4	3	4	2	3	3	4	3	3	4	3
5	5	2	3	4	5	4	3	4	4	2	5	4	3	4	3	4	4
5	5	4	2	3	5	2	1	1	3	5	1	1	4	3	1	2	1
5	5	5	4	5	2	5	5	5	4	1	5	5	5	5	4	4	5
2	2	2	3	2	2	2	2	2	2	4	3	2	4	2	3	2	2
5	5	5	5	5	1	5	5	5	5	1	5	5	5	3	2	5	4
5	5	5	2	5	3	4	4	4	5	2	4	4	4	4	3	4	3
5	4	5	2	5	2	4	4	4	5	2	3	3	4	4	3	4	3
5	4	4	4	5	4	4	3	4	4	3	4	4	5	5	3	4	5

Attitude Posttest Raw Data for Treatment Group Students 1-15 - Questions 1-18

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
4	1	5	5	5	1	1	5	5	1	1	1	4	2	4	5	5	5
5	4	5	5	5	2	5	5	5	5	5	3	5	4	1	5	5	5
4	2	5	5	3	5	5	4	4	5	4	4	3	4	2	3	3	4
4	1	2	5	2	3	5	3	5	4	4	1	5	5	3	3	3	4
5	3	5	5	1	3	5	5	5	5	5	5	5	5	4	5	5	5
4	3	5	4	4	4	5	4	4	4	5	2	4	4	2	4	3	5
4	4	5	4	4	1	5	4	5	5	5	4	3	4	2	2	4	5
5	4	4	5	2	3	2	4	4	4	2	3	4	4	4	3	3	2
4	4	5	5	4	3	5	5	5	5	5	1	5	5	3	3	4	5
5	1	5	5	4	4	5	4	1	1	5	4	4	5	2	4	5	5
5	3	4	4	3	4	4	4	4	4	3	3	4	4	4	4	4	3
5	1	5	5	5	1	1	4	5	5	5	5	4	4	1	4	5	5
5	4	5	5	4	4	5	4	5	5	5	4	4	2	2	4	4	4
4	1	4	4	3	4	5	4	4	4	5	4	4	2	2	4	4	5
4	4	5	5	3	5	5	4	4	5	5	3	5	4	3	4	4	5

Attitude Posttest Raw Data for Treatment Group Students 1-15 - Questions 19-36

Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36
5	4	4	4	4	2	4	4	4	4	2	4	2	5	1	1	2	2
5	5	4	5	5	2	3	4	4	3	1	5	4	4	4	3	4	4
4	4	5	4	5	3	4	4	4	4	2	4	4	4	4	4	4	4
5	5	5	3	5	4	4	3	4	3	3	4	4	4	3	3	4	3
5	5	5	5	5	5	5	2	5	5	4	5	3	5	1	3	3	3
5	4	4	2	5	5	4	3	2	5	2	4	2	4	2	2	2	2
5	5	4	4	5	2	4	4	3	5	2	3	2	4	2	3	4	2
4	4	4	4	4	5	4	2	4	4	4	3	3	4	4	4	4	3
5	5	5	5	5	5	5	1	1	5	5	1	1	4	1	1	1	1
5	5	5	4	5	2	5	4	5	4	1	4	5	5	5	5	5	5
4	4	4	4	4	4	4	4	4	4	2	3	4	2	2	3	4	4
5	5	2	5	5	1	5	3	5	5	1	5	5	4	4	2	2	1
5	5	5	4	4	3	5	4	4	5	2	4	4	4	3	3	4	2
4	4	4	2	5	2	4	4	3	4	2	3	3	4	4	3	4	4
5	4	4	4	5	3	4	3	4	4	2	4	4	5	5	3	5	5

Attitude Pretest Raw Data for Control Group Students 1-15 - Questions 1-18

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
4	4	2	5	4	3	5	5	5	5	5	4	4	3	2	4	4	4
4	4	4	4	5	4	5	4	5	4	5	4	4	3	2	4	4	4
4	4	3	5	4	4	5	4	4	4	5	1	4	4	3	3	3	4
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4	4	5	5	5	5	5	5	5	5	5	3	4	4	1	4	4	5
4	3	4	4	3	3	4	3	5	3	3	4	4	4	3	4	4	3
4	4	3	4	3	2	4	4	4	4	4	4	4	3	4	4	4	4
4	4	4	5	4	4	5	4	5	5	5	3	5	3	2	4	5	5

Attitude Pretest Raw Data for Control Group Students 1-15 - Questions 19-36

Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36
5	5	5	2	5	2	4	4	3	4	2	4	3	4	3	4	4	3
5	4	4	4	2	4	4	4	4	3	4	4	3	4	2	4	4	4
4	4	4	3	4	5	3	3	3	3	3	2	3	4	3	1	2	1
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5	5	4	4	3	4	3	3	2	3	3	3	3	4	4	2	2	2
4	5	4	3	4	4	4	3	4	3	3	4	3	4	4	4	3	2
5	4	4	4	3	4	4	3	4	3	2	3	3	4	5	2	4	4

Attitude Posttest Raw Data for Control Group Students 1-15 - Questions 1-18

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
4	3	5	5	3	3	5	4	5	4	5	4	4	4	2	4	4	4
4	4	4	4	4	3	5	2	5	4	5	3	4	4	3	4	4	5
4	4	5	5	3	4	5	5	5	4	4	2	4	4	3	3	3	4
5	3	5	5	2	5	4	4	4	4	4	4	5	5	3	4	4	4
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4	4	5	5	4	4	5	5	5	4	4	3	4	2	2	4	4	4

Attitude Posttest Raw Data for Control Group Students 1-15 - Questions 19-36

Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36
4	4	4	4	5	2	5	4	3	5	2	4	3	4	4	4	4	4
5	4	4	4	3	4	4	3	3	3	2	4	4	4	4	4	4	4
5	4	4	3	4	4	3	3	3	3	3	3	3	4	3	1	2	1
4	5	4	4	4	3	5	4	3	4	2	3	4	4	4	2	4	4
5	5	4	3	4	4	4	4	1	4	2	4	2	4	2	4	2	3
5	5	4	4	5	4	4	5	4	4	2	4	5	4	5	2	4	2
4	4	3	4	5	5	3	3	1	4	3	3	2	5	3	3	3	3
5	5	5	2	5	5	4	3	2	5	3	2	2	4	2	1	3	1
4	4	4	3	4	5	4	3	4	4	3	4	2	3	4	4	4	4
5	5	4	4	5	3	5	2	4	4	2	5	3	5	3	3	5	5
5	5	5	4	5	2	4	3	4	4	2	3	4	5	4	5	4	5
5	4	5	3	5	4	4	3	1	3	3	4	3	4	4	3	3	3
5	5	5	4	4	5	2	3	3	4	2	1	3	5	3	4	2	2
4	4	4	2	4	3	4	4	2	3	2	3	3	4	4	2	2	2
5	4	5	4	4	2	4	4	4	3	2	4	4	5	4	4	2	2

Pretest and Posttest Measures of Attitudes Toward Science and Computers

Question	Pretest (N=30)		Posttest (N=30)	
	Mean	SD	Mean	SD
1. Science is indispensable to society.	4.50	0.71	5.00	0.00
2. There are many job opportunities in science.	5.00	0.00	5.00	0.00
3. Our society values science more than it should.	4.00	0.00	3.50	0.71
4. Science does not address social problems such as poverty, crime, and drugs.	4.00	0.00	4.50	0.71
5. Studying science will help me in my career.	5.00	0.00	5.00	0.00
6. Scientists are out of touch with the real world.	4.50	0.71	4.50	0.71
7. What I learn in science class is not important outside of school.	4.50	0.71	4.50	0.71
8. Studying science only helps students who are in a university.	4.50	0.71	4.50	0.71
9. I would enjoy a career in science.	5.00	0.00	4.50	0.71
10. Jobs involving science usually require a Ph.D. degree.	3.00	0.00	3.00	0.00
11. Science is a way of looking at the world.	5.00	0.00	4.50	0.71
12. Science involves learning lots of facts and figures.	3.50	0.71	3.00	1.41
13. Science creates more problems than it solves.	2.50	0.71	3.00	0.71
14. Science is a way of life, not just a job people do.	4.00	0.00	4.00	0.00
15. Science helps make the world a better place to live.	4.50	0.71	4.00	0.00
16. Careers in science are exciting.	4.50	0.71	4.50	0.71
17. Science is all around us every day.	5.00	0.00	5.00	0.00
18. Math and science are closely related subjects.	4.00	0.00	4.00	0.00
19. What I learn in science classes is not important in my other classes.	4.00	0.00	4.50	0.00
20. Computers are indispensable to society.	4.00	0.00	4.00	0.00
21. There are many job opportunities in computer science.	4.00	1.41	4.50	0.71
22. Our society values computers more than it should.	4.00	0.00	2.50	0.71
23. Studying computer science will help me in my career.	4.00	0.00	4.00	0.00
24. Computer specialists are out of touch with the real world.	3.00	0.00	3.50	0.71
25. I would enjoy a career that involves working with a computer.	4.00	0.00	4.00	0.00
26. Jobs involving computers usually require a Ph. D. degree.	3.50	0.71	3.50	0.71
27. Computers create more problems than they solve.	2.50	0.71	2.00	0.00
28. Computers help make the world a better place to live.	3.50	0.71	4.00	0.00
29. Careers in computer science are exciting.	3.50	0.71	4.00	0.00
30. Everyone should be computer literate.	4.50	0.71	5.00	0.00
31. I would enjoy using a computer tutorial for learning about science.	5.00	0.00	4.50	0.71
32. I would rather learn about science from a computer than a textbook.	2.50	0.71	3.50	0.71
33. I enjoy using computers for doing my class work.	4.00	0.00	3.50	2.12
34. I would rather do homework assignments using a computer than a textbook	4.50	0.71	3.50	2.12

Note: (1) Responses measured on a Likert-Scale of 1 = I strongly disagree, 2 = I disagree, 3 = I am undecided or don't know, 4 = I agree, 5 = I strongly agree;(2) Question response ranged from 2 to 5.

Achievement Pretest Raw Data for Treatment Group Students 1-15 - Questions 1-15

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
3	4	2	3	5	5	4	4	2	5	2	5	3	2	3
3	4	4	3	4	2	4	3	3	5	4	5	3	2	3
3	4	4	3	4	2	5	5	5	5	3	5	4	2	3
3	3	2	4	2	2	5	4	2	5	2	5	5	2	3
3	4	4	4	2	2	4	5	2	4	2	5	5	3	4
3	4	4	3	4	2	4	5	5	4	3	3	4	4	3
3	4	4	3	4	2	2	5	3	5	3	5	4	4	2
4	3	4	5	4	2	4	2	3	5	3	3	4	2	3
5	4	4	3	2	2	5	2	2	4	3	5	3	4	3
3	3	4	3	2	2	4	4	2	4	3	3	4	2	4
3	2	4	3	5	2	5	4	5	4	3	5	5	3	4
3	3	3	2	5	2	4	5	3	5	3	5	3	4	3
3	4	4	3	2	2	4	5	2	3	3	2	5	4	2
3	4	4	4	3	2	4	4	2	5	3	3	5	2	4
3	4	4	3	5	2	5	4	2	4	3	2	5	2	4

Achievement Pretest Raw Data for Treatment Group Students 1-15 - Questions 16-30

Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
2	4	5	3	3	4	3	5	4	4	4	2	4	5	3
2	4	5	5	3	4	3	3	3	4	4	3	2	5	4
2	5	5	2	4	2	2	3	3	4	3	2	3	5	4
2	2	5	3	3	4	2	3	4	4	5	2	3	5	5
2	2	2	3	3	4	4	4	4	4	4	3	3	5	4
2	4	5	5	4	4	4	3	3	4	4	2	5	4	3
2	3	5	4	3	5	5	5	3	4	4	2	3	5	4
2	4	3	3	3	2	3	3	3	5	4	4	3	3	4
2	2	2	5	3	4	2	3	2	4	4	2	3	5	5
4	3	2	5	3	5	3	4	5	4	2	2	3	4	4
2	4	5	5	3	4	3	3	3	4	4	2	5	5	4
2	4	2	3	3	4	3	3	3	4	4	2	2	5	5
2	4	5	3	3	4	3	3	3	4	4	2	5	2	3
2	5	5	3	3	5	3	5	2	4	5	2	4	5	4
2	3	5	3	4	5	2	5	3	4	5	2	3	3	5

Achievement Posttest Raw Data for Treatment Group Students 1-15 - Questions 1-15

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
3	2	4	3	5	2	5	2	2	4	3	3	5	4	3
3	3	4	3	4	2	5	5	2	4	3	3	5	4	3
3	4	3	2	2	2	5	3	2	4	3	5	4	4	3
3	5	4	3	5	2	4	5	2	4	2	5	5	4	3
3	3	4	3	4	2	4	5	2	4	3	4	5	3	5
3	3	4	3	5	2	5	5	2	4	3	3	5	4	3
3	3	4	4	3	2	2	4	2	4	3	5	4	4	2
3	4	4	2	4	3	4	5	2	4	2	3	4	2	3
3	3	4	3	5	2	4	4	2	4	3	5	5	4	4
3	3	4	3	2	2	4	4	2	4	3	3	5	3	3
3	5	4	3	5	2	4	2	2	4	3	5	4	4	5
3	3	4	3	5	2	5	5	2	4	3	3	4	4	3
3	3	4	3	5	2	2	5	3	4	3	3	5	4	3
3	3	4	3	3	2	4	4	3	4	3	5	5	4	5
3	4	4	3	5	2	3	2	3	4	3	3	5	4	3

Achievement Posttest Raw Data for Treatment Group Students 1-15 - Questions 16-30

Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
2	5	5	3	2	4	3	5	4	4	4	2	4	4	3
2	5	5	3	3	4	3	5	3	4	4	2	2	4	4
2	5	5	3	4	4	2	5	2	4	4	2	3	5	4
2	5	4	4	3	4	3	3	3	3	4	2	2	5	5
2	2	3	3	3	4	4	4	2	4	4	2	5	5	3
2	4	5	3	3	4	3	3	2	4	4	2	5	4	5
2	5	5	3	3	4	5	3	3	4	4	2	3	5	4
2	4	2	3	3	4	3	3	3	4	4	4	5	5	4
2	5	5	5	3	4	2	4	2	4	2	2	4	5	3
2	4	5	3	4	4	3	3	3	4	4	2	2	2	4
2	5	5	5	3	4	3	4	4	4	4	2	3	5	4
2	4	4	3	3	4	3	5	3	4	4	2	2	5	3
2	4	5	3	3	4	3	5	2	5	4	2	3	3	4
2	5	5	3	3	4	5	5	4	4	4	2	3	5	3
2	4	5	3	4	4	3	4	2	4	4	2	3	5	4

Achievement Pretest Raw Data for Control Group Students 1-15 - Questions 1-15

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
3	3	4	3	4	2	4	5	5	3	3	5	2	2	2
3	3	4	2	4	2	4	4	3	5	2	5	4	4	3
2	4	3	3	2	2	4	5	4	5	3	3	4	4	3
5	3	4	4	2	2	4	3	2	4	2	3	2	4	3
3	2	2	3	4	5	5	5	4	5	4	3	3	2	4
3	3	4	3	5	2	4	5	3	4	3	5	4	2	2
3	4	5	3	4	2	4	2	5	4	3	2	3	4	4
3	3	3	3	4	2	4	4	3	5	2	5	5	4	3
3	4	4	3	2	2	4	5	2	5	3	5	5	4	3
3	4	4	5	4	2	4	3	2	5	3	5	2	3	4
3	4	4	3	2	2	5	5	2	5	3	3	5	4	4
3	4	4	2	4	5	3	2	2	5	3	3	2	4	3
3	5	4	4	5	2	4	3	2	4	3	3	4	4	3
3	3	4	3	4	2	4	2	5	5	3	5	5	4	3
3	3	2	4	2	2	4	2	3	4	3	5	2	3	3

Achievement Pretest Raw Data for Control Group Students 1-15 - Questions 16-30

Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
2	4	5	5	3	4	3	3	3	3	4	3	3	5	4
2	4	2	5	3	4	4	3	5	2	4	2	4	5	4
2	4	5	4	3	4	2	5	5	3	5	2	2	5	3
2	5	4	4	4	4	4	5	3	4	5	2	3	5	3
2	4	5	2	3	4	3	5	4	3	3	2	3	5	4
2	5	3	3	3	4	4	3	3	4	4	2	5	5	4
2	4	5	5	4	3	3	2	5	5	4	4	3	2	2
2	5	3	3	3	4	4	5	5	3	5	2	3	4	4
2	4	5	3	3	4	4	3	4	4	4	2	5	5	2
2	5	5	3	3	5	3	3	3	4	4	2	3	3	5
2	4	5	3	3	5	4	3	4	4	4	2	4	5	4
2	3	5	3	3	4	4	4	4	3	4	2	5	3	4
2	4	5	3	4	4	3	3	4	5	4	4	2	4	3
2	5	5	3	2	4	2	3	3	5	4	2	4	3	4
2	3	4	3	4	2	2	2	3	4	4	3	3	5	3

Achievement Posttest Raw Data for Control Group Students 1-15 - Questions 1-15

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
3	3	4	3	5	2	4	5	3	4	3	5	5	2	5
3	3	4	2	5	2	4	5	3	4	3	3	5	4	3
3	3	3	3	4	2	5	5	2	4	3	3	5	4	5
3	3	4	3	2	2	4	5	2	4	2	2	4	4	5
4	4	3	2	2	5	4	2	4	3	5	5	4	3	2
3	3	4	3	5	2	2	5	2	4	3	3	5	4	3
3	3	4	3	4	2	4	2	5	4	3	3	5	4	4
5	5	4	3	5	2	4	4	2	4	2	5	5	4	5
3	3	4	3	5	2	2	5	2	4	3	3	5	4	3
3	4	4	2	5	2	4	5	2	4	2	3	5	4	4
3	3	4	3	2	2	5	5	2	4	3	3	5	4	3
3	3	4	3	5	3	5	5	2	4	3	3	5	4	3
3	4	4	4	3	2	4	4	3	4	3	3	4	4	3
3	4	4	3	4	2	4	5	3	3	3	5	4	5	2
3	3	2	2	4	2	5	5	2	4	3	3	4	3	4

Achievement Posttest Raw Data for Control Group Students 1-15 - Questions 16-30

Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
2	2	5	5	3	4	3	3	2	4	4	2	3	4	3
2	5	5	3	3	4	3	4	2	4	4	2	3	4	5
2	4	5	3	3	4	3	5	4	4	4	2	2	5	4
2	5	5	5	3	2	3	3	5	4	4	2	4	5	2
4	5	5	3	4	5	3	4	4	4	2	5	4	3	4
2	4	5	3	3	4	3	3	3	4	4	2	2	4	4
2	5	5	5	3	4	2	3	4	4	2	2	2	2	4
2	3	5	3	3	4	3	5	4	4	4	3	3	4	3
2	4	5	3	3	4	5	4	3	4	4	2	5	5	4
2	4	5	3	3	4	3	4	2	4	4	2	3	5	4
2	4	5	3	3	4	3	5	2	4	4	2	4	5	4
2	5	5	3	5	4	3	5	3	4	4	2	4	5	4
2	4	4	3	4	4	3	4	5	4	4	4	4	4	3
4	5	4	3	4	3	3	2	4	4	2	5	4	5	4
2	5	5	3	4	2	3	3	4	4	2	2	5	3	4