COMPARATIVE EFFECTIVENESS OF PAIRED VERSUS INDIVIDUAL LEARNING OF COGNITIVE SKILLS USING COMPUTER-BASED INSTRUCTION

DISSERTATION

Presented to the Graduate Council of the University of North Texas in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Elane K. Seebo, B.A., M.Ed., M.A.
Denton, Texas
December, 1991
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This study examined the comparative effectiveness of learning of cognitive skills when instruction is presented through computer-based instruction using student-to-computer ratios of one-to-one and two-to-one. Effectiveness was gauged through scores on posttests administered subsequent to completion of each of nine computer-based lessons and on a single composite test score.

Subjects were assigned to a control group (one-to-one student-to-computer ratio) or a treatment group (two-to-one student-to-computer ratio). Data were collected for 63 subjects in the control group and 58 subjects in the treatment group and included scores attained on posttests administered after each computer-based lesson and composite test scores derived from written tests administered.

A statistical analysis conducted using *t* tests revealed that results for only one of the hypotheses tested were statistically significant at the .01 level. Confidence intervals were also calculated at the .01 level for each set of results. Based on results of the confidence interval calculations, it could not be concluded that any of the differences between the means of the control and treatment
groups were true differences. In addition, effect sizes were calculated to determine practical significance of results. These calculations revealed that the difference between the two groups discovered for one hypothesis had possible limited practical application to the fields of education and training.

The findings of the study parallel the cumulative results of a limited body of research conducted previously. The findings have implications for resource allocations in planning and implementing computer-based instruction and for designing teaching-learning activities associated with computer-based instruction.

There are also indications that additional research may prove beneficial. Additional research should address larger student-to-computer ratios and different types of learning which may incorporate computer-based instruction.
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CHAPTER I

BACKGROUND

One of the primary concerns of any institution in the business of teaching is providing the best learning environment within the constraints imposed upon it. That task usually translates to providing quality education or training in the most economical way possible. Efforts to accomplish that end have included a myriad of approaches to deriving valid curricula and endless variations on teaching methodologies, developing instructional materials in numerous formats, and incorporating a variety of media into teaching-learning activities. From open classrooms and team teaching to computer laboratories, from traditional textbooks to programmed texts, from flip charts to classroom interaction provided through two-way audio-video satellite downlinks, one point becomes abundantly clear. While virtually all of the variations conceived in the minds of educators have a place in the world of education, no single innovation has proved to be a panacea for all educational ills. Consequently, conscientious teaching and administrative staff members at all levels continue their quests to find the optimum methods, materials, and media to support education and training efforts.
With increasing numbers of people requiring access to such education and training and with proportionately fewer public dollars available to educational institutions, it is incumbent upon educational entities to provide the maximum amount of education and training with the funds available to them. Current efforts are focusing on effective use of instructional personnel and the selection of media which allow institutions to provide education and/or training to more of students at optimum cost. Included in those efforts for many institutions are increasing class sizes, adjusting course offerings, and taking advantage of technological advances in development and delivery of instruction.

In fact, some advanced technology such as satellite communication capability even makes possible the implementation of concepts such as distance learning. In some distance learning applications, institutions have the capability to send and receive live satellite transmissions in which both instructors and students may have visual, audio, and electronic (computer) contact with each other, allowing immediate interaction. However, such technology is not readily available to all educational institutions, nor would it be appropriate for all institutions. Consequently, greater numbers of educators are focusing on technology which is more available to them, which requires fewer of their limited resources to implement, and which may be better suited to their overall circumstances.
One technology receiving increased attention is computer-based instruction. Decreasing capital investment requirements, coupled with advances in computer hardware and software, render the technology more accessible. In addition, computer-based training has been incorporated into the education and training environments long enough to enable educators and trainers to make a reasonable assessment of which uses of the technology are most appropriate.

Since the military services provide more technical training than any other single education or training entity, computer-based training has been eagerly embraced by the training organizations within each of the services. The review of literature in Chapter II includes numerous references to past, current, and planned applications of computer-based training. This study focused on applications within the U. S. Air Force's Air Training Command. Within the Air Force, Air Training Command is the organization responsible for providing most technical training and for training the instructors who provide that training. It is through the Air Training Command's Technical Training Instructor Course that virtually all Air Force technical training instructors are taught the fundamentals of classroom instruction.

After reviewing existing research and conducting additional studies concerning appropriate applications for
computer-based training in the technical training environment, Air Training Command acknowledged that computer-based training should play an integral role in its technical training programs. Consequently, a joint decision was made by Air Training Command and its customers (primarily other government agencies) that it would be appropriate to incorporate examples of computer-based training into the Technical Training Instructor Course.

First, they reasoned, incorporating computer-based training into the course would provide at least a minimal initial exposure to computers, which are rapidly becoming an integral part of both training and work environments within the Air Force. Secondly, new instructors would have some insight into appropriate use of computer-based training, learning through examples presented in the course which kinds of material and instruction can be most effectively delivered through computer-based training. Finally, an examination of the course content using media selection models included in Air Force regulations revealed that there were several course content areas which were excellent candidates for presentation through computer-based instruction.

Subsequent to the determination that incorporating computer-based training into the Technical Training Instructor Course would be appropriate, a contract for the development of that training through a civilian organization
was funded. Based on contract specifications, the contractor ultimately developed nine computer-based lessons and three remedial computer-based instructional segments which were incorporated into the course.

Need for the Study

Although the education and training communities have effectively defined valid roles for computer-based training in producing quality training, they have not been as effective in determining how to use computer-based training most economically. Although initial capital investment requirements for hardware and software have declined significantly in recent years, incorporating computer-based training into new or existing programs still entails a major expenditure of funds in the increasingly constrained fiscal environment within which most educational and training institutions exist. For example, incorporating computer-based training into the Technical Training Instructor Course required acquisition of 45 computers configured to support color graphic presentation, peripheral devices such as printers, assorted software, and a local area network. The initial capital investment approached $100,000.00. When capital expenditures of such magnitude are required to implement computer-based training in a single course of study, prudent managers of limited resources must be concerned with making optimum use of their funds to provide the best teaching-learning environment possible.
To date, few decision-makers have thoroughly examined all the details of implementing computer-based training with a critical eye. One implementation detail which could make a significant difference in resource requirements is the student-to-computer ratio for which the institution must plan and allocate resources. Current cost projection models almost exclusively presume a one-to-one student-to-computer ratio, as was the case with the Technical Training Instructor Course. However, research in the realm of traditional instruction, particularly instruction focusing on cognitive skills, strongly suggests that students learn better when participating in teaching-learning activities in pairs or small groups.

In reviewing research on computer-based instruction, very little was found which addressed how effectively students learned when computer-based instruction was provided with students assigned as pairs or in small groups. In fact, only four studies dealing specifically with student-to-computer ratio were found.

If a higher student-to-computer ratio would allow for equivalent, or near-equivalent, learning, institutions could proportionately reduce their initial capital expenditure for equipment. Accordingly, if initial investments can be reduced while continuing to provide a quality teaching-learning activity through computer-based instruction, then institutions would have the options of
initiating or expanding computer-based instruction. As one of the world's single largest technical training entities, the Air Force allocates a significant portion of the training budget for equipment used to deliver computer-based instruction. Savings in resource requirements for computer-based instruction within the Air Force would have positive results not only within the Air Force, but also for the taxpayers who support the program.

However, before arbitrarily reducing resource allocations, additional research is required to form the foundation for a modified resource allocation decision model suggested by findings of the limited previous research outlined in Chapter II. This study was developed to examine the comparative effectiveness of learning if student-to-computer ratios are increased from the current one-to-one ratio to a two-to-one ratio in Air Force technical training as represented by the Technical Training Instructor Course.

Statement of the Problem

The purpose of this study is to compare the effectiveness of learning cognitive skills for students in technical training based on student-to-computer ratio (a one-to-one ratio compared to a two-to-one ratio).

Hypotheses Tested

For purposes of this study, ten hypotheses were tested:
1. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Using Computers in Instruction" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

2. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Student as an Individual" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

3. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Dynamics of Small Learning Groups" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

4. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Effective Feedback Techniques" in the
Technical Training Instructor Course at Sheppard Air Force Base, Texas.

5. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Instructional System Development (ISD) Process" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

6. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Developing Criterion Objectives" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

7. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Characteristics of Evaluation" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

8. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based
instruction designed to develop cognitive skills in the content area "Developing Written Test Items" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

9. Null form: There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Common Rating Errors" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

10. Null Form: There will be no significant difference in composite test grades of students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

Delimitations

The sole delimitation of this study was the structure of classes to help preclude a Hawthorne effect. Six consecutive classes were selected as control group classes, with an additional five subsequent consecutive classes selected to serve as the treatment group. Since six to ten classes are in session at any given time, scheduling consecutive classes as either the control or treatment group
served to help preclude interaction with students attending classes where teaching-learning activities were structured differently. Consequently, students were less likely to be aware of differences in class activities.

Limitations

This study was limited to technical training students attending the Technical Training Instructor Course at Sheppard Technical Training Center. Further, although classes were randomly assigned to treatment groups, it was not possible to randomly assign students because assignment to a particular technical training center is done through the Air Force Manpower and Personnel Center using a screening process based on the Air Force specialty taught at different technical training centers and the specialty code already assigned to potential instructors. The students sampled are representative of instructors teaching in specialty areas currently taught at Sheppard Air Force Base.

A related limitation of this study was the inability to survey students who had not met at least prerequisite requirements for attending the Technical Training Instructor Course. These prerequisite requirements are relatively stringent when compared to requirements for some other Air Force specialties, and include:

1. Technical qualification in the subject or career field in which the individual is to instruct;
2. High school graduation (or equivalent);
3. A score of 60 in the "General" category of the Airman's Qualification Examination, the battery of entrance tests taken by individuals enlisting in the U. S. Air Force;
4. Maintaining a rating of eight on the five latest performance assessments (nine is the highest possible score);
5. Clear speaking voice with no speech impediments;
6. Exemplary military bearing, appearance, conduct, and good moral character as verified by the person's commander (5).

Definition of Terms

To clarify the intent of specific terminology used within the scope of this study, the following definitions are provided.

**Air Training Command:** The major command within the U. S. Air Force responsible for recruiting and training officers and airmen for the regular Air Force.

**Block:** One or more related units or modules grouped to cover major subject or task areas of a course (1).

**Block test:** A written test which measures accomplishment of knowledge-oriented objectives and knowledge components of performance-oriented objectives covered during a block of instruction. Block tests are sampling tests and are not comprehensive in nature (1).
Cognitive skills: For purposes of this study, cognitive skills are defined as those skills related to the acquisition and application of knowledge, including theories and principles demonstrated through practical application.

Composite test grade: A grade assigned to students at the end of a course. The grade is computed as the average of block test scores.

Computer-assisted instruction: One application of computer-based training that involves an on-line interactive process between a learner and a computerized delivery system, in which the computer assumes a direct instructional role (3).

Computer-based instruction: The term used to described instruction delivered using a computer. It includes computer-assisted instruction and computer-managed instruction (3).

Computer-based training: An interactive instructional experience between a computer and a learner in which the computer provides the majority of the stimulus and the learner responds; progress toward increased knowledge or skill results (3).

Computer-managed instruction: The use of the computer to support the management of instruction. It includes testing, scheduling, allocating resources, collecting student data, and providing status reports. It may also include diagnosing student needs, prescribing learning activities, and evaluating student accomplishments (3).
Content area: In this study, content area refers to specific related subject matter addressed in a computer-based instruction lesson. The content area is directly related to the instructional objective which the computer-based instruction lesson supports.

Course structure: Because the structure of Air Force technical training courses is somewhat different from the structure of most other technical training, a brief definition of that structure as referenced in this study is appropriate. The smallest discrete portion of an Air Force technical training course is an instructional segment, also called a lesson. The computer-based instruction lessons described in the study are instructional segments supporting a training objective. A training objective is comprised of one or more instructional segments (lessons), and a unit is made up of one or more objectives grouped together by virtue of their coverage of related subject matter. A block is a grouping of related units. Finally, a course is comprised of one or more blocks.

Distance learning: The use of telecommunications technology to join real time instructors with students at remote or separated locations.

Dunn-Bonferroni Adjustment for Experiment-Wide Error Rate: A statistical adjustment technique applied to take into consideration multiple comparisons the researcher makes using the same population and body of data during the course
of an experiment or study. The effect of the adjustment is to count multiple rejections of the null hypothesis as multiple rejections rather than as the single rejection calculated through the error rate experimentwise for standard multiple comparison tests. The adjustment is calculated by dividing the selected level of significance by the number of research questions addressed through the experiment or study. The adjustment enlarges the overall error rate, thus avoiding undue loss of power (4).

**Individual:** In the context of computer-based instruction, a student assigned to work alone to complete lessons presented by the computer.

**Instructional System Development (ISD):** The systematic approach used by the U. S. Air Force to develop curriculum and instruction for training. The process is represented by a five step model which includes:

1. Determining what the skilled performer does when doing the job, how well the job must be done, and under what conditions.
2. Determining if instruction is needed and, if so, what instruction the untrained person needs to complete to do the job effectively.
3. Expressing instructional outcomes as specific objectives and devising measurement devices to determine whether or not students have achieved those objectives.
Step 4. Designing instructional procedures and materials to help students achieve the objectives and having students try out the procedures and materials to be sure they are effective.

Step 5. Conducting and evaluating the instruction. Later, the ability of the graduates to do their jobs is also evaluated (5).

Learning gains: As referenced in this study, learning gains are defined as scores achieved on posttests for each computer-based lesson and the composite test scores. Because students have equivalent backgrounds and beginning knowledge and skill levels, comparisons of these scores should yield a relative measure of the gain in learning which resulted primarily from participation in teaching-learning activities during their attendance at the Technical Training Instructor course.

Occupational Survey Data: Data collected during the occupational survey. The occupational survey is the Air Force procedure for analyzing Air Force occupations. Occupational survey data typically includes a list of all tasks performed, the percentage of members performing each task, the relative learning difficulty of each task, and the training emphasis which should be placed on each task (5).

Paired: In the context of computer-based instruction, students assigned in groups of two to complete lessons presented by the computer.
**Statistical tests:** Since effect sizes can be calculated for several different purposes, it is beneficial to define effect sizes as used in this study. For this study, effect sizes were calculated as a means of making an inference about the practical significance of research results because tests of statistical significance have been deemed inappropriate for that purpose (2).

**Student-to-computer ratio:** The ratio representing the number of students assigned to a computer to complete computer-based instruction.

**Validated test:** A test which has been determined to successfully measure the objectives it was intended to measure. The validation process includes administering each version of the test a minimum of three times. If the developer is not confident measurement is valid, validation may be extended to encompass a larger sample. During validation of the test, measurement data is analyzed through an automated test analysis system and reviewed by faculty members after each test administration. The review includes checks for validity of the item, appropriateness of the stem and distractors, adherence to good test construction techniques, adequacy of course materials and presentation covering the information tested, and the test environment. Individual test items subsequently determined to be ineffective are replaced or revised as indicated by the review. Before the validation process is complete, the
average scores for all versions of the test must be within five points (1).

Summary

As education and training institutions face a future bounded by increasingly constrained resources, the search for more efficient and economical ways of providing instruction continues. Computer-based training is one option receiving increased attention. The education and training communities have effectively defined valid roles for computer-based training, but have been less effective in determining how to use such training most economically.

One factor affecting resource requirements for computer-based training is student-to-computer ratio. Most current cost-projection models presume a one-to-one ratio. However, research on traditional instruction suggests students learn better when participating in teaching-learning activities in pairs or small groups. Consequently, a study comparing the effectiveness of learning for individuals and pairs of students in the computer-based training environment could provide the foundation for revising or refining cost-projection models and resource decision models to help make optimum use of resources available for implementing computer-based training. Ten hypotheses comparing learning gains for individuals completing computer-based instruction with those completing
the same instruction in pairs were proposed for such a study.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF RELATED LITERATURE

In the realm of educational advances, no issue appears to have received greater attention during the past decade than the introduction of computers into the teaching-learning environment. Few educators are ambivalent toward computers; either computers are perceived to be of virtually incalculable value or as the bane of the classroom teacher's existence. Whatever the philosophical perspective on the issue of computers, however, educators are faced with incontrovertible evidence that the era of increasingly austere fiscal resources has arrived. Consequently, administrators, classroom instructors, and other staff members must search for ways to manage and deliver instruction in the most effective and efficient manner.

Computer-based training has been lauded as one of the most promising components of a potential solution to the dilemma of continuing to provide quality training with fewer resources. However, the use of computer-based training is severely limited in the current educational environment. There have historically been three major technical obstacles to the widespread adoption of computer-based training: the initial capital investment required for hardware and
software, the availability of expertise in design and systems to make full use of existing technology, and the high cost of implementing interactive instructional sequences on the computer using available programming tools.

With the advent of more economical hardware and software, the first hurdle has diminished significantly. The second obstacle, lack of expertise, is lessening due to the proliferation of military, industrial, and academic programs which are producing instructional developers with the requisite expertise in computer-based training hardware, software, and design. Increasingly sophisticated and powerful instructional systems design and development models and research programs have provided the foundation for development of a design science which will effectively use existing expertise. The final remaining barrier is rapidly and concurrently dissolving with the introduction of a number of tools for authoring computer-based training which are compatible with rising levels of expertise in the development arena (5).

Computer-Based Training in Education

Gloria Geary, one of the pioneers in computer-based training, agrees that the educational community has had the capability to produce practical interactive learning in varying degrees for about a decade (even longer if B. F. Skinner and his teaching machines are included in the
discussion of interactive learning). However, she cites as an additional limitation the fact that the body of knowledge specifically addressing computer-based training has been, in her words, "fragmented, inadequate, and generally inaccessible to those charged with meeting the increasingly diverse and complex training and learning needs in complex organizations." She further concurs that many of the obstacles to successfully incorporating computers into education and training management and instructional delivery have been successfully ameliorated or eliminated entirely with the phenomenal advances in all facets of computer technology, including hardware, authoring systems, design tools, productivity software, and media with integration capabilities (4).

Even though many of the obstacles which existed in the past are no longer realities, computer-based training is far from commonplace in the nation's academic and technical training environments. Full recognition of the benefits of computer-based training has not yet dawned on enough influential members of the educational community to insure longevity for what holds promise as an educational tool capable of providing quality instruction and training while reducing the overall average cost per student. One such obstacle and a probable long-term solution are clearly articulated by David Godfrey and Sharon Sterling in their discussion of computers and learning theory. Godfrey and
Sterling hypothesize that, generally, educators, particularly classroom teachers, are overworked and have precious little time for evaluating themselves or the instruction they present. The lack of time for analysis and creativity engenders conflict between "educational tribes" (e.g., Skinnerists or Piagetists). Such conflict stems from the fact that there is rarely sufficient justification for a particular theoretical position on education and learning theory in light of the dearth of verifiable and viable supporting data. Computer-based training promises to provide teachers a mechanism for gathering their own data about the teaching environment through management capabilities inherent in computer-based training (6). The resultant expansion of knowledge concerning the efficacy of different instructional methodologies should generate positive changes in attitude toward computer-based training. More positive attitudes would subsequently facilitate expansion of appropriate applications of computer-based training within the teaching-learning environment, thus paving the way for implementation of the advances in extant educational technology.

With such anticipated attitudinal changes come greater opportunities for capitalizing on benefits of computer-based training and for focusing on providing quality training in an increasingly resource-constrained environment. As A. F. O'Neal points out, however, any discussion of the cost-
effectiveness of computer-based training without a concomitant demonstration that computer-based training is an effective training approach is, at best, academic. Although no other existing training approach offers the potential of computer-based training for individualization on pace, content, sequence, and difficulty. It can also effectively provide trials with feedback, item or response-specific helps, simulations of complex processes or systems, and management and control. Nonetheless, this potential is doomed to remain unrealized unless effective instruction is developed for computer-based training applications (8).

**General Research in Computer-Based Training**

The growing body of research on computer-based instruction supports a high degree of optimism. Several cost-benefit analyses conducted within the past five years reflect significant benefit both in terms of enhanced learning and in decreased resource requirements resulting from implementation of computer-based training. A particularly comprehensive cost-benefit analysis was conducted by Pacific Bell of San Ramon, California in 1985 and 1986. The study concluded that several organizational benefits were derived from computer-based training.

(1) Training time was reduced by 20 to 40 percent, a direct cost savings of 15 to 25 percent.
(2) Travel costs were reduced through savings of both travel time and expenses and unproductive time.

(3) Timeliness and availability were enhanced, with training available upon demand.

(4) The need for word processing, printing, material storage, and distribution of material was reduced, producing a savings of 50 to 75 percent.

(5) Revisions were more timely and material dissemination costs were reduced.

(6) Real-time information was readily available for individual and group performance and the automatic record-keeping and data collection functions of computer-based training saved time in collecting and storing student records.

(7) Increased testing capabilities reduced the probability of end-users continuing training beyond the point of required competence while reducing the need for tutor time and waiting time for the students.

(8) A reduction in training delivery staff was possible because training could be administered on the job by a supervisor.

In addition to organizational benefits, the following individual benefits were noted:

(1) Training effectiveness was enhanced. Computer-based training developed highly motivated, self-reliant students, ultimately increasing confidence and reducing the
time required to master topics and virtually eliminating over- and under-training.

(2) Inconsistent delivery by different instructors was eliminated.

(3) Instruction was individualized, providing the right level of difficulty with appropriate student progress checks. Boredom was reduced through the student's ability to control instructional step size, games, interaction, and simulations and to improve retention with drill, practice, and frequent testing.

Besides improving the overall effectiveness of the training program, costs were significantly reduced. Three different comparisons were made during the study: conventional classroom instruction, on-site instruction delivered by an instructor, and instructor-independent computer-based training. Extrapolating from daily training costs and projecting over a one year period, computer-based training resulted in an 83 percent cost reduction over classroom instruction and a 75 percent cost reduction when compared with on-site training delivered by an instructor. Costs included in the comparison included course tuition (a constant), transportation, lodging for either students or instructors, meals, instructor salary, equipment rental, meeting rooms or classrooms, trainee material, and trainee salaries (3).
Other research studies have documented the positive impact of computer-based training on education, showing significant achievement gains for computer-based training over traditional instruction. The average gain for students using computer-based training over students trained using traditional instruction was fifteen points on a one hundred-point test. Findings are consistent at all levels of education (college, secondary schools, and elementary schools) and for both cognitive skills and hands-on training in the psychomotor domain. Similar positive impacts parallel to those found in the Pacific Bell study have also been documented in the areas of managerial effectiveness and economics through studies conducted at International Business Machines, Digital Equipment, Bank of America, Jaguar, GTE, and branches of the United States military services (9).

A. F. O'Neal concisely encapsulated the essence of the findings in the extensive body of literature encompassing the issue of the effectiveness of computer-based training when he wrote:

Absence of evidence (of the effectiveness of computer-based training) is not evidence of absence. Ineffective CBT is, in most cases, merely ineffective instruction which has been put on a computer (8).

However, even when computer-based training is effectively designed and integrated into the teaching-learning process, there are additional requirements if the
instruction is to be of maximum benefit to both the students and the institution. A 1990 study conducted by Randall E. Schumacker of the University of North Texas and Punnipa G. Hossain of Indian Hills Community College examined the potential of computer learning centers in fulfilling a basic instructional role in the university setting. The purpose of the study was to determine how computer learning centers were perceived and whether such centers could feasibly fulfill the potential role of centralizing computer instructional materials and human resources effectively and efficiently. Accordingly, the researchers examined the role of computer learning centers in providing instructional support, faculty perceptions toward computer learning centers, faculty use of computer learning centers, and faculty recommendations for improving functionality of computer learning centers.

Using a structured interview approach with a questionnaire, the researchers interviewed 19 of 24 faculty and staff members who used the computer learning centers at a midwestern university for various instructional purposes. Based on results of the interviews, the researchers concluded that:

(1) educators were experiencing learning curves in areas of computer literacy and effective use of computer technology in the instructional process;
(2) generally, educators had positive attitudes about using computers in support of instruction, expressing the belief that computers enhanced student enjoyment, motivation, and enthusiasm; and

(3) faculty members' use of and perception about the use of computer learning centers are critical to ensuring optimum use of computer-based instructional technology (12).

Although it appears that computer-based training promises to enable educators to provide higher quality training at a significant cost savings, a general caution appears in almost every responsible publication concerning computer-based training: computer-based training is not a panacea for all educational ills. Computer-based training cannot be expected to replace instructor-to-student and student-to-student human interactions, nor can it replace actual hands-on use of many types of equipment. It is simply one additional tool to add to the inventory already in place. Keeping this caution firmly in mind, education and training designers and developers are free to explore appropriate applications of computer-based training. Basic computer-based training strategies are effectively limited to:

(1) presentation of information;

(2) drill and practice (applying what has been learned to allow the learner to actively use concepts, skills, and procedures that have been taught and to practice
transferring and generalizing concepts and strategies to problems dissimilar from demonstrated examples);

(3) tutorials (frames of text and graphics interspersed with embedded questions with immediate feedback messages and schemes);

(4) simulations or games (practicing whole procedures and tasks or solving problems in life-like or job-like sequence);

(5) inquiry (interaction or dialogue with the instructional system is controlled by the student to obtain what he or she wants or needs to learn); and, to a limited degree,

(6) intelligent computer-based training (two-way student-computer dialogue approximates human tutoring) (13).

To most effectively use these computer-based instructional strategies, a clear understanding of the instructional and management functions provided by computer-based instruction is essential. A technical report produced by the Defense Technical Information Center defines over fifty such functions and compiles functions interspersed throughout the body of literature reviewed (10).

Research in Student-to-Computer Ratio in Computer-Based Training

Current design models for computer-based training assume a one-to-one student-to-computer ratio for courses focusing on cognitive skills for adult learners. However,
based on a review of peer tutoring in traditional instruction and a limited body of knowledge revealed through research in the area of computer-based training, it appears that learning might be equally effective using a higher student-to-computer ratio.

Four studies specifically addressed aspects of comparative effectiveness of computer-based training using student-to-computer ratios as an assessment factor. Although the number of available research studies was limited, results of all four studies were consistent and parallel.

The first study was conducted by Carol A. Carrier and Gregory C. Sales using thirty-six students in their junior year at the University of Minnesota. These students were in a teacher training program and were administered computer-based training dealing with the five levels of intellectual skills. Twelve pairs of students were compared with twelve individuals. The study ultimately concluded that there was no significant difference in post-test or retention test scores for students taking the computer-based training lesson in pairs when compared to students taking the lessons individually (1).

The second study focused on two sections of a college level introductory class in special education and encompassed 64 students. Two groups were formed; each group received both individual and paired computer-based
instruction. Again, no statistically significant difference was found between group and individual computer-based instruction conditions (7).

A third study was conducted by the Research Institute for the Behavioral and Social Sciences for the United States Army in 1988. In that study, two experiments were conducted to examine the effects of student-to-computer ratios. The first experiment grouped twenty-four soldiers into three different groups: eight were assigned to two groups of four per computer terminal, eight were assigned to four groups of two per computer terminal, and eight were assigned as individuals (one to a computer terminal). No significant differences were found in learning as indicated by posttests or in retention tested after two weeks. To try to determine whether similar results would be obtained using groups of lower ability soldiers, a follow-on study was conducted using thirty-six lower ability soldiers grouped as follows: twelve were assigned to three groups of four per computer terminal, ten were assigned to five groups of two per computer terminal, and twelve were assigned one-on-one to a computer terminal. Again, based on an immediate posttest, a delayed posttest delivered after two weeks, and a second delayed posttest delivered after six weeks, no significant difference in either immediate learning or retention was found (11).
The final study was conducted at Sheppard Air Force Base in January, 1988, in a course designed to teach computer software applications. Thirty-two students were assigned to work as individuals to complete exercises and activities presented through computer-based instruction. Fifty-four students were paired in groups of two to complete the same exercises and activities. No significant difference was found in student performance scores between the two groups of students (2).

Summary

A review of the literature dealing with use of computer-based training in education reveals that computer-based training holds considerable promise for presenting effective instruction at reduced costs. It is not, however, a cure for all educational ills, nor is it an appropriate media for all types of instruction. A limited number of studies assessing the comparative effectiveness of student-to-computer ratios for computer-based training have not revealed any significant difference in learning for students assigned to computers in ratios ranging from one-to-one to three-to-one.
CHAPTER BIBLIOGRAPHY


CHAPTER III

METHODS AND PROCEDURES

This chapter describes the procedures used in collecting and treating data for this study. The study focused on determining relative learning for students assigned to use computers as individuals compared to those assigned in pairs during computer-assisted instruction covering nine separate lessons designed to teach cognitive skills.

Design of the Study

The design of the study was posttest-only control-group. The first requirement of the design was that subjects be randomly assigned to experimental and control groups. The population for the study was all students attending the Technical Training Instructor Course during the period of the study. Students were assigned to classes based on the dates they reported for duty. The second requirement of the posttest-only control-group design, that a treatment is administered to the experimental group but not to the control group, was also met. The control group proceeded through the course under the original design with students assigned as individuals to complete computer-based instruction. The treatment was assignment as pairs to
complete the same instruction. The course consists of 216 academic hours (approximately six weeks, because academic days are eight hours long). The final requirement for the design was that the posttest be administered to both groups. Posttests were given for each of the nine computer-based lessons. All students were individually tested. Composite test grades for each student were also obtained. Because of the controlled nature of enrollment and assignment, there was no attrition of subjects during the course of the study. Since no appropriate pretest was available, a relatively large number of participants was selected to minimize any possible initial differences between the experimental and control groups.

Selection of Population

The subjects consisted of all students who attended the Technical Training Instructor Course, J3AIR75000 005, at Sheppard Air Force Base, Texas for the period covered by the study. The Technical Training Instructor Course is taught at six training centers within the Air Training Command (Chanute Air Force Base, Goodfellow Air Force Base, Keesler Air Force Base, Lackland Air Force Base, Lowry Air Force Base, and Sheppard Air Force Base). Location of training for prospective instructors is determined by the Military Personnel Center and depends primarily upon the location at which training for the Air Force specialty in which they
will instruct is conducted. Consequently, students attending the Technical Training Instructor Course at Sheppard during the time of the study were, with minor exceptions, projected to instruct in the areas of medical services, communications, missiles, accounting and finance, aircraft maintenance, and civil engineering.

Class start dates and class sizes are managed through the Air Force Training Management System, an automated system which includes projected class schedules and class sizes. Based on information from that system, six consecutive classes (63 students) were selected in which students were to serve as the control group (assigned as individuals to complete computer-assisted instruction). The next five consecutive classes (58 students) were selected to receive the treatment (assigned as pairs to complete computer-assisted instruction). Since six to ten classes are in session at any given time, consecutive classes were selected for both groups to help preclude the likelihood that any changes demonstrated by the treatment group were influenced by knowledge of their participation in an experiment (a Hawthorne effect). Neither students in the control group nor those in the treatment group were aware that the instructional design for their particular classes differed from that of other classes.
Tests and Testing Procedures

Both the posttests for the computer based lessons and written block tests for the course were contractor-developed and were validated according to procedures outlined in the Instructional Systems Development (ISD) process used by the Air Force. Under the ISD concept as it is applied in Air Training Command, test validation is a process designed to determine if a test successfully measures the training objectives it was intended to measure. The validation process usually includes administering a particular version of a test to at least three classes (approximately 36 students), analyzing the test results after each administration and as a composite of all administrations, and revising or deleting ineffective measurement items. A minimum of two test versions are constructed for each testing point. A validated test must meet two criteria:

(1) the average score for each alternate test must be within five percentage points and

(2) the test must not contain individual test items which are consistently missed by 50% or more of the students during the validation period unless the questions have been designated as critical (e.g., a critical safety item).

For the Technical Training Instructor Course, content validity was established through extensive coordination between the staff of the contractor developing the tests and
subject matter experts who drew on over ten years experience offering the Technical Training Instructor Course. Content validity was further strengthened by using updated occupational survey data.

Reliability was initially established for the written tests by administering two forms of each test to approximately 72 students (each form was administered to approximately 36 students) and ensuring the average scores were within five percentage points by either deleting or revising test items determined to be inadequate through analysis of test results. Reliability for the computer administered posttests was similarly established, except that no alternate versions were used; scores were tracked for the same number of cases and adjustments were made as indicated by the test item analysis.

Test results were then tracked for approximately 15 additional administrations over a six-month period. Analyses conducted quarterly continued to confirm validity and reliability.

Subsequent to these validation efforts, results of the final analysis were submitted to the Training and Systems Integration Division, Headquarters, Air Training Command, Randolph Air Force Base, Texas, for approval to implement the tests in the Technical Training Instructor Course at all six technical training centers. Approval was granted. Approval was then obtained from the Commander, 3700th
Technical Training Wing, Sheppard Air Force Base, Texas, to conduct a study comparing learning of students assigned as individuals and students assigned in pairs to complete computer-assisted instruction in the Technical Training Instructor Course. A copy of the letter of approval is included as Appendix A.

After receiving approval, instructors were contacted by the chief of the Curriculum and Training Division, Faculty Development Division. Instructors were directed to structure scheduled classes into paired or individual assignment to computers during computer assisted instruction lessons. They were provided instructions concerning minor modifications to record-keeping procedures.

Subsequently, normal teaching-learning activities were pursued throughout the term of the study, with the only variation being that students in the treatment group were assigned as pairs to complete computer-assisted instruction while those in the control group were assigned as individuals to complete the same instruction. Students in each of the groups completed nine lessons through computer-assisted instruction and were administered the posttest for each lesson. In addition, all students completed the three written block tests at the assigned testing points in the course. All tests, both the posttests and the written block tests, were administered individually to students in both groups.
Data Analysis

Since the design of the study was posttest-only control-group, the data yielded was analyzed by doing a simple $t$ test comparison of the mean posttest scores for the treatment and control groups. Scores for each posttest, for each block test grade, and the composite test grades for control and treatment groups were compared. After data were sorted using a spreadsheet (Multiplan), a statistical analysis software package, StatPac Gold, was used to produce the analysis. Although the $t$ test is a robust test even under substantial violations of the underlying assumptions, the StatPac Gold statistical analysis package routinely produces the Mann-Whitney U along with the $t$ test. The non-parametric test was included so that results of that test could have been reported should the data depart substantially from $t$ test assumptions. However, no substantial departure was noted.

A significance level of .05 was established. However, since ten separate research questions were being addressed through the same body of data, the Dunn-Bonferroni Adjustment for Experiment-Wide Error Adjustment was applied. The Dunn-Bonferroni Adjustment for Experiment-Wide Error Adjustment is a statistical adjustment technique applied to take into consideration multiple comparisons the researcher makes using the same population and body of data during the course of an experiment or study. The effect of the
adjustment is to count multiple rejections of the null hypothesis as multiple rejections rather than as the single rejection calculated through the error rate experimentwise for standard multiple comparison tests. The adjustment is calculated by dividing the selected level of significance by the number of research questions addressed through the experiment or study. In this study, the selected significance level of .05 was divided by 10, yielding an adjustment of .01. The adjustment enlarges the overall error rate, thus avoiding undue loss of power (1).

Finally, an effect size was calculated to determine whether any differences found have practical application. Confidence limits were also established to indicate whether observed differences indicated a true difference between the populations represented by the samples.

Summary

The posttest-only control-group design was selected for the study and a significance level of .05 was determined. The study included 121 students from 11 Technical Training Instructor Course classes. Sixty-three were assigned as individuals to complete nine lessons through computer-assisted instruction. Fifty-eight were assigned in pairs to complete the same instruction. Posttests were then individually administered to each student. Three written block tests were also administered individually to each student. Results from all tests were compared between the
two groups using the $t$ test. In addition to the $t$ test, effect size and confidence levels were computed. Finally, the Dunn-Bonferroni Experiment-Wide Error Adjustment was applied to each research question.
CHAPTER BIBLIOGRAPHY

CHAPTER IV

ANALYSIS OF DATA

The purpose of this study was to determine the comparative effectiveness of learning for two groups of students, those who were assigned to work at computers as individuals and those assigned to work in pairs to complete computer-based lessons in cognitive areas. One hundred twenty-one students in the Technical Training Instructor Course at Sheppard Air Force Base, Texas were divided into two groups, a control group which included 63 of the students and a treatment group which included 58 of the students. Students in the control group were assigned as individuals to complete computer-based lessons. Students in the treatment group were assigned in pairs to complete the same instruction. Ten comparisons were included in the study. Nine were comparisons of scores of both groups on the posttest administered after completion of each lesson. The final comparison was a comparison of composite test grades, which were based on three written tests.

This chapter presents the analysis of the data. In addition to presentation of the results of data analysis, a description of how data were manipulated and an outline of the statistical procedures used are included.
Statistical Procedure

The raw data collected during the study were entered into a spreadsheet (Multiplan) to allow for ease of structuring and examination. A summary of this data is contained in Appendix B. Data collected included scores for each student on the nine computer-based lessons and a composite test score.

A significance level of .05 was established for this study. To account for multiple rejections of the null hypothesis as multiple rejections rather than as a single rejection, the Dunn-Bonferroni Adjustment for Experiment-Wide Error Adjustment was applied because all ten research questions were being examined from the same body of data. Application of that adjustment yielded a revised significance level of .01 for each of the ten research questions (.05/10 = .01).

After data were entered into the spreadsheet and sorted, analysis was accomplished using the StatPac Gold Statistical Analysis Software Package. Ten separate t tests for independent groups were conducted. In the first nine tests, the dependent variables were the posttest scores for the computer-based lessons. In the final test, the dependent variable was the composite test grade. In each case, the independent variable was group assignment (individual or paired).
The StatPac Gold analysis produced \( t \) test statistics which included the difference between means of the control and treatment groups, the standard error of the difference, a \( t \) statistic, degrees of freedom, and probabilities of \( t \) for both one-tailed and two-tailed tests. Only results for the two-tailed test is included in the tables summarizing analysis results. In addition, the Mann-Whitney U was automatically calculated and included two-tailed probability.

Formulas to calculate effect size and confidence intervals were entered into the Multiplan spreadsheet and both effect size and confidence intervals were calculated. Because the Dunn-Bonferroni adjustment was applied, confidence intervals were calculated for both the .05 and the .01 levels of significance.

Comparison of Paired Versus Individual Learning: Findings

The first hypothesis for which data were analyzed was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Using Computers in Instruction" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. For purposes of reporting data, this hypothesis is also called Hypothesis 1. Results of the analysis for Hypothesis 1 are summarized in Table 1.
TABLE 1
COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR
THE CONTENT AREA "USING COMPUTERS IN INSTRUCTION"

<table>
<thead>
<tr>
<th>T Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>-3.7794</td>
</tr>
<tr>
<td>(Control Group Mean - Treatment Group Mean)</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.8753</td>
</tr>
<tr>
<td>t Statistic</td>
<td>2.0153</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.0434</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mann-Whitney U Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
</tr>
</tbody>
</table>

Confidence Intervals at .05 Level of Significance

| Control Group Upper Limits | 92.56     |
| Control Group Lower Limits | 87.12     |
| Treatment Group Upper Limits | 96.16    |
| Treatment Group Lower Limits | 91.08    |

Confidence Intervals at the .01 Level of Significance

| Control Group Upper Limits | 93.41     |
| Control Group Lower Limits | 86.27     |
| Treatment Group Upper Limits | 96.95    |
| Treatment Group Lower Limits | 90.29    |

Effect Size          0.3532
The $t$ test revealed that there was a difference between the control and treatment groups which was statistically significant at the .05 level, where scores for the treatment group were significantly better, but not at the .01 level. Consequently, although the null hypothesis would have been rejected at the .05 level of significance, the null hypothesis was retained based on application of the Dunn-Bonferroni adjustment.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 91.08 and the upper limit of the control group was 92.56. These figures indicate the true mean of the control group is likely to be as high as 92.56 and the true mean of the treatment group is likely to be as low as 91.08, resulting in an overlap of 1.48. To parallel the level of significance resulting from application of the Dunn-Bonferroni adjustment, confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 93.41 and the true mean of the treatment group is likely to be as low as 90.29, an overlap of 3.12. Consequently, the possibility that the two population means are the same could not be disregarded.

The findings of the study were also converted to an effect size to try to determine the practical significance of the results of the research conducted during this study.
The effect size of .3532 was interpreted to mean that the average student in the experimental group scored at about the 64th percentile of the control group distribution. However, since the total difference between the means of the groups was less than four percentage points, it is doubtful that the statistical difference has practical significance for the practice of education and training.

The second hypothesis for which data were analyzed was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Student as an Individual" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 2. Results of the analysis for Hypothesis 2 are summarized in Table 2.

The t test revealed that there was a difference between the control and treatment groups which was statistically significant at the .05 level, but not at .01. Test scores for the treatment group were significantly better than those for the control group at only the .05 level. Consequently, based on application of the Dunn-Bonferroni adjustment, the null hypothesis for Hypothesis 2 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of
### TABLE 2

**COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR THE CONTENT AREA "THE STUDENT AS AN INDIVIDUAL"**

<table>
<thead>
<tr>
<th><strong>T Test Statistics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>-3.5829</td>
</tr>
<tr>
<td>(Control Group Mean - Treatment Group Mean)</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.7117</td>
</tr>
<tr>
<td>t Statistic</td>
<td>2.0932</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.0361</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mann-Whitney U Statistics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>2141.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.103</td>
</tr>
</tbody>
</table>

**Confidence Intervals at .05 Level of Significance**

- Control Group Upper Limits: 94.48
- Control Group Lower Limits: 89.05
- Treatment Group Upper Limits: 97.35
- Treatment Group Lower Limits: 93.34

**Confidence Intervals at the .01 Level of Significance**

- Control Group Upper Limits: 95.33
- Control Group Lower Limits: 88.19
- Treatment Group Upper Limits: 97.97
- Treatment Group Lower Limits: 92.72
- Effect Size: 0.3352
the treatment group was 93.34 and the upper limit of the control group was 94.48, an overlap of 1.14. To parallel the level of significance resulting from application of the Dunn-Bonferroni adjustment, confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 95.33 and the true mean of the treatment group is likely to be as low as 92.72, an overlap of 2.61. Consequently, the possibility that the two population means are the same could not be disregarded.

The research findings were also converted to an effect size to try to determine the practical significance of the results of the research conducted during this study. The effect size of .3352 was interpreted to mean that the average student in the experimental group scored at about the 63rd percentile of the control group distribution. However, since the total difference between the mean of the control group and the mean of the experimental group was less than four percentage points, it is doubtful that the statistical difference has significance for the practice of education and training.

The third hypothesis for which data were analyzed was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the
content area "Dynamics of Small Learning Groups" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. For purposes of reporting data, this hypothesis is also called Hypothesis 3. Results of the analysis for Hypothesis 3 are summarized in Table 3.

The $t$ test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 or the .05 level. Consequently, the null hypothesis for Hypothesis 3 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 94.75 and the upper limit of the control group was 96.47, an overlap of 1.72. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 97.09 and the true mean of the treatment group is likely to be as low as 94.27, an overlap of 2.82. Consequently, it seems possible that the two population means are the same.

The findings for this hypothesis were also converted to an effect size to try to determine practical significance of the results of the research conducted during this study. The effect size of .2201 was interpreted to mean that the average student in the experimental group scored at about the 59th percentile of the control group distribution.
**TABLE 3**

COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR THE CONTENT AREA "DYNAMICS OF SMALL LEARNING GROUPS"

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T Test Statistics</strong></td>
<td></td>
</tr>
<tr>
<td>Difference (Control Group Mean - Treatment Group Mean)</td>
<td>-1.8010</td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.3122</td>
</tr>
<tr>
<td>t Statistic</td>
<td>1.3725</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.1690</td>
</tr>
</tbody>
</table>

| **Mann-Whitney U Statistics**                                              |             |
| Mann-Whitney U                                                            | 2002.5000   |
| Two-tailed Probability                                                     | 0.363       |

**Confidence Intervals at .05 Level of Significance**

- Control Group Upper Limits: 96.47
- Control Group Lower Limits: 92.52
- Treatment Group Upper Limits: 97.83
- Treatment Group Lower Limits: 94.75

**Confidence Intervals at the .01 Level of Significance**

- Control Group Upper Limits: 97.09
- Control Group Lower Limits: 91.90
- Treatment Group Upper Limits: 98.31
- Treatment Group Lower Limits: 94.27
- Effect Size: 0.2201
However, since the total difference between the mean of the control group and the mean of the experimental group was less than two percentage points, the statistical difference appears to have little or no significance.

The fourth hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Effective Feedback Techniques" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 4. Results of the analysis are summarized in Table 4.

The $t$ test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 level or the .05 level. Therefore, the null hypothesis for Hypothesis 4 was retained.

When confidence intervals were calculated for the .05 significance level, the lower limit of the treatment group was 88.27 and the upper limit of the control group was 92.88, an overlap of 4.61. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 93.50 and the true mean of the treatment group is likely to be as low as 87.54, an overlap of 5.96. Consequently, it seems possible that the two population means are the same.
### Table 4

**Comparison of Control and Treatment Group Scores for the Content Area "Effective Feedback Techniques"**

**t Test Statistics**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Difference (Control Group Mean - Treatment Group Mean)</td>
<td>0.3013</td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.5772</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.1910</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.8431</td>
</tr>
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</table>

**Mann-Whitney U Statistics**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>1790.5000</td>
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<tr>
<td>Two-tailed Probability</td>
<td>0.848</td>
</tr>
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</table>

**Confidence Intervals at .05 Level of Significance**

<table>
<thead>
<tr>
<th>Group</th>
<th>Upper Limits</th>
<th>Lower Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>92.88</td>
<td>88.93</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>92.93</td>
<td>88.27</td>
</tr>
</tbody>
</table>

**Confidence Intervals at the .01 Level of Significance**

<table>
<thead>
<tr>
<th>Group</th>
<th>Upper Limits</th>
<th>Lower Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>93.50</td>
<td>88.31</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>93.67</td>
<td>87.54</td>
</tr>
</tbody>
</table>

**Effect Size**

-0.036
The findings were also converted to an effect size to try to determine the practical significance of the results of the research conducted during this study. The effect size of -.036 was interpreted to mean that the average student in the experimental group scored at about the 49th percentile of the control group distribution. However, since the total difference between the mean of the control group and the mean of the experimental group was three tenths of one percentage point, the statistical difference appears to have no significance for the practice of education and training.

The fifth hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Instructional System Development (ISD) Process" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 5. Results of the analysis for Hypothesis 5 are summarized in Table 5.

The t test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 level or the .05 level. Accordingly, the null hypothesis for Hypothesis 5 was retained.
## TABLE 5

**COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR THE CONTENT AREA "THE INSTRUCTIONAL SYSTEM DEVELOPMENT PROCESS"**

<table>
<thead>
<tr>
<th>T Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>0.9469</td>
</tr>
<tr>
<td>(Control Group Mean - Treatment Group Mean)</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.5718</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.6024</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.5552</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mann-Whitney U Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>1648.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.353</td>
</tr>
</tbody>
</table>

Confidence Intervals at .05 Level of Significance

<table>
<thead>
<tr>
<th>Control Group Upper Limits</th>
<th>95.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Lower Limits</td>
<td>90.79</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>94.16</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>89.98</td>
</tr>
</tbody>
</table>

Confidence Intervals at the .01 Level of Significance

<table>
<thead>
<tr>
<th>Control Group Upper Limits</th>
<th>95.94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Lower Limits</td>
<td>90.10</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>94.81</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>89.33</td>
</tr>
<tr>
<td>Effect Size</td>
<td>-0.104</td>
</tr>
</tbody>
</table>
When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 89.98 and the upper limit of the control group was 95.24, an overlap of 5.26. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 95.94 and the true mean of the treatment group is likely to be as low as 89.33, an overlap of 6.64. Consequently, it seems likely that the two population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research conducted during this study. The effect size of -.104 was interpreted to mean that the average student in the experimental group scored at about the 46th percentile of the control group distribution. However, since the total difference between the mean of the control group and the mean of the experimental group was less than one percentage point, the statistical difference appears to have no significance for the practice of education and training.

The sixth hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Developing Criterion
Objectives" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 6. Results of the analysis for Hypothesis 6 are summarized in Table 6.

The t test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 or the .05 level. Consequently, the null hypothesis for Hypothesis 6 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 92.26 and the upper limit of the control group was 95.94, an overlap of 3.68. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 96.56 and the true mean of the treatment group is likely to be as low as 91.57, an overlap of 4.99. Consequently, it is possible the two population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research conducted during this study. The effect size of .0665 was interpreted to mean that the average student in the experimental group scored at about the 53rd percentile of the control group distribution. However, since the total difference between the mean of the control
TABLE 6
COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR
THE CONTENT AREA "DEVELOPING CRITERION OBJECTIVES"

<table>
<thead>
<tr>
<th>T Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>-0.5145</td>
</tr>
<tr>
<td></td>
<td>(Control Group Mean - Treatment Group Mean)</td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.4867</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.3461</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.7299</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mann-Whitney U Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>1966.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.471</td>
</tr>
</tbody>
</table>

Confidence Intervals at .05 Level of Significance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
<td>95.94</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
<td>91.99</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>96.70</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>92.26</td>
</tr>
</tbody>
</table>

Confidence Intervals at the .01 Level of Significance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
<td>96.56</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
<td>91.37</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>97.40</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>91.57</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.0665</td>
</tr>
</tbody>
</table>
group and the mean of the experimental group was less than one percentage point, the statistical difference appears to have no significance for the practice of education and training.

The seventh hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Characteristics of Evaluation" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 7. Results of the analysis for Hypothesis 7 are summarized in Table 7.

The \( t \) test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 level or the .05 level. Consequently, the null hypothesis for Hypothesis 7 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 83.54 and the upper limit of the control group was 89.93, an overlap of 6.39. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 91.02 and the true mean of the treatment group is likely to be as low as 82.32, an overlap
### TABLE 7

**COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR THE CONTENT AREA "CHARACTERISTICS OF EVALUATION"**

<table>
<thead>
<tr>
<th><strong>T Test Statistics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>-0.9376</td>
</tr>
<tr>
<td>(Control Group Mean - Treatment Group Mean)</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>2.6599</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.3525</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.7255</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mann-Whitney U Statistics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>1920.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.629</td>
</tr>
</tbody>
</table>

**Confidence Intervals at .05 Level of Significance**

- **Control Group Upper Limits**: 89.93
- **Control Group Lower Limits**: 83.02
- **Treatment Group Upper Limits**: 91.29
- **Treatment Group Lower Limits**: 83.54

**Confidence Intervals at the .01 Level of Significance**

- **Control Group Upper Limits**: 91.02
- **Control Group Lower Limits**: 81.93
- **Treatment Group Upper Limits**: 92.50
- **Treatment Group Lower Limits**: 82.32
- **Effect Size**: 0.066
of 8.70. Consequently, it is possible the two population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research for this hypothesis. The effect size of .066 was interpreted to mean that the average student in the experimental group scored at about the 52nd percentile of the control group distribution. However, since the total difference between the mean of the control group and the mean of the experimental group was less than one percentage point, the difference appears to have no significance for the practice of education and training.

The eighth hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Developing Written Test Items" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 8. Results of the analysis for Hypothesis 8 are summarized in Table 8.

The t test revealed that the difference between the control and treatment groups was statistically significant at both the .01 and the .05 levels. Consequently, the null hypothesis for Hypothesis 8 was rejected.
# TABLE 8

**COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR THE CONTENT AREA "DEVELOPING WRITTEN TEST ITEMS"**

<table>
<thead>
<tr>
<th>T Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference (Control Group Mean - Treatment Group Mean)</td>
<td>-4.7069</td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.7408</td>
</tr>
<tr>
<td>t Statistic</td>
<td>2.7039</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.0078</td>
</tr>
</tbody>
</table>

**Mann-Whitney U Statistics**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>2353.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.006</td>
</tr>
</tbody>
</table>

**Confidence Intervals at .05 Level of Significance**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
<td>91.49</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
<td>86.55</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>95.98</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>91.43</td>
</tr>
</tbody>
</table>

**Confidence Intervals at the .01 Level of Significance**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
<td>92.26</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
<td>85.77</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>96.70</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>90.72</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.4604</td>
</tr>
</tbody>
</table>
When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 91.43 and the upper limit of the control group was 91.49, an overlap of only .06. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 92.26 and the true mean of the treatment group is likely to be as low as 90.72, an overlap of 1.54. Based on the information provided by calculating confidence intervals, it appears possible the two population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research for this hypothesis. The effect size of .4604 was interpreted to mean that the average student in the experimental group scored at about the 68th percentile of the control group distribution. The total difference between the mean of the control group and the mean of the experimental group was almost five percentage points. Therefore, the difference may have practical significance for the practice of education and training.

The ninth hypothesis was that there will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Common Rating Errors"
in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 9. Results of the analysis for Hypothesis 9 are summarized in Table 9.

The \( t \) test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 or the .05 level. Consequently, the null hypothesis for Hypothesis 9 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 87.52 and the upper limit of the control group was 95.13, an overlap of 7.61. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 95.82 and the true mean of the treatment group is likely to be as low as 86.26, an overlap of 9.56. Based on the information provided by calculating confidence intervals, it appears probable the two population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research for this hypothesis. The calculated effect size of \(-.156\) was interpreted to mean that the average student in the experimental group scored at about the 44th percentile of the control group distribution. However, the
TABLE 9

COMPARISON OF CONTROL AND TREATMENT GROUP SCORES FOR
THE CONTENT AREA "COMMON RATING ERRORS"

<table>
<thead>
<tr>
<th>T Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td>-0.1987</td>
</tr>
<tr>
<td>(Control Group Mean - Treatment Group Mean)</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>1.8212</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.1091</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.9096</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mann-Whitney U Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>1948.0000</td>
</tr>
<tr>
<td>Two-tailed Probability</td>
<td>0.530</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confidence Intervals at .05 Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confidence Intervals at the .01 Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Upper Limits</td>
</tr>
<tr>
<td>Control Group Lower Limits</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
</tr>
<tr>
<td>Effect Size</td>
</tr>
</tbody>
</table>
total difference between the mean of the control group and the mean of the experimental group was only slightly more than one percentage point. Therefore, the statistical difference appears to have little or no significance for the practice of education and training.

The final hypothesis was that there will be no significant difference in composite test grades for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the Technical Training Instructor Course at Sheppard Air Force Base, Texas. This hypothesis is also called Hypothesis 10. Results of the analysis for Hypothesis 10 are summarized in Table 10.

The t test revealed that the difference between the control and treatment groups was not statistically significant at either the .01 level or the .05 level. Consequently, the null hypothesis for Hypothesis 10 was retained.

When confidence intervals were calculated for the .05 significance level, they revealed that the lower limit of the treatment group was 89.17 and the upper limit of the control group was 91.88, an overlap of 2.71. Confidence intervals were also calculated at the .01 level. At that level of significance, the true mean of the control group is likely to be as high as 92.27 and the true mean of the treatment group is likely to be as low as 88.75, an overlap
<table>
<thead>
<tr>
<th>Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference (Control Group Mean - Treatment Group Mean)</td>
<td>0.1680</td>
</tr>
<tr>
<td>Standard Error of the Difference</td>
<td>0.8803</td>
</tr>
<tr>
<td>t Statistic</td>
<td>0.1909</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>119</td>
</tr>
<tr>
<td>Probability of t (Two Tailed Test)</td>
<td>0.8432</td>
</tr>
</tbody>
</table>

**Mann-Whitney U Statistics**

<table>
<thead>
<tr>
<th>Mann-Whitney U</th>
<th>1847.5000</th>
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</thead>
<tbody>
<tr>
<td>Two-tailed Probability</td>
<td>0.915</td>
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</tbody>
</table>

**Confidence Intervals at .05 Level of Significance**

<table>
<thead>
<tr>
<th>Control Group Upper Limits</th>
<th>91.88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Lower Limits</td>
<td>89.41</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>91.80</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>89.17</td>
</tr>
</tbody>
</table>

**Confidence Intervals at the .01 Level of Significance**

<table>
<thead>
<tr>
<th>Control Group Upper Limits</th>
<th>92.27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group Lower Limits</td>
<td>89.02</td>
</tr>
<tr>
<td>Treatment Group Upper Limits</td>
<td>92.21</td>
</tr>
<tr>
<td>Treatment Group Lower Limits</td>
<td>88.75</td>
</tr>
<tr>
<td>Effect Size</td>
<td>-0.0353</td>
</tr>
</tbody>
</table>
of 3.52. Based on the information provided by calculating confidence intervals, it appears possible the population means are the same.

The findings were also converted to an effect size to try to determine the practical significance of the results of the research for this hypothesis. The calculated effect size of -.0353 was interpreted to mean that the average student in the experimental group scored at about the 48th percentile of the control group distribution. However, the total difference between the mean of the control group and the mean of the experimental group was negligible (.17 of one percentage point). Therefore, the statistical difference appears to have no significance for the practice of education and training.

Summary

Because analysis revealed no statistically significant difference at either the .05 or the .01 levels of significance between the control group and the treatment group for nine of the ten hypotheses, the null hypothesis was retained for those hypotheses: one, two, three, four, five, six, seven, nine, and ten. Analysis revealed that there was a statistically significant difference for one hypothesis (Hypothesis 8). Accordingly, the null hypothesis was rejected for Hypothesis 8. In the case in which the null hypothesis was rejected, the treatment group performed
better than the control group. For the nine hypotheses for which no statistically significant difference was found, the treatment group performed somewhat better than the control group in seven of the nine areas.

Confidence intervals were calculated at both the .05 and the .01 levels of significance. In each case, there was some overlap of scores. Consequently, it could not be concluded that differences were true differences.

Based on calculated effect sizes, only one of the hypotheses appeared to have probable practical statistical significance for application in the fields of education and training (Hypothesis 8). The magnitude of the statistical differences for the other nine hypotheses promised no significant practical application.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study was conducted to examine the effect of increasing student-to-computer ratio on learning gains when instruction on cognitive skills is presented through computer-based instruction. Specifically, one-to-one and two-to-one ratios were studied in ten different research questions. This chapter presents a summary of the methods and procedures used during data collection and analysis, the findings, limitations, conclusions, and recommendations stemming from the study.

Summary

The study included a total of one hundred twenty-one subjects. The subjects were all students attending the Technical Training Instructor Course at Sheppard Air Force Base, Texas during the period of the study. Sixty-three of the students in six consecutive classes were assigned to a control group where students completed nine computer-based lessons as individuals. Fifty-eight of the students in five consecutive classes were assigned to a treatment group where students completed the same computer-based instruction while working in pairs.
The computer-based instruction included in the Technical Training Instructor Course covered cognitive material which was an integral part of the overall course. Following completion of each lesson, a posttest was administered to each student individually and scores were recorded. In addition, a composite test grade was determined based on scores from three written tests administered to each student during the course.

A null hypothesis was developed and tested for each of the research questions. Data collected were analyzed using \( t \) test comparisons. In addition to the \( t \) statistics, confidence intervals and effect sizes were calculated for each research question. Hypotheses tested were as follows:

1. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Using Computers in Instruction" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

2. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Student as an Individual" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.
3. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Dynamics of Small Learning Groups" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

4. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Effective Feedback Techniques" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

5. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "The Instructional System Development (ISD) Process" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

6. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Developing Criterion Objectives" in the
Technical Training Instructor Course at Sheppard Air Force Base, Texas.

7. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Characteristics of Evaluation" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

8. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Developing Written Test Items" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

9. There will be no significant difference between learning gains for students assigned as individuals and those assigned in pairs to complete computer-based instruction designed to develop cognitive skills in the content area "Common Rating Errors" in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

10. There will be no significant difference in composite test grades of students assigned as individuals and those assigned in pairs to complete computer-based
instruction designed to develop cognitive skills in the Technical Training Instructor Course at Sheppard Air Force Base, Texas.

In each case, the independent variable was assignment to a group. In the first group, students completed computer-based instruction individually. In the second group, students were assigned in pairs to complete computer-based instruction. For the first nine hypotheses, the dependent variable was the score attained on the posttest administered after the computer-based instruction lesson. For the tenth hypothesis, the dependent variable was the composite test grade.

Although the .05 level of significance was established for the study, application of the Dunn-Bonferroni Adjustment for Experiment-Wide Error resulted in a revised significance level of .01. Consequently, basis for retention or rejection of the null hypothesis was the .01 level of significance. The hypothesis was retained when the probability of $t$ was greater than .01. Conversely, when the probability of $t$ was less than .01, the null hypothesis was rejected. In summary, the results of the analyses were:

1. For Hypothesis 1, the probability of .0434 justified retention of the null hypothesis.
2. For Hypothesis 2, the probability of .0361 justified retention of the null hypothesis.
3. For Hypothesis 3, the probability of .1690 justified retention of the null hypothesis.

4. For Hypothesis 4, the probability of .8431 justified retention of the null hypothesis.

5. For Hypothesis 5, the probability of .5552 justified retention of the null hypothesis.

6. For Hypothesis 6, the probability of .7299 justified retention of the null hypothesis.

7. For Hypothesis 7, the probability of .7255 justified retention of the null hypothesis.

8. For Hypothesis 8, the probability of .0039 justified rejection of the null hypothesis.

9. For Hypothesis 9, the probability of .9096 justified retention of the null hypothesis.

10. For Hypothesis 10, the probability of .8432 justified retention of the null hypothesis.

In addition to the probability determined for each hypothesis, confidence intervals were also calculated. Based on results of confidence interval calculations for each of the questions, the possibility that population means were the same could not be completely disregarded for any of the hypotheses.

Similarly, effect sizes were calculated for each hypothesis. The results revealed that differences had little or no practical application in the fields of education and training for nine of the ten hypotheses. For
Hypothesis 8, the effect size suggested possible limited practical application.

Limitations of the Study

The primary limitation of the study was the inability to survey students who had not met prerequisite requirements for attendance at the Technical Training Instructor Course. Because those prerequisites are relatively stringent in comparison to prerequisites for many other Air Force courses, generalizability to lower-ability students appears to be limited.

Secondly, although the population studied was comprised entirely of personnel working in a military environment, the composition roughly paralleled that of a post-secondary institution. Attendees were at least high school graduates and had passed admissions screening, including aptitude testing. The similarities in populations might encourage the tendency to generalize to the post-secondary academic community. However, even though the study focused on completion of instruction designed to develop cognitive skills, comparisons with and generalizability to instruction in academic post-secondary settings should be approached with some degree of caution. While the populations share a number of similarities, the design of both computer-based instruction and the teaching-learning activities used in conjunction with that instruction in a technical training
environment may vary significantly from those used in an academic setting.

Conclusions

Based on the findings of the study as interpreted in light of its limitations, the following conclusions were drawn and are submitted for consideration.

1. Findings of this study are relatively parallel to findings of the limited number of studies conducted previously. As in previous studies, the findings of this study also support the conclusion that students assigned in pairs to complete computer-based instruction show learning gains at least comparable to those assigned as individuals to complete the same instruction.

2. This study also bears out the finding that when there is a significant difference in learning, students assigned in pairs show greater learning gains than do those assigned as individuals.

3. Even when differences are statistically significant, they reflect relatively small differences in means of the control and treatment groups.

Discussion of Conclusions

The conclusions drawn as a result of this study are not surprising. Rather, they serve to confirm the conclusions of a limited body of previous research. However, some discussion of these conclusions is in order.
The first conclusion was that students learn at least as well when the student-to-computer ratio is two-to-one as they do when the student-to-computer ratios is one-to-one. Research addressing conventional classroom instruction has long shown that students learn from each other and that students studying in pairs or small groups show learning gains comparable to or better than those who study individually. Consequently, it is not a major revelation that they also learn from each other when instruction is presented through another medium, such as computer-based instruction.

The second conclusion was that when there is a significant difference in learning gains, students working with a two-to-one student-to-computer ratio show greater learning gains than do students working with a one-to-one student-to-computer ratio. Again, working together at a computer terminal may well encourage more active participation and interaction for each individual in a small group than activities such as classroom discussions or class projects where students have discrete assignments as team members. For some students, it most assuredly encourages more active participation than they experience when they are assigned to complete activities on their own. Since active participation is one of the keys to learning, it seems logical that enhancing individual participation through increased interaction with other students leads to greater learning gains.
Finally, the hypothesis dealing with the content area "Developing Written Test Items" revealed that students assigned to the two-to-one student-to-computer ratio scored significantly higher than their counterparts working with a one-to-one student-to-computer ratio. Several other hypotheses revealed similar, although not statistically significant, results. However, in all cases, the differences in means of the two groups were relatively small, ranging from three tenths of one percentage point to 4.7 percentage points.

Recommendations

1. The results of this study can form the foundation for a resource decision model to be used in determining resource allocations for computer hardware to be used in support of computer-based instruction designed to develop cognitive skills. If students learn as well in a two-to-one student-to-computer environment, then capital investments for hardware can be reduced by approximately 50% without yielding any significant degradation of learning. On the contrary, educators and trainers could anticipate a slight learning gain if student-to-computer ratios are increased from one-to-one to two-to-one.

2. Results of this study will be provided to the U. S. Air Force through the Air Training Command. The Air Training Command should subsequently institute a test
program based on results of this study in which computer-based instruction in cognitive areas will be delivered in a two-to-one student-to-computer environment. If the test proves as successful as this study would suggest, a policy requiring at least a two-to-one student-to-computer ratio for computer-based instruction in cognitive areas should be implemented.

3. Results of this study should also be disseminated to education and training institutions using or contemplating use of computer-based lessons to provide instruction in cognitive areas. The study should provide some insight for projecting, justifying, and allocating resources for computer hardware.

4. Instructional developers should consider the implications of the results of this study when designing teaching-learning activities which include computer-based instruction. Minor modifications to current design techniques for computer-based instruction may provide even more effective learning if activities are designed with pairs or small groups of individuals in mind. For example, some computer-based instruction lessons which address individuals by name when providing feedback are limited to a single name. Minor modification of the program would allow acknowledgment of pairs or groups of individuals.

5. Based on the potential resource savings suggested by this study, additional research in two related areas is
appropriate. First, research should be conducted to determine the impact of increasing student-to-computer ratios beyond two-to-one. Groups of three or four may prove to learn as effectively as do pairs, which might allow for even greater reductions in resource requirements. Secondly, studies should be conducted which address areas other than cognitive skills to determine whether increased student-to-computer ratios yield comparable results. Areas to consider include teaching of job skills using computers (e.g., word processing or use of data bases and spreadsheets) or simulations presented using computers. Finally, research should be conducted to determine how student perceptions and attitudes about learning through computer-based training differ from perceptions and attitudes about more traditional instructional methodologies.

Concluding Statement

As funding for education and training programs becomes increasingly austere, making optimum use of available dollars becomes more and more critical. It is essential that educators and trainers determine the most effective and efficient methods for designing and delivering instruction. Equally important is the development of mechanisms which will encourage application of such methods.

Computer-based instruction is one method which holds promise as a partial solution to the problem of providing
greater access to education and training to increasing numbers of people with limited resources. This study verifies that it is possible to provide at least some types of computer-based instruction with far less capital investment in computer hardware than may have been estimated previously.

It is therefore incumbent upon prudent educators, trainers, and resource managers to consider the results of studies such as this one in developing long-range plans for computer hardware acquisition to support computer-based instruction. Making better use of limited funds will be beneficial to taxpayers, administrators, managers, and others interested in the effective financing of educational endeavors. Finally, and more importantly, freeing resources for other uses may help the educational and training communities achieve the ultimate goal of providing the best learning environment for the most people at the least cost.
APPENDIX A

REQUEST FOR PERMISSION TO CONDUCT TEST PROGRAM - LETTER
Request for Permission to Conduct Test Program

1. Request permission to conduct a test program in the J3AIR75000 005, Technical Training Instructor Course (TTIC), where students would work in pairs during computer assisted instruction (CAI) lessons. Both research and our experiences in the Computer Based Instruction Designers Course indicate students should learn at least as well working in pairs during CAI. If we can verify that learning is as good (or even almost as good) as that produced using one computer per student, we can provide justification for resource decisions which will allow us to better use available computer resources.

2. The test program should encompass approximately 80 students (about 8 classes over a period of approximately 3 months) to provide an adequate basis for comparison using appropriate statistical treatment. The only change to the course would be the assignment of students to work on CAI lessons in pairs. Appraisals on the lessons would continue to be administered individually to provide an appropriate comparison basis for the test.

3. I would like to use the data as the basis for my doctoral dissertation. In addition, if the results of the test indicate we can produce equally effective training using fewer computers, the results could be made available to HQ ATC/TTIS for consideration command-wide.

ELANE K. SEEBO
Chief, Curriculum and Training
Faculty Development Division
APPENDIX B

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