US Army Corps of Engineers
Office of the Chief of Engineers

TECHNOLOGY TRANSFER TEST BED PROGRAM

USA-CERL TECHNICAL REPORT P-89/03
October 1988
T^3B: Intelligent Embedded Instruction for CAD Systems

Intelligent Embedded Instruction for Computer-Aided Design (CAD) Systems

by
Doris Smith Shaw
L. Michael Golish
Robert L. Johnson

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The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has developed and tested an embedded instruction program for teaching CAD. The program was demonstrated in a field test funded under the Technology Transfer Test Bed (T^3B) program. The field test results indicate that architects and engineers profit from online instruction embedded in the CAD system that they are learning. There is wide variability in the time spent studying the lessons as well as in learning strategies employed by different students. Follow-up questionnaires revealed a preference for this type of instruction over traditional methods.

The program developed by USA-CERL has been transferred to industry through a Cooperative Research and Development Agreement (CRDA) in accordance with the Federal Technology Transfer Act of 1986. The agreement is with Electronic Courseware Systems, Inc., which after refining the program, has named it "Teaching Assistant for AutoCAD" and placed it on the commercial market. This version of the Teaching Assistant is designed for the AutoCAD microcomputer software; a second version for Intergraph's Microstation CAD system is currently under development.

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TECHNOLOGY TRANSFER TEST BED PROGRAM

FINDINGS AND RECOMMENDATIONS OF TEST/DEMONSTRATION

WORK UNIT NO./TITLE OF TEST: T^3B Project, "Computer-Aided Instruction (AutoCAD)"

PERFORMING LABORATORY: USA-CERL

PRODUCT/SYSTEM: Teaching Assistant for AutoCAD

TEST SITES: Huntsville Division, New England Division, Baltimore District

DESCRIPTION/OBJECTIVE OF TEST/DEMONSTRATION:

The objective was to field-test a computer-based educational program that uses the embedded instruction concept to teach architects and engineers (A/Es) how to use computer-aided drafting (CAD) software. The program is intended to serve as an alternative to traditional forms of training, which can be costly and time-consuming. In addition, embedded instruction provides for self-paced learning to optimize time spent on lessons. The goals of the test were to validate the program's effectiveness in training users and to determine its responsiveness to professionals with different learning patterns.

RESULTS OF TEST/DEMONSTRATION:

The 84 test participants provided feedback to document their experience with the Teaching Assistant. A questionnaire was also completed to measure attitude. Results were analyzed and showed that, in general, A/Es benefit from online instruction on the CAD program they wish to learn. The wide variation in time spent on the lessons and in the learning strategies used reinforce the goals of embedded instruction--self-paced, self-serving education. Results further suggested that the program is flexible enough to ensure responsiveness to different levels of user expertise. Most participants indicated a preference for this form of training over conventional classroom methods.

RECOMMENDATIONS FOR PRODUCT/SYSTEM:

The successful outcome of this T^3B demonstration has resulted in a Cooperative Research and Development Agreement (CRDA) between USA-CERL and a private company, Electronic Courseware, Inc. (ECS). This CRDA was possible through the Federal Technology Transfer Act of 1986 and Public Law 99-502. ECS has refined the prototype system and is marketing it under the tradename "Teaching Assistant for AutoCAD."

Embedded instruction has a very far-reaching potential for application in teaching other types of computer programs. In addition to the advantages of self-paced learning and reinforcement, this type of instruction offers a lower cost alternative to classroom training. There is a huge potential savings in terms of employee travel expenses, tuition/materials, and the cost of retraining or refresher courses. One set of the Teaching Assistant software can be shared among several users; in addition, training time is not dependent on an outside organization's schedule, but can be incorporated into the daily workflow. The Army should explore other applications for this technology to ensure effective training on software and avoid the cost of offsite instruction when practical.

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The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has developed and tested an embedded instruction program for teaching CAD. The program was demonstrated in a field test funded under the Technology Transfer Test Bed (T^3B) program. The field test results indicate that architects and engineers profit from online instruction embedded in the CAD system that they are learning. There is wide variability in the time spent studying the lessons as well as in learning strategies employed by different students. Follow-up questionnaires revealed a preference for this type of instruction over traditional methods.

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FOREWORD

This project was demonstrated as part of the Technology Transfer Test Bed (T^3B) program under the T^3B Work Unit entitled "Computer-Aided Instruction (AutoCAD)." The T^3B demonstration was coordinated with the Corps of Engineers National Automation Team (CENAT). The research and development phase was conducted for the Directorate of Engineering and Construction, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Project 4A162731AT41, "Military Facilities Engineering Technology"; Work Unit AO-087, "Intelligent Embedded Instruction for CAD Systems." The HQUSACE Technical Monitor was Donald Dressler, CEEC-ED.

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. Michael O'Connor is Chief of USA-CERL-FS. The USA-CERL technical editor was Dana Finney, Information Management Office.

Appreciation is expressed to Dr. Deborah Little of USA-CERL and to James Holtzman and Robert Johnson, both University of Illinois graduate students, for contributions to this report.

COL Carl O. Magnell is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

TABLES

FIGURES

FIGURES (Cont'd)

INTELLIGENT EMBEDDED INSTRUCTION FOR COMPUTER-AIDED DESIGN (CAD) SYSTEMS

1 INTRODUCTION

Background

To ensure continued productivity and quality of work, the U.S. Army Corps of Engineers (USACE) is increasingly switching to automated methods in its daily operations. One technology with a high potential benefit to USACE is computer-aided design (CAD), which can improve the cost-effectiveness and accuracy of design drawings for facilities requiring a great deal of unit repetition, as is common with most military construction. In addition, CAD offers the advantage of storing "standard" designs online for use by architects/engineers (A/Es) throughout USACE.

It has become apparent that many current CAD systems are not being used to their full potential, making them less cost-effective than intended. Part of the reason for this deficit is that training programs for the CAD software have been ineffective and costly. Customary classroom methods of training are not suitable for designers: time schedules and individual needs vary too widely to structure a course meeting everyone's needs. While individual tutoring might prove more effective from a learning standpoint, it would be too expensive for widespread use within USACE. Adding to the problem is that new developments in computer software to increase system power occur almost daily, but these advances require constant updating of skills. This requirement allows little complacency in the field; cost-effective, continuing training of A/Es in the use of automated drafting and design tools is essential.

Embedded instruction offers a promising alternative to classroom training. This technology involves "embedding" a tutorial program directly into the software program being learned, using the system itself as a delivery medium for the lessons. CAD systems are especially well suited to embedded instruction. Users can learn at their own pace on the actual software they will be using in daily work.

Training programs that use embedded instruction could both improve users' effectiveness on USACE CAD systems and lower the cost of employee training. To be of most benefit to USACE, the embedded instruction program must be "intelligent" enough to respond to the trainees' individual learning styles and objectives.

The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has developed a training program for AutoCAD based on the embedded instruction concept. To learn if this training program would meet the needs of USACE AutoCAD users, a field test was funded under the Technology Transfer Test Bed (T^3B) program. T^3B is a USACE initiative to ensure that research and development are responsive to the customer's needs as determined through site demonstrations and formal user groups.

Purpose

The purpose of this research was to develop and field-test a computer-based educational system using embedded instruction technology to provide USACE with a low-cost, effective alternative to traditional forms of training. The program must be "intelligent" for responsiveness in training professional A/Es.

Approach

The approach involved first studying A/Es in the field as they learned to use a CAD system. A simple computer-based learning environment was modeled as an observation tool. Chapter 2 summarizes the educational requirements used to develop this model.

Computer-based instruction was then developed within a widely used CAD system. (See Chapter 2 for a complete description of the training program.) The target audience was design professionals and technicians within USACE. Lessons covered the materials commonly taught in introductory CAD courses.

After the lessons were completed, they were officially field-tested at three USACE sites--Huntsville Division, New England Division, and Baltimore District. The test subjects were asked to supply personal information about experience, time spent on the lessons, and other relevant comments. They were tested for subject matter mastery and then administered an attitude questionnaire. Chapter 3 includes the findings of this test.

Mode of Technology Transfer

In accordance with the Federal Technology Transfer Act of 1986 and Public Law 99-502, the program described in this report has been transferred through a Cooperative Research and Development Agreement (CRDA) between the U.S. Army Construction Engineering Research Laboratory (USA-CERL) and Electronic Courseware Systems (ECS), Inc. ECS refined the prototype for teaching AutoCAD, and it is now available on the commercial market under the trademark "Teaching Assistant for AutoCAD." A second version of the Teaching Assistant is being developed for the Intergraph Microstation; Intergraph is the commercial product selected for the Corps-wide Computer-Aided Design and Drafting (CADD) Buy. The same concepts developed in this research could be adapted for a wide range of applications within USACE and the private industry.

2 DEVELOPMENT AND TESTING

Selection of an Educational Method

Several factors pointed to computer-based instruction (CBI) as an educational approach for training A/Es in CAD. Among these factors are cost and applicability to the type of learning situation required by the target audience. Embedded CBI, as explained below, offers even more benefits because of the characteristics inherent in the subject matter.

Computer-Based Instruction

Traditional classroom methods of instruction often prove to be inefficient. They usually assume that most students have similar entry-level skills and similar objectives. Another assumption is that everyone will learn at comparable rates and that all have the same block of time available for the class. Users who do not meet these prerequisites may not be able to make good use of their time. Because CAD is a relatively new technology, design professionals vary greatly in their needs and objectives.

CBI resolves the problems of classroom methods by offering the advantage of self-paced learning, which can be done at users' convenience and according to their individual learning preferences. This benefit is extremely valuable for adult professionals whose needs may be highly specialized and whose schedules require flexibility. Learners may pursue a subject in depth or choose to skim the material for quick review. The increased efficiency of training time could be a great cost savings. Also, the classroom environment produces social pressure for perfection which can limit experimentation by the learner.

CBI could still be used in a classroom situation to advantage; teachers could let the more independent students work without intervention, but provide help to those needing more support. However, for USACE's needs, walk-in training is the more promising environment. Walk-in training offers the flexibility in time and scheduling that many professionals need.

Embedded instruction is a tutorial computer program that is installed within the actual computer system to be learned. It can be very effective in avoiding the problems that occur when users learn on one system and then attempt to transfer their knowledge to different equipment. With embedded instruction, the situations encountered in learning are the same ones that can be expected in actual use, so that all experimentation is educational--and encouraged. The lessons in these programs often are sequenced according to difficulty or classification, perhaps not offering all options at first, but leading to an understanding of the complete program by the end of the tutorial. The student can learn to use shortcuts and other aids provided by the program and can compare different methods for solving problems.

Adult designers tend to develop their own personal ways of using CAD software which can optimize a system's use. This ability has been referred to as "making the computer an extension of oneself" and is based on a conceptual understanding of the way CAD programs operate. To promote this level of understanding, instruction for computerized design must allow for experimentation to help users begin to conceptualize the CAD environment. Such an approach is in contrast to teaching methods that are just a step-by-step presentation of procedures.

The Instructional Program

Effective computerized instruction is based on knowledge of three areas: the subject, the educational media, and the stages in development of expertise in the learner. Since computer-based instruction attempts to reduce the need for human intervention in training, a thorough analysis of the learning process is necessary. The usual accommodation of teacher to student must be predicted and simulated as closely as possible.

Design has traditionally been considered a product of the imagination, not subject to computerization. Therefore, development of an instructional program involved not only procedural knowledge in learning CAD, but also the concept of designing with the help of a computer. A case-study approach was used to investigate patterns of thinking as A/Es learned to use AutoCAD.[1] This system was chosen because of its open design which offered the possibility of embedding instruction and also because most USACE District and Division Offices, as well as a large number of commercial A/Es, use AutoCAD for some of their work.

From initial observations, the following requirements for the computer-based lessons were established:

1. The course content would be represented better by a concept specification hierarchy than by a traditional task analysis of skills.[2] Different designers employed different procedural approaches.

2. If A/Es could learn to envision the computer as an extension of their own design processes, they might be more inclined to use it. There was little acceptance for the idea of changing design practices to comply with constraints set by the computer.

3. It would be necessary to allow the designer time and space for individualized experimentation. The study showed wide variations in such needs.

4. In the interest of efficiency, however, some structure would be needed in the presentation. The first lessons should be aimed at developing a general familiarity; the next few lessons should help the user grasp the concept of the software's power; and the last ones should impart more detailed knowledge.

Based on these observations, conceptual difficulties were predicted and six lessons were prepared that were aimed at preventing error pattern formation. The lessons were programmed in AUTOLISP, with AutoCAD graphics to create the screen displays.

During a lesson, users are monitored and provided with feedback if they commit expected errors or fail to practice a command. Extra help is offered from some lesson screens when the student types the letter X. This help is context-sensitive; that is, the same keypress will result in different help screens from different lesson screens. The first two lessons provide a general framework; the next two suggest different design applications; and the last two address details of editing and documentation.

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[1] D. Shaw, "Case Studies in Architectural CADD Education," *Architectural Education, Research, and Practice in the Next Decade, ACADIA Workshop '86 Proceedings*, J. Turner (Ed.) (University of Houston, October 1986).

[2] M. Birenbaum, and D. Shaw, "Task Specification Chart: A Key to a Better Understanding of Test Results," *Journal of Educational Measurement*, Vol 22 (1985), pp 219-230.

The commands CONTINUE, BACK, and INDEX were added to the AutoCAD screen menu and are always active. In addition, typing the letter B at the Command prompt produces a blank screen for practice. Example lesson screens are shown in Figures 1 through 4.

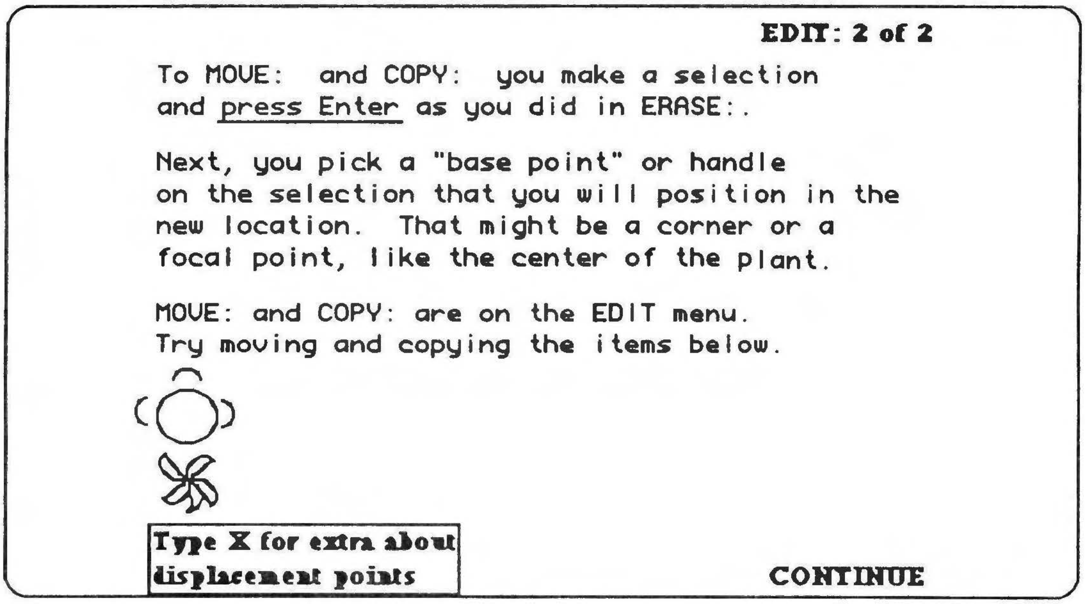

Figure 1. Context-sensitive help. If students do not understand about base points and displacement points, they can type X to receive context-sensitive help.

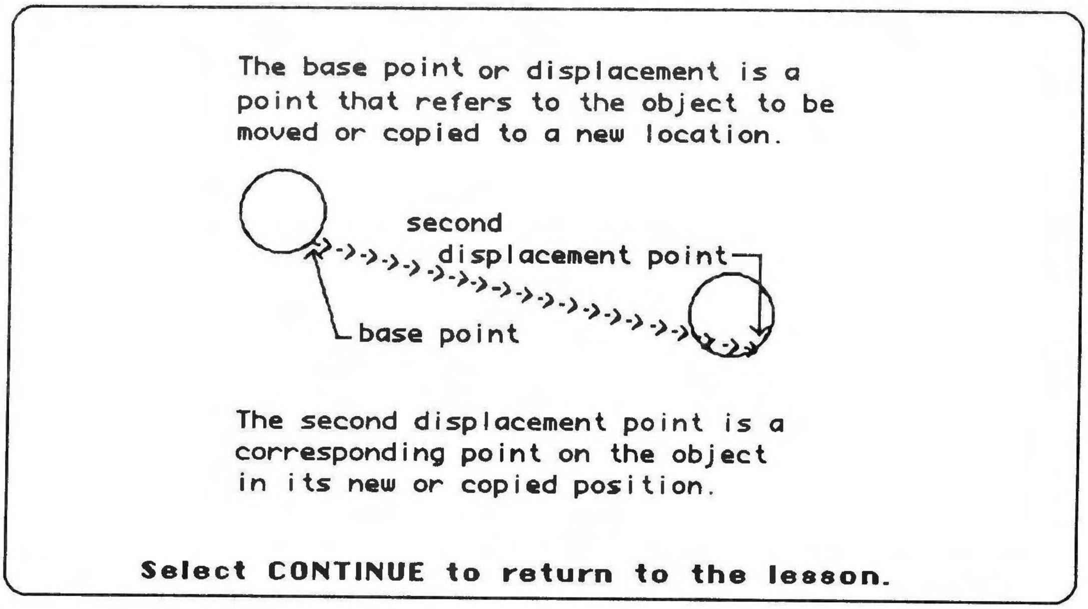

Figure 2. Help example. When help is requested, more detail is offered. Often the help includes graphics or animation.

If the copy or moved object disappeared
from your screen, it is likely that you
pressed the Enter or Return key rather
than the pick button for the second point.

Be sure that the first point that you
pick has reference to the object that
you want to move or copy. Then select
a corresponding point in the new position.

Select CONTINUE to return to the lesson.

Figure 3. Error feedback. If a common error is made (e.g., pressing the Return key rather than the Pick button), this message attempts an explanation.

The display you just saw offered an
opportunity to try an AutoCAD command.

Select BACK: to return to the page and
experiment. Select CONTIUE to go on.

Figure 4. Practice opportunity. This display is seen if the student fails to try the exercise when he/she is directed to practice.

Field Test

Three official (i.e., funded) test sites and several volunteer sites agreed to solicit subjects to work through the lessons, answer a questionnaire, and do a test drawing. The sites funded under T^3B were three USACE Offices--Huntsville Division, New England Division, and Baltimore District. No written documentation was provided to accompany the lessons. Each test site named a test coordinator who was responsible for installing the program, helping the learners start, and being available for questions at appointed hours. The objective was to conduct the testing through the site coordinators rather than through an outside project director. This arrangement was predicted to give more realistic data, even though there might be incomplete records and unexpected differences between the test sites (see Chapter 3). In addition, this configuration was the most economical way to use the programs and was expected to help reveal any weaknesses in the instruction.

The three official sites and two of the volunteer groups sent their project coordinators to USA-CERL for one day of training in administration of the research. Only one of the coordinators was experienced with AutoCAD; one had no previous microcomputer experience. The coordinators were asked to give careful instruction to beginners on how to operate the lessons and the input device in use at the workstation. An additional test was conducted in a classroom situation with a teacher present for the first 4 hr of instruction. This test was intended to assess the program's performance in a formal classroom environment. Six students completed the class.

All data were provided anonymously. The test director knew only the numbers of test subjects, and the site coordinators did not know the test or questionnaire results. Demographic information collected included age, sex, computer/CAD experience, and educational background. (Not all participants provided these data.) Each subject was asked to record time spent in each lesson. Appendix A contains blank subject information forms.

The final test drawing was a USACE castle for which precise specifications were given (Figure 5). Students were asked to record the time spent on the drawing. Items graded were: drawing location, intersections, circles and arcs, angles of lines, layering (linetype and color), and block creation and insertion. A program written in AUTOLISP examined the values in the drawing file and calculated the drawing score. Appendix B is the drawing test presented to subjects.

Research Questions

In addition to performance rating, this study was designed to assess attitudes regarding computer use, CAD, computer-aided instruction, perceived knowledge about CAD, and the lessons themselves. A questionnaire was designed to measure all of these factors. There were 30 questions, 15 of which were worded to be answered "yes" and 15 "no" by a completely positive test subject. The questionnaire was subjected to the Student Problem Package (SPP) analysis[3] to analyze the items and also to determine if any classification of test subjects was significantly different from the others. The results are reported in Chapter 3 and are shown in Appendix C.

[3] D. Harnisch and N. Romy, *SPP Student Problem Package on the IBM-PC* (University of Illinois, 1985).

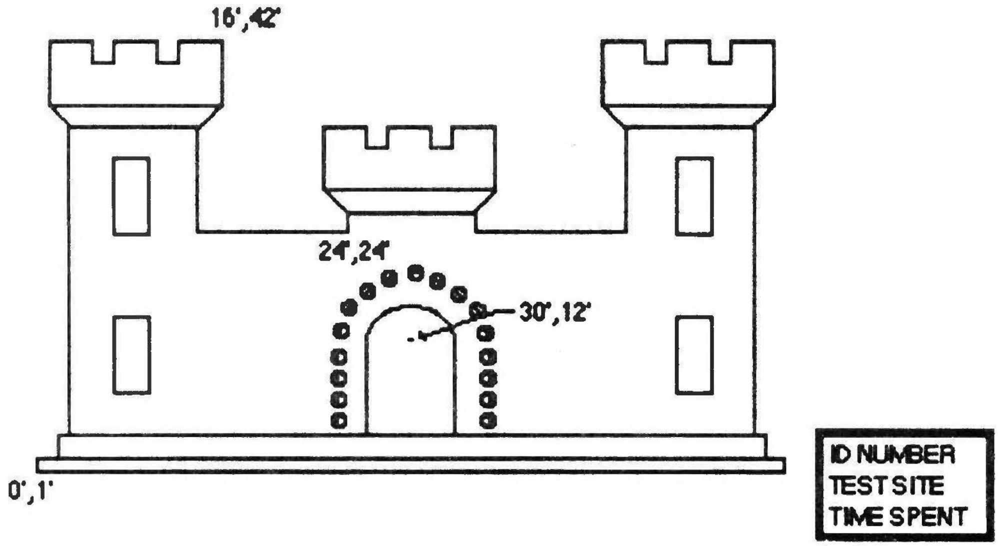

Figure 5. Final test drawing. Specific layers, blocks, colors, and titles were requirements.

Some questions that the test attempted to answer are:

1. Is computer-based training effective? Do students learn as much as they would from traditional classroom training?

2. Which features are most effective? Which are least effective?

3. How does perceived competency compare with actual competency in the use of CAD?

4. How much time is required for computer-based CAD instruction?

5. How effective is the walk-in training concept?

6. What factors, if any, determine success in computer-based CAD training?

Appendix D is a blank questionnaire. Not all of the questions were answered, but enough data were collected to report some general findings. Several new questions were raised as a result of the testing. More study is needed to answer these questions and to validate the data from this test.

3 FINDINGS AND ANALYSIS

Differences Due to Test Plan

As expected, having onsite project coordinators run the test produced some local differences in areas that may have impacted the results. Among these differences were the following:

- One site offered group instruction at the beginning whereas the others started subjects individually.
- At one site, the project coordinator was present most of the time; at the others, they were not.
- One site had AutoCAD reference manuals nearby and others had no manuals.
- Only one site set a schedule for the users.
- The attitudes of managers above the project coordinator ranged from encouraging to antagonistic.

Sample Demographics

Eighty-four subjects participated in some part of the test. Seventy-nine completed the castle drawing and 64 answered the questionnaire. The official test sites were represented nearly equally (Figure 6). The total number of subjects provided by those sites was 61. Unofficial sites supplied 23 more test subjects.

Nineteen percent of the test subjects were female. The total test sample was represented by a professional background as shown in Figure 7, where "other" signifies draftsmen or technicians for the most part. As may be observed from the figure, the sexes reflected about the same proportion within each professional background as the total sample.

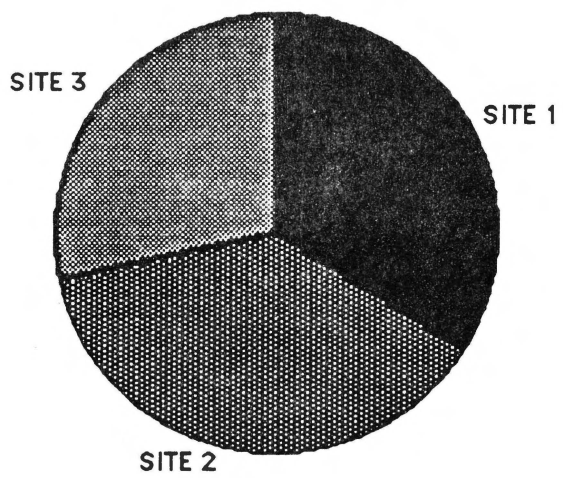

Figure 6. Representation from the three official test sites.

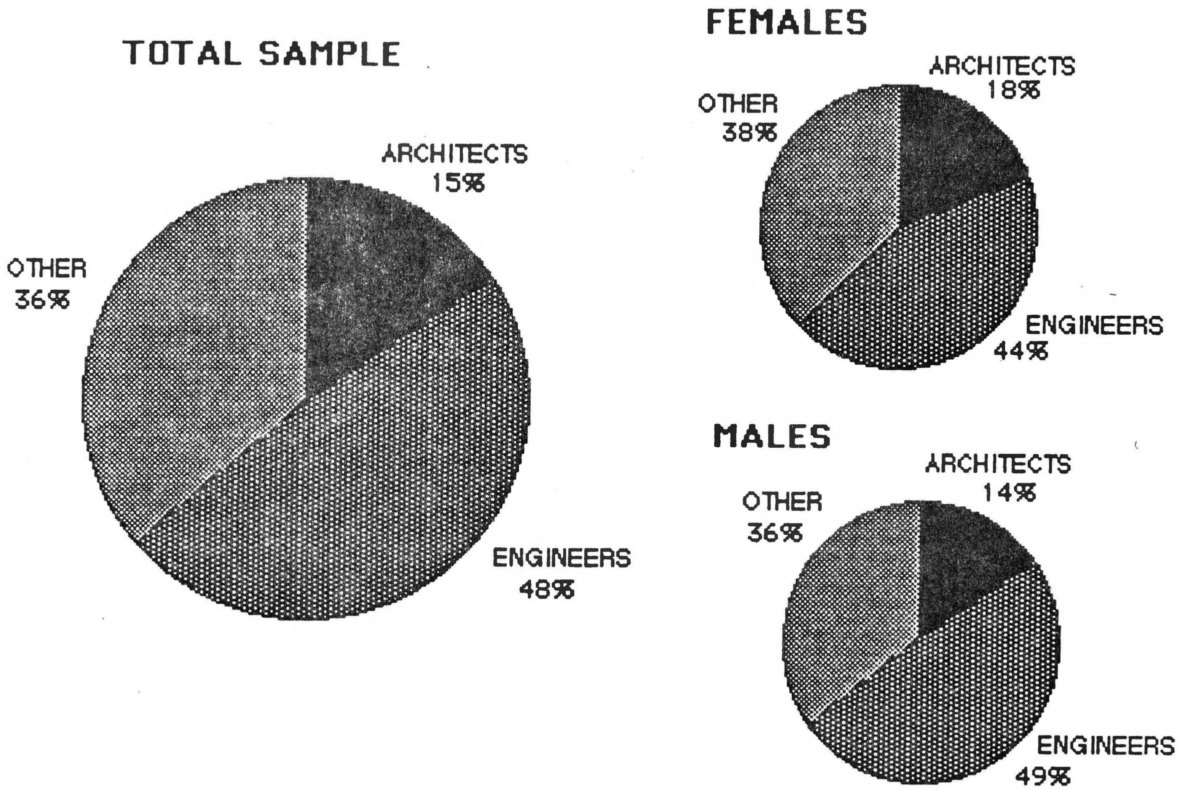

Figure 7. Representation by background. Breakdown by sex was nearly identical to the total sample.

With respect to computer literacy, engineers had the most previous experience in the sample group, closely followed by draftsmen and technicians. The architects had the least computer experience (Figure 8).

The average age of the test subjects was 36.7 years. There was a notable difference in average age of those with little computer experience compared with those having extensive experience on computers (Figure 9). The average age for subjects with more than 1 year of computer experience was 34 whereas those with less than 2 months of experience averaged 41 years old.

Table 1 contains the statistical data showing differences between the youngest and oldest groups. The level of significance represents 99 percent certainty.

With respect to experience on AutoCAD and other CAD systems, only four subjects had spent a great deal of time using AutoCAD. None of those four had extensive experience with other CAD systems. However, 19 percent of the total sample claimed expertise in another CAD system (Figure 10). The breakdown in professional background of those subjects with "extensive CAD experience" (Figure 11) is quite similar to that of the total sample. Appendix E shows the demographic data.

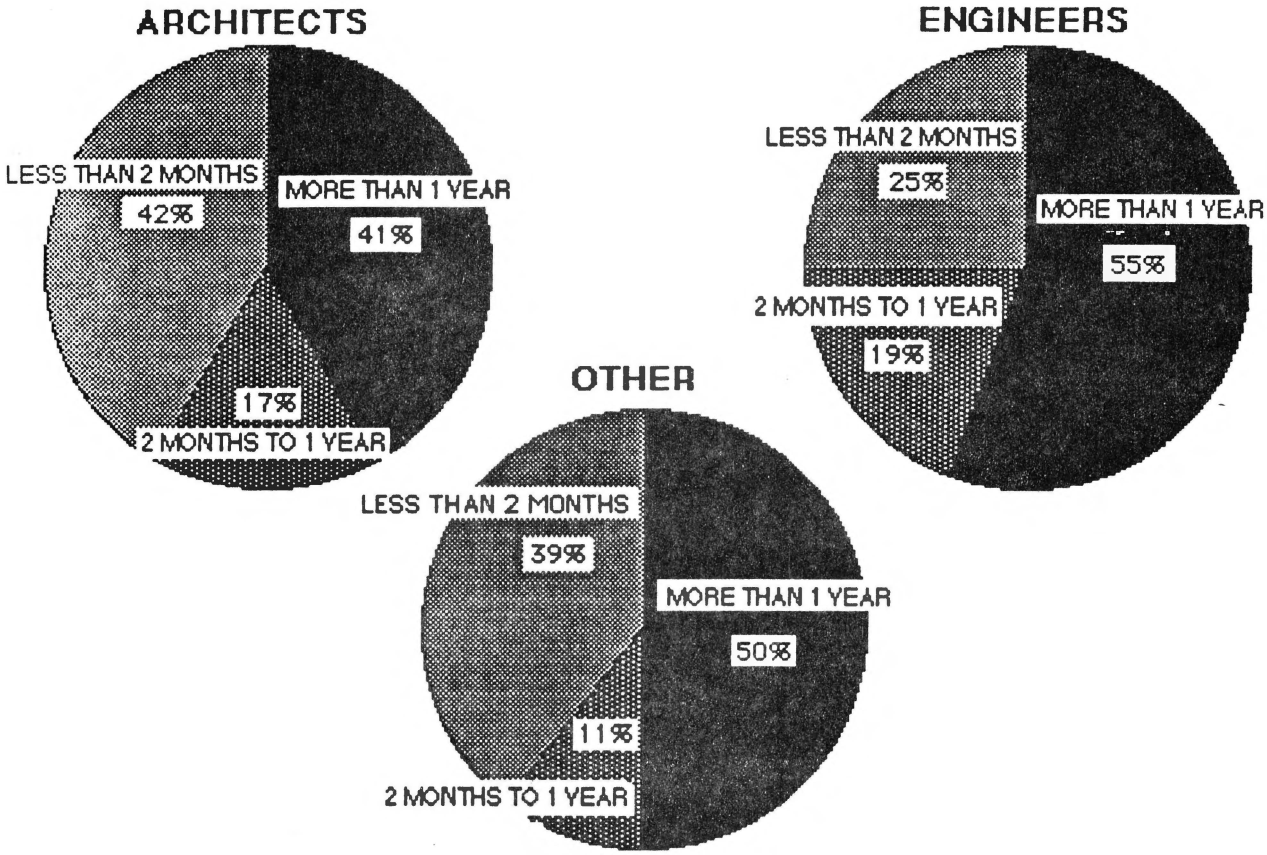

Figure 8. Computer experience of the different groups.

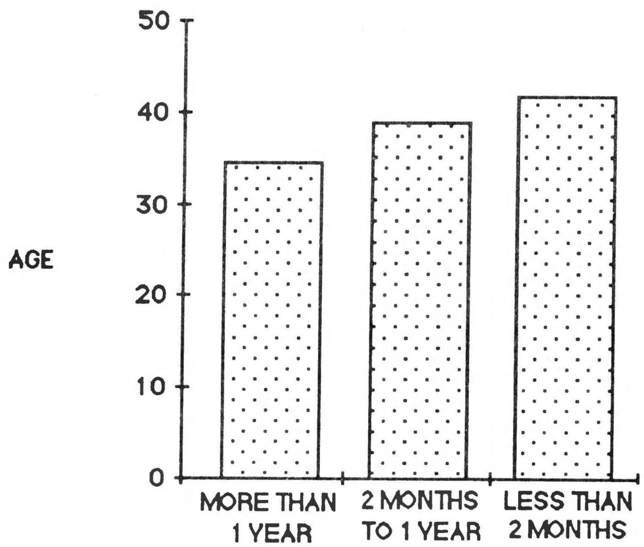

Figure 9. Age and amount of computer experience.

Table 1

Computer Experience by Average Age

Experience	Avg Age (yr)	Std Dev	N
More than 1 yr*	34	8.8	40
2 mo. to 1 yr	38	13.1	13
Less than 2 mo.*	41	10.6	26

*t = 2.896; significant at the 0.01 level for a two-tailed test.

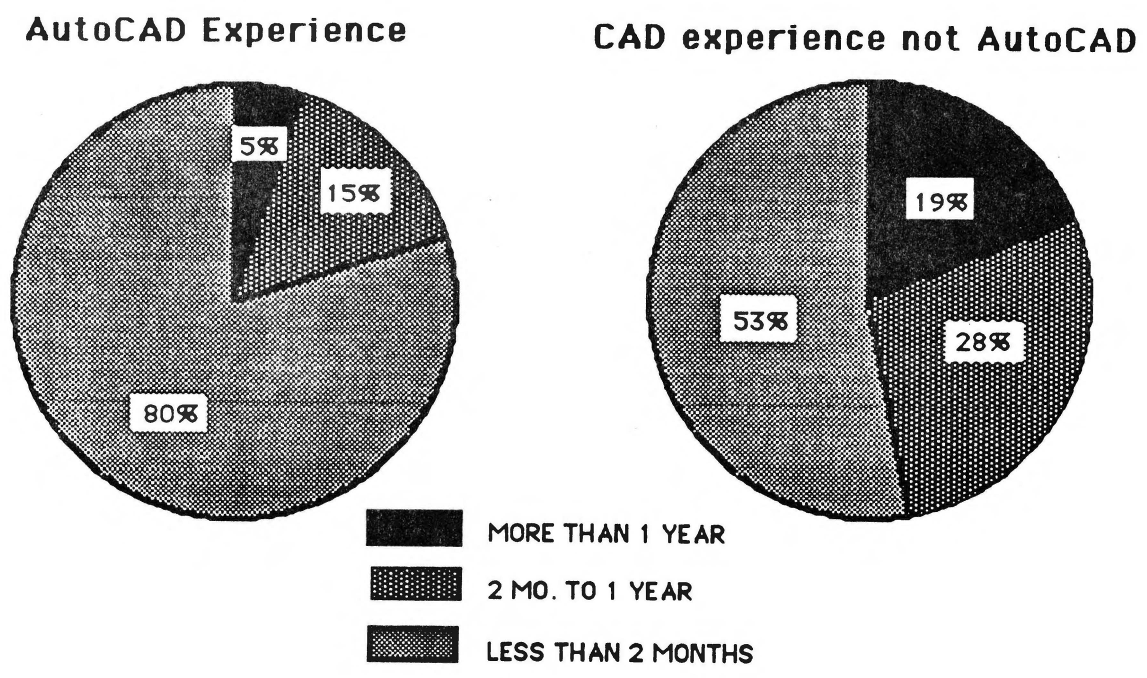

Figure 10. Previous experience with CAD systems.

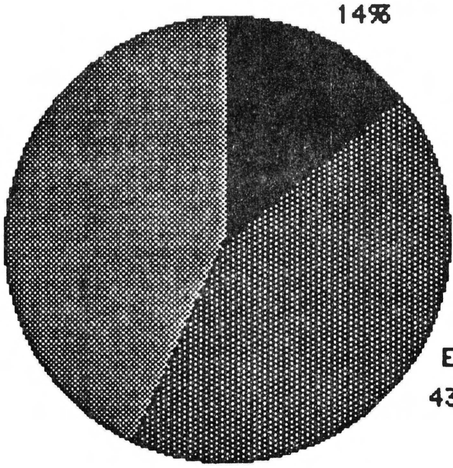

Figure 11. Extensive experience with CAD by background.

Learning Time

The average time spent on the six lessons was 730 min or about 12 hr. The range, however, was from 46 min to 3300 min, with a standard deviation of 673. Forty-six subjects kept records of their time. One test site reported several very large numbers. Excluding that site, the average time on the lessons was 9.7 hr. Students in the special classroom test environment (Chapter 2) required 6.3 hr to complete the lessons. The graph of scores for the 46 test subjects shows that 82 percent required less than the average time (Figure 12).

There was no significant relationship (correlation coefficient = 0.33) between time spent on the lessons and the age of the subject (Figure 13). It is interesting to note, though, that all peaks representing extremely long periods of time in the lessons occurred in the over-40 group. The graph of time with attitude, as measured by the questionnaire, also showed no significant correlation (Figure 14).

The interesting data regarding time was its relationship to previous CAD experience. Subjects with experience using a CAD system required about half the time to complete the lessons as those with no other CAD experience. The results are shown in Figure 15 and Table 2.

Drawing Scores

The drawing scores averaged 83 percent with a standard deviation of 12.3. One of the test directions had proved to be confusing: the term "title block" had a double meaning to many of the students. Success on that item seemed to be related to the subject's CAD experience and/or to test coordinator assistance. If that item were removed from the scoring, the average test score would be above 90 percent. AutoCAD drawings from students not trained by the computer lessons averaged 90 percent; however, there was no comparison of background information in that group and the sample was very small. In the special classroom test environment, the average drawing score was 89 percent. The instructor was not present during the testing period.

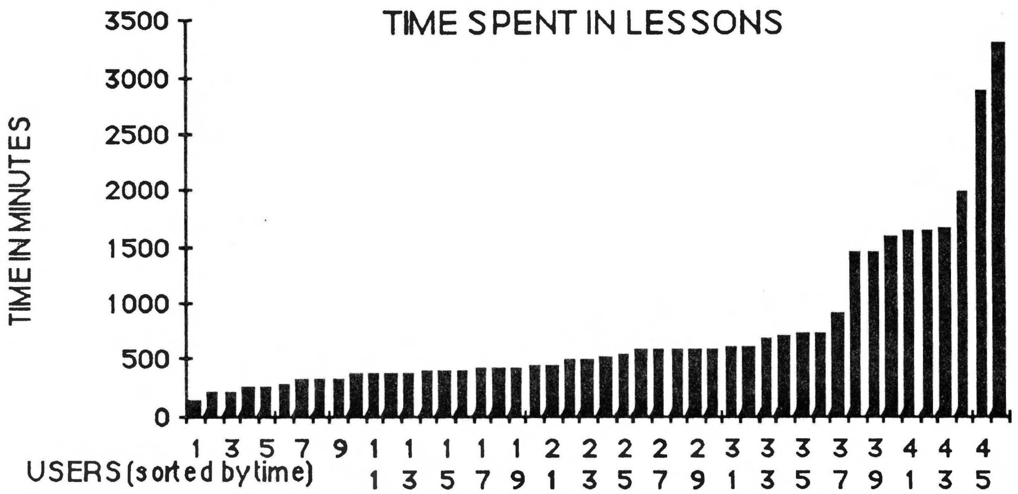

Figure 12. Time spent in the six AutoCAD lessons.

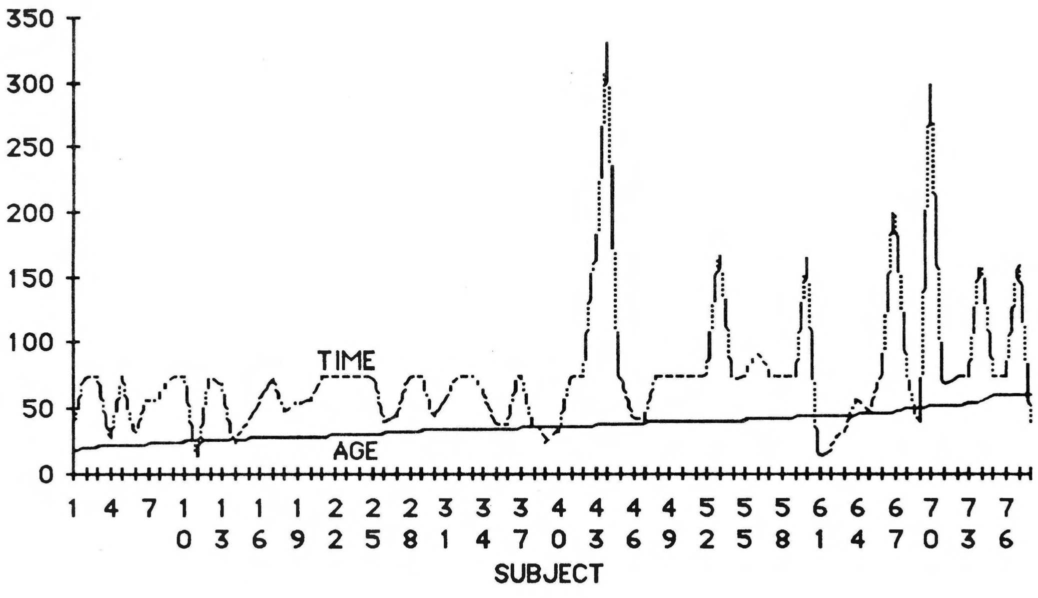

Figure 13. Plot of subject age and time spent on the lessons.

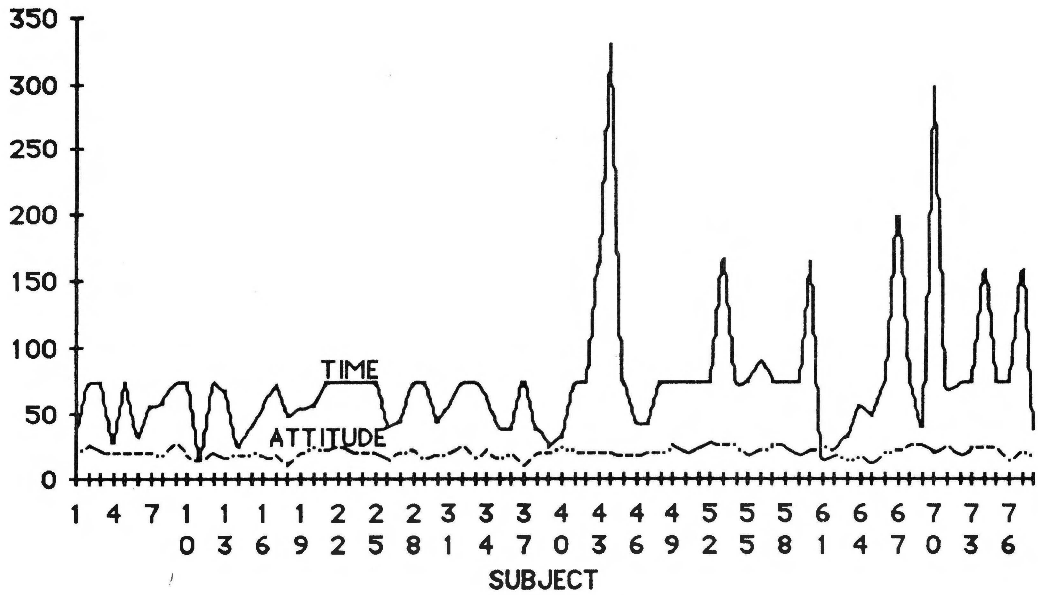

Figure 14. Plot of subject attitude and time spent on lessons.

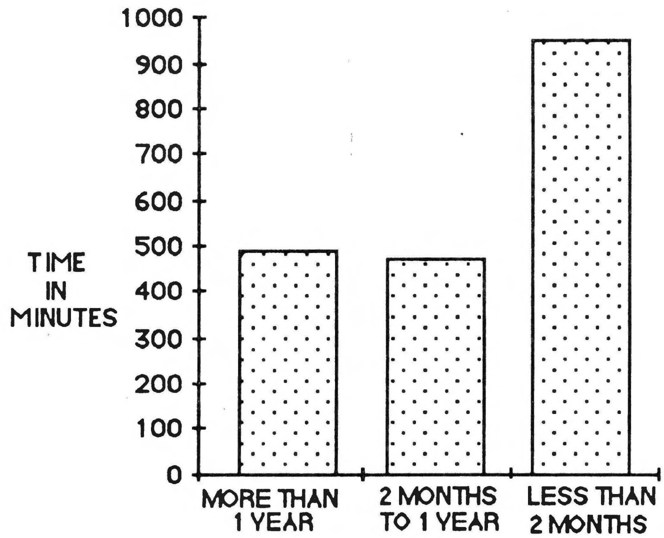

Figure 15. Time spent on lessons by previous CAD experience other than AutoCAD.

Table 2

CAD Experience Other Than AutoCAD by Time Spent on Lessons*

Experience	Avg Time (min)	Std Dev	N
More than 1 yr	491	470.9	8
	{479} {325}		
2 mo. to 1 yr	471	202.6	12
None	950	807.1	26

*t = 2.45, significant at the 0.01 level for a two-tailed test (99 percent certainty). The first two groups, representing some experience in CAD systems other than AutoCAD, were grouped for the test. The average and standard deviation are shown in brackets { }.

Most of the factors considered in this study had no significant effect on the drawing scores. The test sites were nearly equal in scoring (Figure 16).

Architects averaged 85 percent, engineers 83 percent, and the others 80 percent. The comparisons are shown in Figure 17. There was no difference on the basis of sex or computer experience (Figure 18). AutoCAD experience did not seem to affect scores (Figure 19), but extensive experience with another CAD system did produce significantly higher scores (Figure 20 and Table 3). The plots of score by age, time, and attitude as measured by the questionnaire show no significant correlations (Figures 21 through 23).

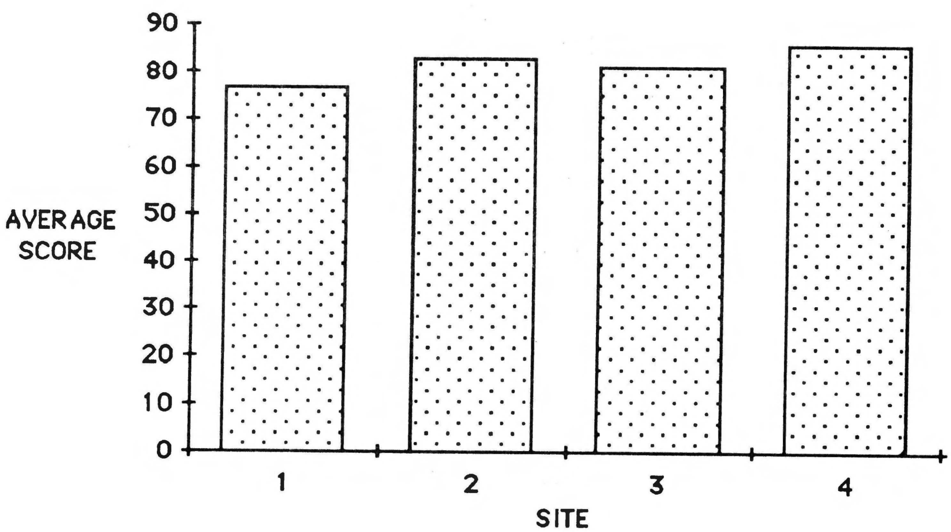

Figure 16. Drawing scores by site. The fourth column represents the largest unofficial test site.

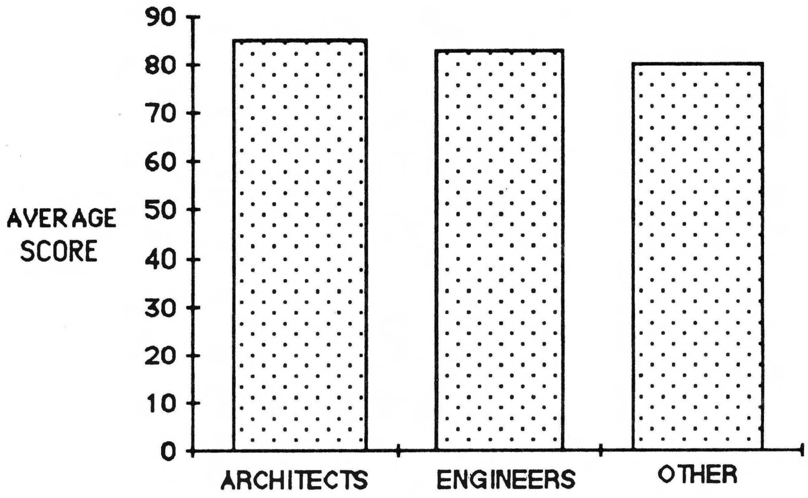

Figure 17. Drawing scores by background.

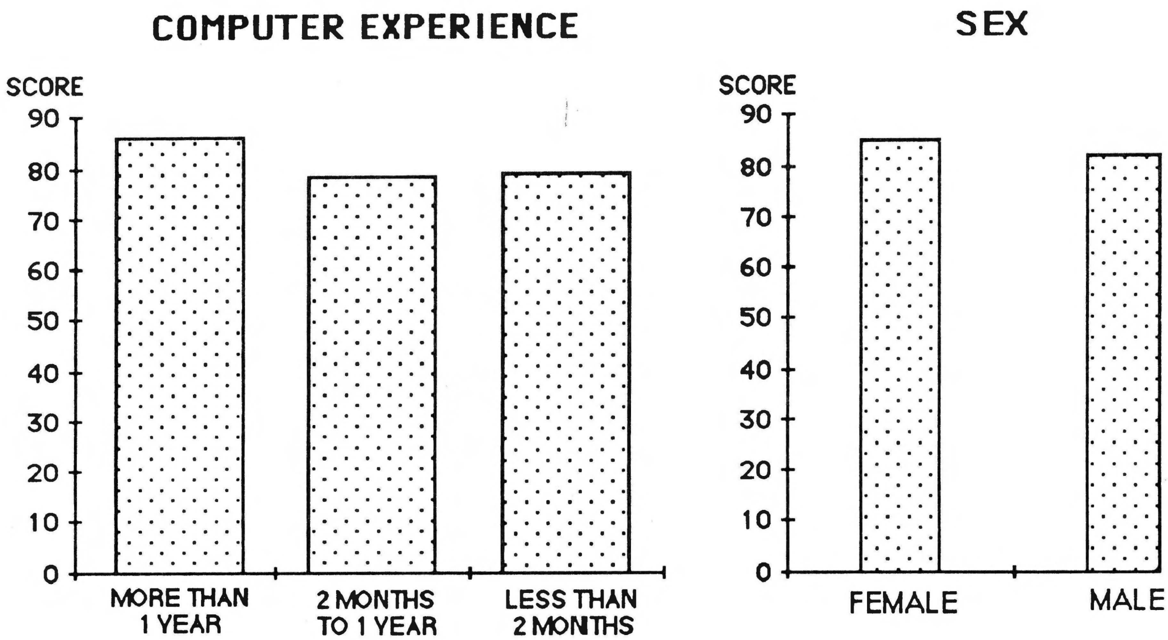

Figure 18. Drawing scores by computer experience and sex.

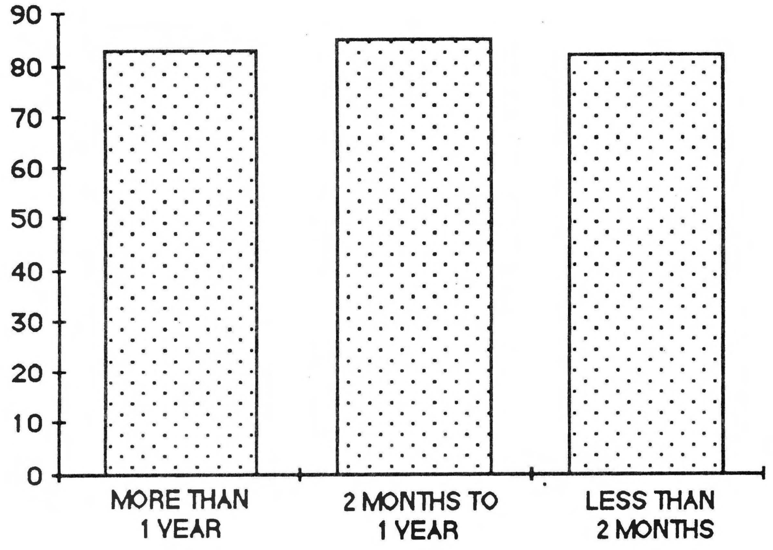

Figure 19. Drawing scores by AutoCAD experience.

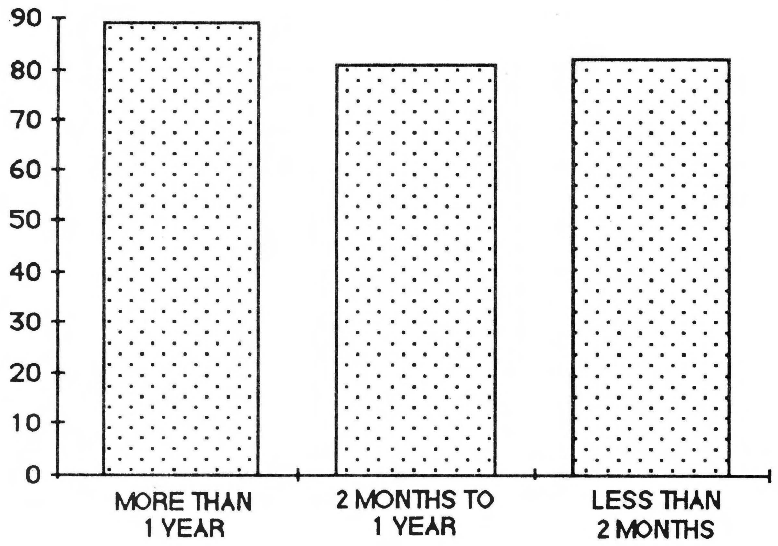

Figure 20. Drawing scores by CAD experience on programs other than AutoCAD.

Table 3

CAD Experience Other Than AutoCAD by Drawing Score*

Experience	Avg Score	Std Dev	N
More than 1 yr	89	7	15
2 mo. to 1 yr	82		22
		{13}	
None	81		42

*The last two groups, representing less than expert experience in CAD systems other than AutoCAD, were grouped. t = 2.349; significant at the 0.025 level (97.5 percent certainty for a two-tailed test); 78 df. t statistic needs to be 2.37 for 0.01 or 99 percent certainty.

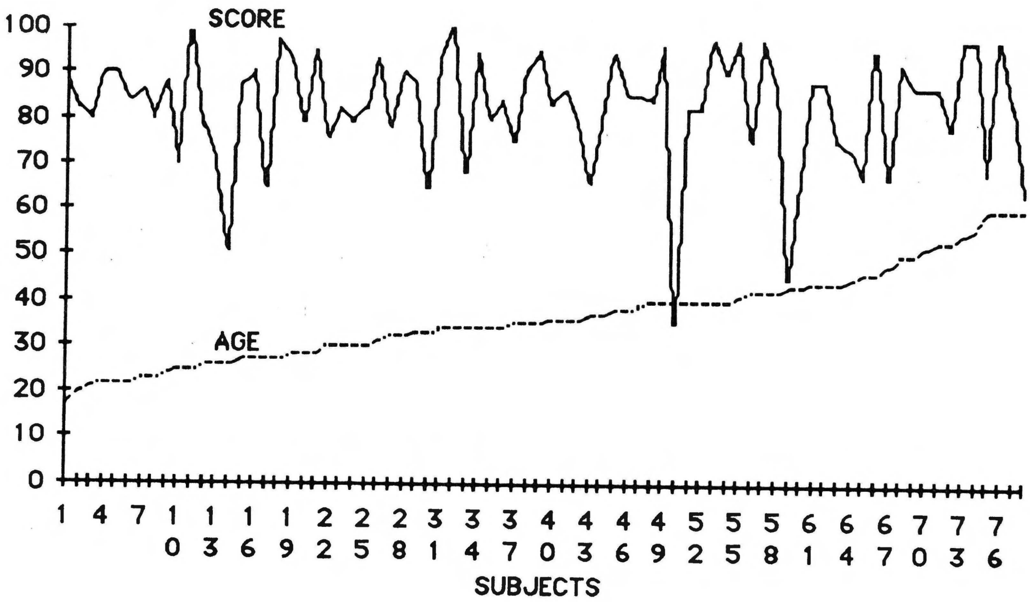

Figure 21. Plot of subject age by drawing score.

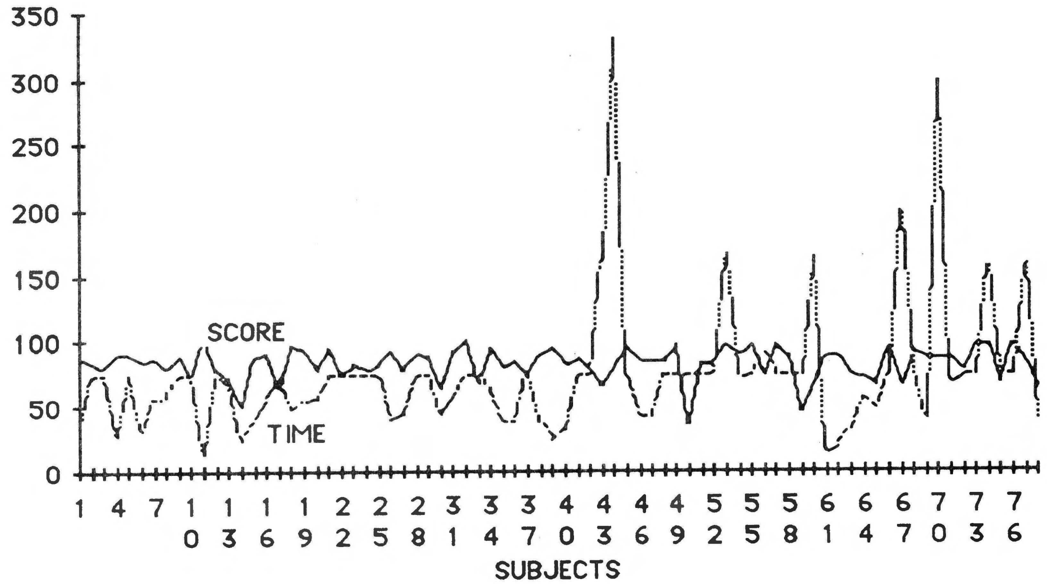

Figure 22. Plot of time on lessons by drawing score.

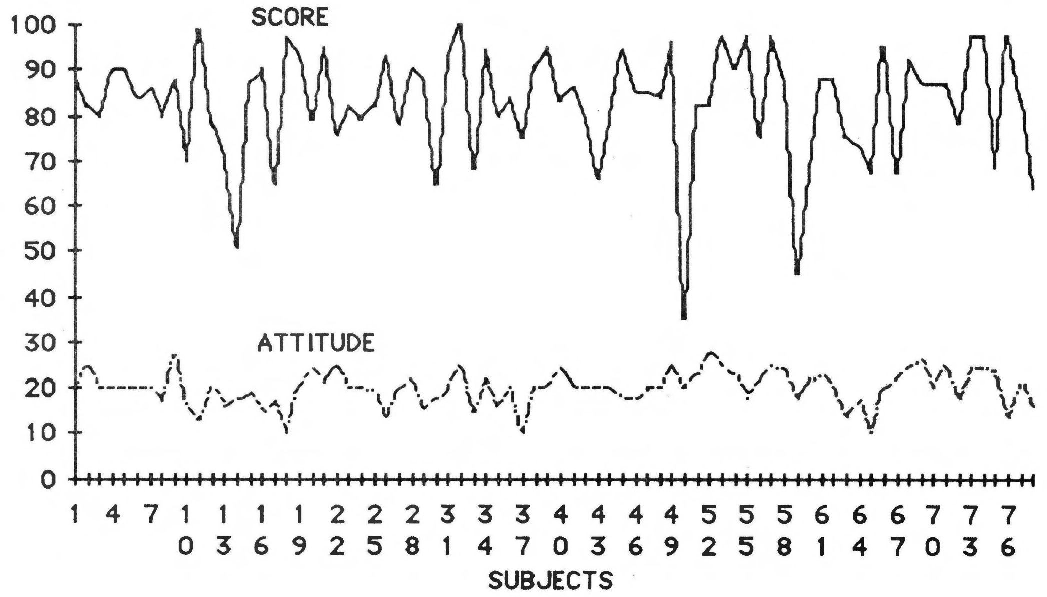

Figure 23. Plot of attitude by drawing score.

Results of the Questionnaire

Some differences were observed between different groups and their questionnaire responses. Fifty-five percent of the inexperienced computer users felt that they learned better from the computer lessons; 60 percent of the nonarchitects felt that way. Forty-three percent of the architects said that they did not understand AutoCAD, with only 15 percent of the other subjects reporting a poor understanding of AutoCAD. Sixty-three percent of the architects responding listed themselves as inexperienced with computers. This compares with 20 percent for the entire sample. None of the architects said they could teach AutoCAD; 50 percent of the others thought that they could. The subjects who had no previous CAD experience stated that they did not understand AutoCAD more than three times as often as those who had experience in CAD systems other than AutoCAD (Figure 24).

Results of the questionnaire showed no significant differences between categories of test subjects with respect to age, sex, and background. Subjects were ranked according to their total favorable responses. This analysis also ranked the test items and reported the percentages of subjects who agreed with the item statement. All statements were worded positively for this purpose, though half were worded negatively in the actual questionnaire (see Appendix D). Agreement with the statements indicated a favorable attitude toward the computer-based training or some component related to it. Notice that all of the statements in Table 4 have more than 75 percent of the users in agreement. Lines are drawn in Table 5 to indicate the cutoff for 50 and 25 percent agreement. Tables 4 and 5 list the questionnaire items in descending order of agreement.

The program used to analyze the questionnaire (the SPP package noted in Chapter 2) provided information on test reliability and item analysis. The reliability coefficient (Cronbach's alpha) was 0.82, which was in the acceptable range for predicting that the questionnaire would give similar results in future testing. A modified caution index was given for both the test subjects and items on the questionnaire. This index reports subjects who answer the questions in an unusual pattern compared with the rest of the sample and also items for which responses deviate from the majority of the subjects. In the case of subjects, the index would indicate that a person did not conform with the attitude expressed by the rest of the group. In the case of items, it would identify those that did not conform to the favorable-unfavorable scale of the test. Items that did not depend on a pro or con attitude were those such as nos. 23 and 24:

- The computer helps me consider different possibilities in my design.
- The reminder pages were annoying.

These statements had high caution indices and can be interpreted as reflecting an attitude on a scale other than favorable-unfavorable. In general, items or subjects having high caution indices that fall in the middle of the scale carry more information. The critical value used for the modified caution index was 0.30. Appendix C, the Student Problem (SP) chart, reports further information about items and students.

Analysis of Findings

The test scores were uniformly good, even though the time spent and the subjects' backgrounds varied widely. This finding suggests that the professionals involved in this test sample knew enough about their own state of knowledge to spend extra time on material they did not fully understand. Such audience control could probably be included

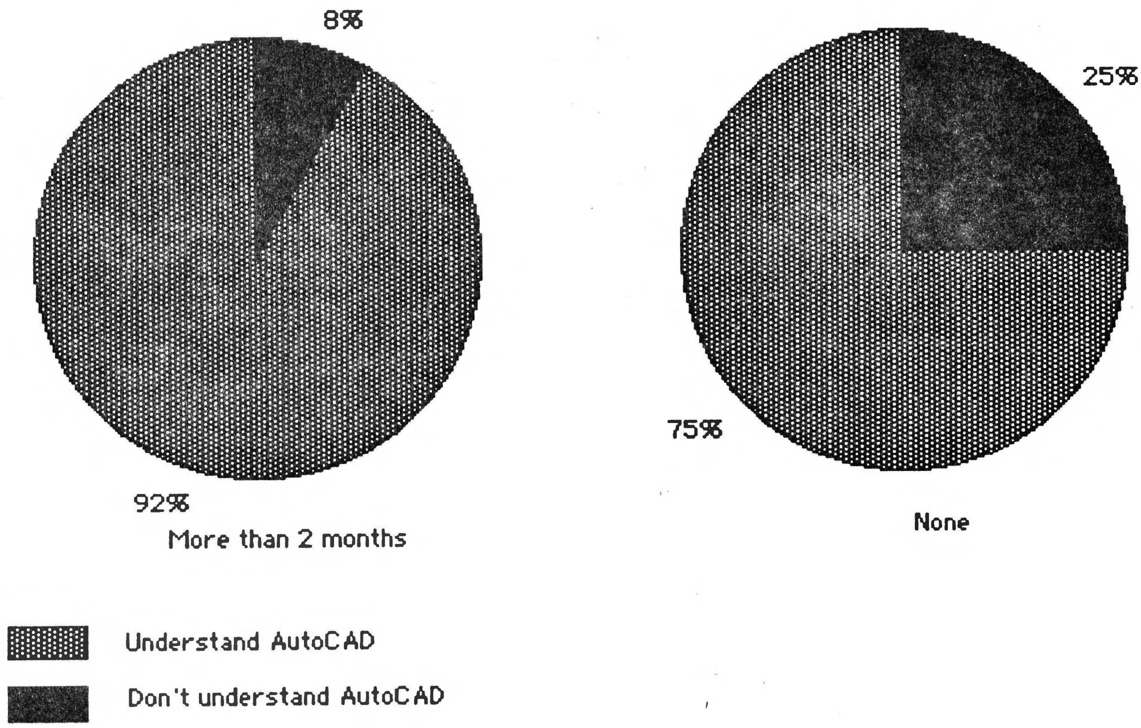

Figure 24. Understanding of AutoCAD based on CAD experience.

in many program options with confidence that users will exercise that control wisely. In some studies of computer-aided instruction with less sophisticated users than tested here, this statement has not proven true.[4]

One condition that became apparent early in the testing was that students with certain learning styles had more difficulty with the computer-based tutorial than others. Three types of learning styles were identified: "discovery" or those who prefer to explore the software undirected, "structured" or those who prefer a set plan for each learning objective, and "guided discovery" or those who like some direction but may choose to explore at times. It was noted in a previous report[5] that students with a "guided discovery" mode of learning make better use of context-sensitive embedded help. In this test, such learners also found the tutorials more helpful. "Discovery" learners often left the lesson format to experiment on their own. While they did learn a great deal, they may not have used their time as efficiently. Their experimentation might well have been postponed until they had at least skimmed the lessons. Users with a "structured" learning style were often frustrated by the freedom to explore and the lack of a detailed course of study and user manual.

[4] E. Steinberg, "Review of Student Control in Computer-Assisted Instruction," *Journal of Computer-Based Instruction*, Vol 3 (1977), pp 84-90.

[5] M. Stoddard, *Learning Styles and Embedded Training: A Case Study*, Government Report No. ED-274 305 (Department of Energy, Los Alamos National Laboratory, 1985).

Table 4

Items With 75 Percent or Greater Agreement

Questionnaire Item	**Agree (%)**	**Disagree (%)**
Computers are helpful in the design process.	100	0
I liked being able to page back and use an index.	99	1
Trying the AutoCAD commands helped me learn.	99	1
I like working with computers.	96	4
I believe that I could use AutoCAD in my work projects.	92	8
I expected to like doing the computerized instruction.	92	8
The use of various colors for text (not the drawings) throughout the lessons was useful.	92	8
The time I used for lessons was well spent.	89	11
I like AutoCAD.	88	12
I like computer-based instruction.	87	13
The lessons were not too difficult for me.	87	13
I usually knew when I did things wrong in the lessons.	86	14
The computer helped me consider different possibilities in my design.	83	17
I understand much about AutoCAD.	83	17
Most of the lessons were not too long for a single session.	75	25
The computer allowed me to express my design ideas as well as I can manually.	75	25

Table 5

Items With Less Than 75 Percent Agreement

Questionnaire Item	Agree (%)	Disagree (%)
The first lesson was easy enough that I didn't feel frustrated.	73	27
I feel generally competent with the AutoCAD concepts covered in the computerized lesson.	73	27
The reminder pages were not annoying.	72	28
I like walk-in training better than scheduled classes and labs.	57	43
I don't need a time schedule to keep myself working on the computer-based instruction.	56	44
50%		
Having previous computer experience is unnecessary before using the embedded AutoCAD instruction.	48	52
I feel capable of teaching AutoCAD to others.	46	54
Having previous experience in drawing and/or drafting is unnecessary before attempting the AutoCAD instruction.	45	55
The lessons helped me learn more quickly than I do from classrooms or textbooks.	41	59
A teacher need not be present during the computerized lessons.	40	60
I did not need more feedback from the computer program.	36	64
I did not have trouble following the directions in the lessons.	36	64
25%		
I do not need more coursework to use AutoCAD productively.	20	80
A manual covering the lessons is unnecessary.	18	82

The architects showed a tendency to differ in their acceptance of the program; however, too few were tested to make a sound judgment. At one test site, there could have been many more architects involved in the testing, but they were not interested in doing the lessons. Some of them had had experience with another CAD system and resisted learning AutoCAD. At a second test site, where there were no CAD experts on any system, AutoCAD was accepted quickly. The coordinator reported that persons were doing production drawing shortly after completing the lessons. Some individuals at the test sites indicated that they did not want to learn a different CAD system. It should be noted that finding a way to combat bias against learning a new CAD system is an important issue, especially since the data show that those who do learn a second program score higher, require less learning time, and feel that they understand CAD better.

The potential benefit of learning a second CAD system is extremely important for further study. The observed bias seemed to be centered on the hesitancy to learn a different set of procedures in a new system because the individual would be threatened with memory overload. However, the evidence suggests that *conceptual* understanding causes the faster and better learning; when the concepts are established, the procedures are no longer a problem. For example, complex entities can be manipulated in a CAD system by following prompts without grasping the essential "conceptual" qualities of the feature. However, when that feature is discovered in another CAD system, its characteristics become meaningful and the designer imagines ways to explore its possibilities. The process of concept development is thus a matter of hypothesis formation and testing. Embedded instruction offers an especially useful environment for that kind of testing.

Responses from the test subjects indicated that most preferred learning about computer programs from interacting with a computer rather than studying a book. While help is necessary for a few individuals, most become independent very quickly. One attractive aspect of training for adults is that the instructional course need not cover every detail of the entire subject. Once users are comfortable with the concepts and understand the scope of the program, application to specific problems is possible. At that time, reference manuals and other users proficient in the same specialty can serve as efficient instructional guides. The tests have shown that embedded computer-based training can present basic techniques and foster the development of a conceptual approach to problem-solving. However, ECS, the company marketing the program, will supply it with documentation since some users feel more comfortable having a hard-copy manual nearby.

Future Research Direction

Revisions

The test results proved valuable for revising the embedded lessons. A manual was prepared and directions for practice have been color-coded and reworded based on suggestions from the users. Increased and expanded optional feedback messages (including reminders) are scheduled for a new version as are advanced modules. The walk-in training concept needs further study and specific directions for implementation. Future tests include case studies at the test sites to explore ways of adapting to learning styles and past experience.

New Programs

As described above, the tests indicated that those who know two or more programs have a better understanding of CAD concepts. For designers to make the computer a part of their design process, an expert level of understanding of CAD is needed. Learning a second system may be especially valuable for that reason. In addition, there are many other advantages to learning a second system, including cost, standards, and ensured compatibility with existing software or drawings.

The results concerning bias against learning a second CAD system have prompted a new line of research. Tutoring software is being designed and implemented for a second CAD system, MicroStation. Using an approach suggested elsewhere,[6] the new instructional program will offer special context-sensitive help to users who indicate that they already know AutoCAD. This help is likely to be applicable to a large percentage of USACE personnel. Figures 25 through 27 show examples of how that feature will work. Users will be told that such help is available. The idea is to make users feel that the new lessons will build upon their past knowledge rather than treat them as beginners. In interviews with those resistant to learning new software, users have said, "I don't have the time to do that" and "I am just getting really good at the system I have." They expect the second system to be totally different and as difficult to learn as the first. Actually, in many cases, knowledge of another CAD system is helpful, as the tests have shown, but in a few cases those who know AutoCAD will have to "unlearn" that program and may need extra help. The lesson design takes this possibility into account. The approach to meeting individual needs will be evaluated carefully to determine if more complex, extensive programs of diagnostics and adaptive branching should be attempted.

In response to requests for more feedback and giving the user more control over the program, the new program will offer an optional exercise check to monitor the drawing file and offer very specific information to the user. This program will diagnose user additions to the drawing data base. If they satisfy the requirements of the task stated in the exercise, the user will receive the "OK" feedback. If the requirements are not met, the program will attempt to determine how the problem occurred and offer corrective feedback if possible. For unpredicted errors, the exercise should be repeated and the user encouraged to try again. Also, there should be a reminder to try the exercise if no changes have been made in the drawing file. The expert critic will be available only if the user calls the "check" function. If the student is merely browsing or reviewing, he or she may not choose to be interrupted by the computer system. Figure 28 shows an example of this diagnostic and prescriptive process.

These program improvements are intended to help overcome bias against learning new CAD software. Giving the learner more options and more precise feedback should also make the process more efficient.

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[6] D. Brown, *From Pascal to C* (Wadsworth Publishing, 1985).

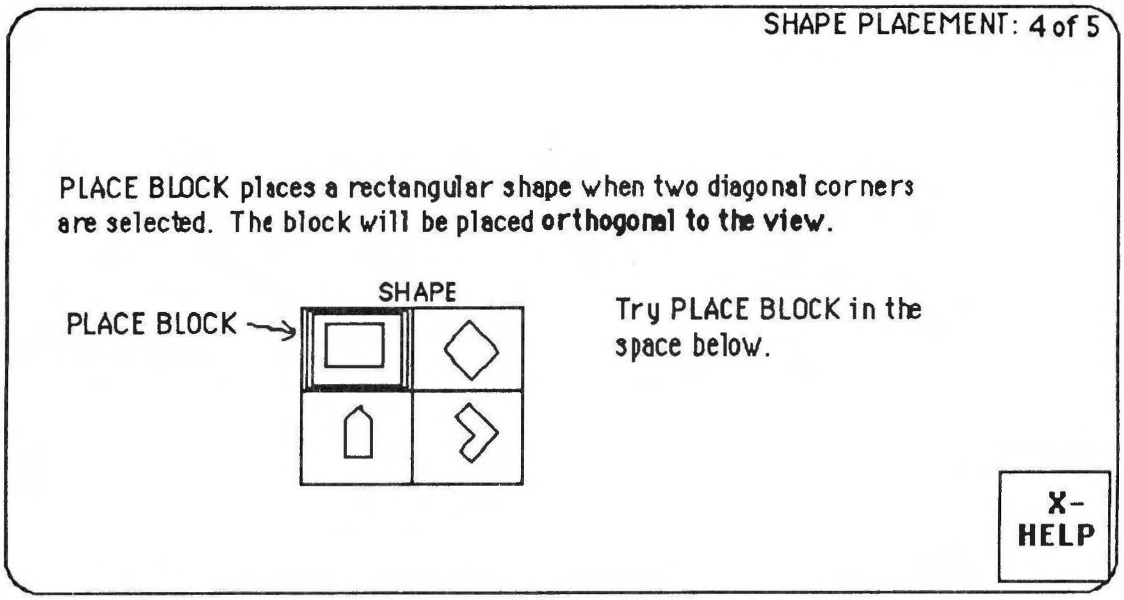

Figure 25. Page requiring help. This screen may introduce problems for users who know AutoCAD. The drawing shows the picture found on the MicroStation menu template.

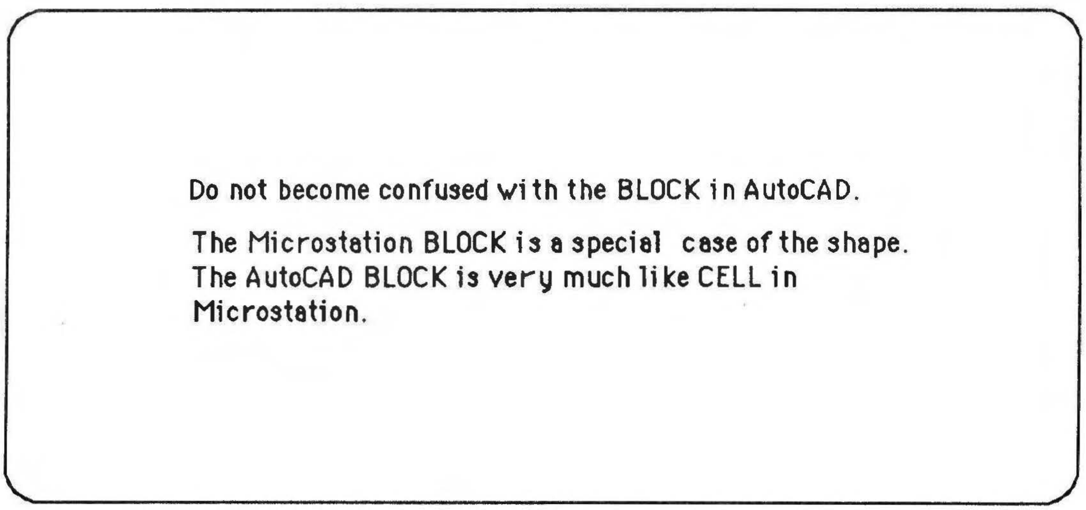

Figure 26. Help for users experienced with AutoCAD. AutoCAD users may have a problem with terminology here. They will, however, have a conceptual understanding of complex entities, once the naming is explained that the new CAD learner lacks.

The BLOCK is a special case of shape. Use the BLOCK command when you wish to place a rectangular shape.

Figure 27. Help for MicroStation users. New MicroStation users receive the message above. They should not find the BLOCK confusing; however, unless they have some previous CAD experience, they probably have no deeper understanding about complex entities.

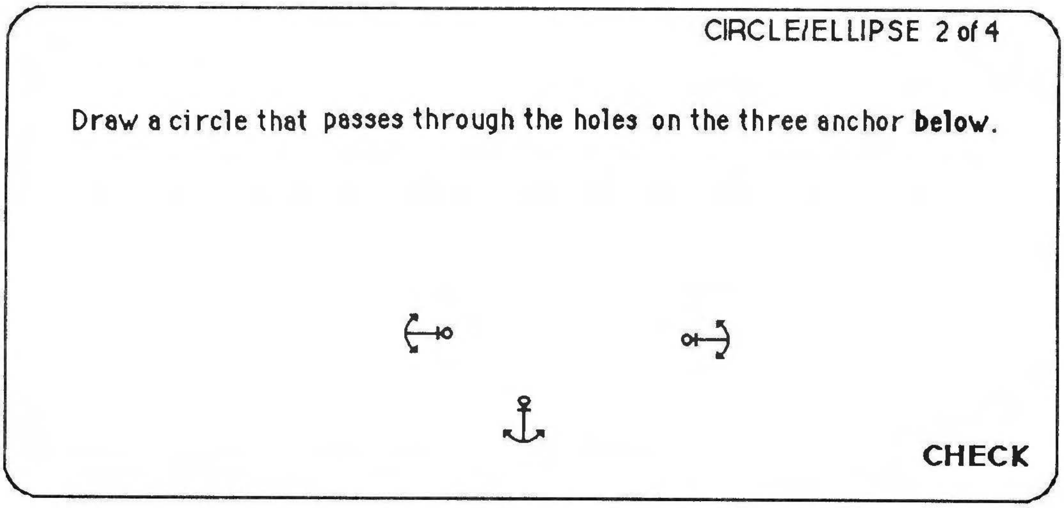

Figure 28. Check and feedback option. The system will check for the required circle. One of the following concept-oriented messages would be given to the user: (1) "Good work, your circle is correct. Computers are very good at this sort of thing, which is time-consuming for humans"; (2) "The circle is not quite correct. Usually we know the radius or the center of a circle but not that is not the case here. Try PLACE CIRCLE EDGE"; (3) "I can't find your circle. Try again and then check."

4 CONCLUSIONS AND RECOMMENDATIONS

A computer-based educational system has been developed and tested in the field. The system uses embedded technology, in which the instructional program is contained within the actual software to be learned. Users thus can work through a training program at their own pace and according to their individual needs. In addition, users are afforded hands-on experience with the system they will actually be using in daily operations, making the training more realistic than in other types of instruction (e.g., an off-site course on a dissimilar system). Embedded training programs also offer the advantage of being more cost-effective than other options. Estimates based on the cost of producing the embedded instruction compared with classroom training offered by a vendor, including the salaries of the professionals being trained and travel/per diem costs, show an 8:1 advantage in favor of CBI.

To develop the embedded program, USA-CERL first studied A/Es who were learning to use a CAD system and identified educational elements that would be needed to ensure a successful program. A prototype program for learning CAD was then produced and officially tested at three District/Division Offices plus some volunteer sites.

The results showed that A/Es benefit from online instruction in the CAD program they wish to learn. The wide variability in the time spent studying the lessons and in the learning strategies used by the students underscore the objectives of embedded instruction--self-paced, self-serving education. A questionnaire administered to test participants revealed a preference for this type of instruction over traditional classroom methods.

The professionals who served as test subjects showed a clear understanding of their own needs and state of knowledge, which optimized their time spent in the instructional program. This finding suggests that tutorials for professionals at different levels could be structured to be "intelligent" in providing only the degree of help needed by the learner. In other words, educational software for such an audience can be largely learner-controlled.

A major factor influencing motivation to use the embedded program was the user's reluctance to learn a second CAD system. A/Es who may have had a difficult time learning one CAD program expected the training to be complicated and not worth their time. In fact, the research has shown that users who know more than one CAD program have a much *easier* time learning another one because they use conceptual knowledge rather than a procedural approach. This area merits further study to find ways of removing the bias against learning new programs.

The product of this research was the revised and enhanced software instruction package which was turned over to Electronic Courseware Systems, Inc., through a CRDA. It is being marketed nationwide as the "Teaching Assistant for AutoCAD."

It is recommended that USA-CERL continue to study embedded instruction programs to identify other potential applications for USACE. In addition, the research should be directed toward finding ways to increase users' willingness to approach new CAD programs as a way of becoming proficient in the CAD concept. This increased proficiency will enable A/Es to use CAD in the early stages of design, become more productive in daily drafting work, adapt more easily to new software programs introduced into the work environment, and gain greater confidence and comfort with automated drafting.

APPENDIX A:

FORMS FOR SUBJECT INFORMATION

Personal Record

Name ______________________ Div ____ Phone ____ ID. No. ____________

ID. No. ______________ SEX ______________ AGE ______________

Background:

Architect ☐
Engineer ☐ Engineering discipline ______________
ORA ☐
Other ______________________________

Student ☐
Year completed education ______________

Experience:

Computers: more than 1 year ☐
2 months to 1 year ☐
less than 2 months ☐

AutoCAD: more than 6 months ☐
less than 6 months ☐
none ☐

Computer Graphics Programs (other than AutoCAD)

extensive ☐
little ☐
none ☐

Figure A1. Personal record form.

ID. NO. _______________ **TIME AND COMMENTS**

LESSON	TIME IN	TIME OUT	TOTAL

COMMENTS:

Figure A2. Time and comments form.

APPENDIX B:

FINAL DRAWING TEST

AutoCAD Final Evaluation Exercise

READ THIS COMPLETELY BEFORE YOU BEGIN YOUR DRAWING. This is a final excercise to see what you have learned about AutoCAD. The computer should keep a record of the time you spend on the drawing. Just in case something happens, I would like you to enter your total time in the title block just before you save the drawing. Please save the drawing to the floppy disk drive (A:). If you don't understand about that, see your test coordinator.

You may follow the suggestions below to obtain the drawing. The objective is to make an exact copy of the castle drawing and a title block that contains the information listed. Your drawing should look like EXAMPLE 1. EXAMPLE 2 is included to show you exact locations and a suggested grid. You don't need to follow the steps if you would rather do it your own way, but be sure that your final result is the same. Suggestions for specific commands are only meant to guide you.

1. From the AutoCAD main menu begin a new drawing. Name it "A:TEST***" where "***" represents your three digit ID number. Be sure that you have a formatted disk in drive A.

2. Set the drawing parameters:
   UNITS: Architectural
   LIMITS: lower left (-10', -10') upper right (94', 54')
   (Your screen may be a little larger in one of the dimensions, but be sure that the X and Y are at least as large as the above.)
   Be sure to ZOOM: ALL after you set the limits.
   Set the GRID: and SNAP: to any values that seem to be helpful.
   Don't forget that COORDS: and ORTHO: may be turned on.
   BLIPS: may be turned off if you like.
   You may want to use OSNAP: for accuracy.

3. Create a layer named CASTLE and color it red. Draw the castle on layer CASTLE to the exact dimensions of EXAMPLE 1. You will need to use LINE:, ARC: and CIRCLE to accomplish the drawing. You may type numeric input or use the drawing tools for accuracy. Don't forget that you can use COPY:, MIRROR: and ARRAY: to save time. The points on the example show you centers for the door arc and the circle. The small circles have a diameter of 1'. To duplicate the circles, try ARRAY: POLAR (9 items fill 180 degrees) and ARRAY: RECTANGULAR. The windows measure 4' X 8'. Also, if you need to edit, don't forget MOVE:, CHANGE:, and BREAK.

4. **Create a layer named TITLE, which you will leave white. Make a block called TITLE which contains the information shown on the drawing. You may find it helpful to ZOOM: in on the title block for the detail** work. The trace width for the border is 6". If you are in snap mode, you will probably need to turn it off to complete the border. Text size for the lettering should be 1'. Insert the TITLE block on layer TITLE and enter the appropriate information.

5. For an added challenge (optional), create a layer named dimension and enter 3 or 4 dimensions that seem important to you. Remember that you may need to change the scale of the dimensioning text and arrows with the DIMSCALE variable (Try a value of 60.00).

The last thing you should do before you save your work is enter the total time you spent on the exercise in the blank on your title block.
When you are finished with the drawing, type SAVE. The computer will ask: file name <test***>.
If the name is correct, press Enter and your file will be saved.
Make corrections in the name if necessary.

After the file is saved to the floppy disk, give the disk to the coordinator.
You may then QUIT the file and exit AutoCAD.

Congratulations!

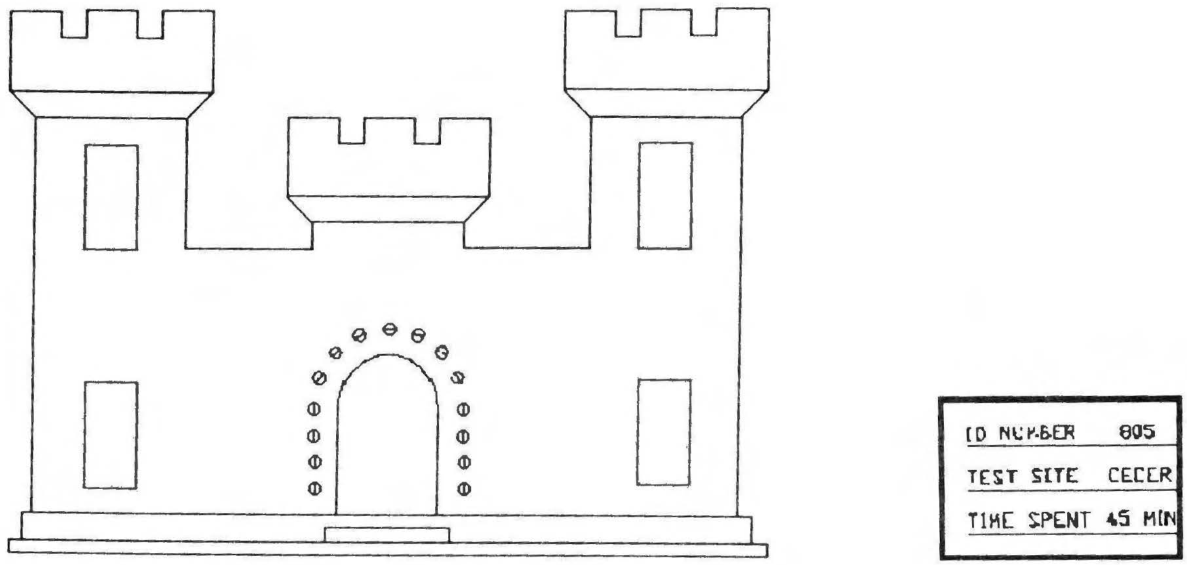

Figure B1. Example 1.

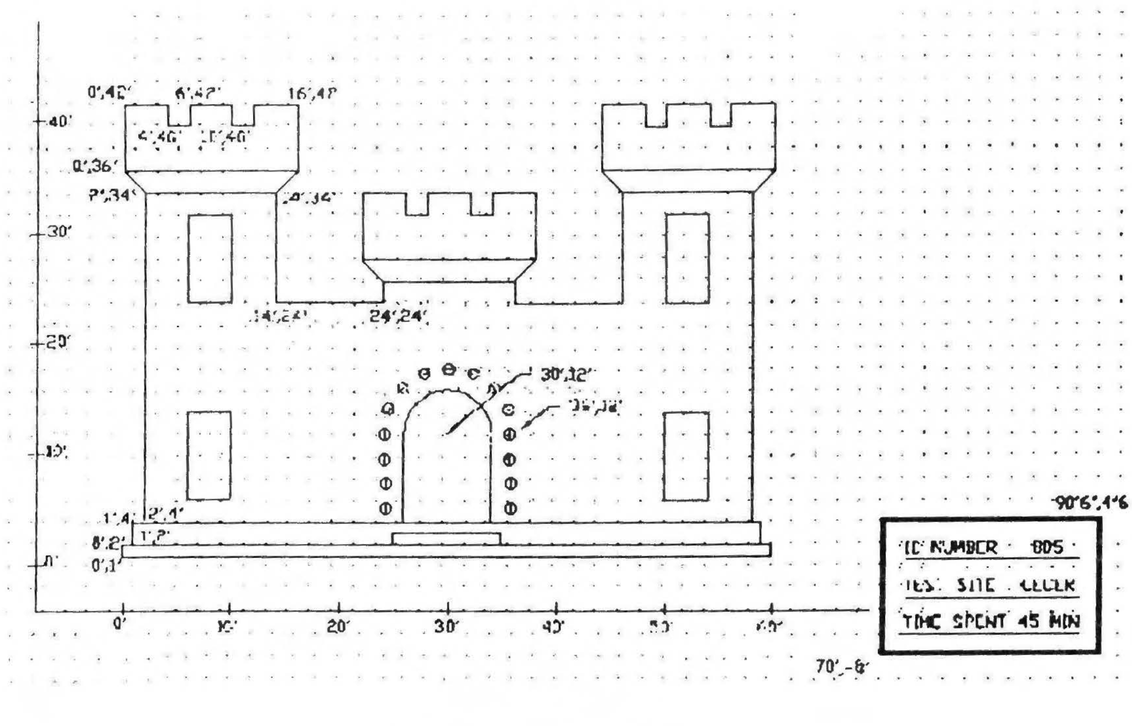

Figure B2. Example 2.

APPENDIX C:

STUDENT PROBLEM CHART

The SP chart (Figure C1) shows individual test subjects' responses on each test item. Responses that agree with the "pro" attitude toward the use of computers, computer-based training, and the CAD system are represented by an asterisk (*) and those disagreeing are represented by a digit. The subjects are listed vertically with their ID numbers at the beginning of each row and the items are listed horizontally with item numbers at the top and bottom of the column. The points at which each subject's responses would be expected to be in agreement, based on his or her score, are plotted by the solid line. The points at which each item would be expected to be answered with agreement, based on the total agreement score for the item, are plotted by the dotted line. All subject responses to the left of the solid line would be expected to be represented by asterisks and those to the right by digits. All item responses above the dotted line would be expected to be represented by asterisks and those below by digits. The chart produced in this study was very close to expectations for both subjects and items. The results show that the subject group was fairly homogenous and that the items measured the expected traits.

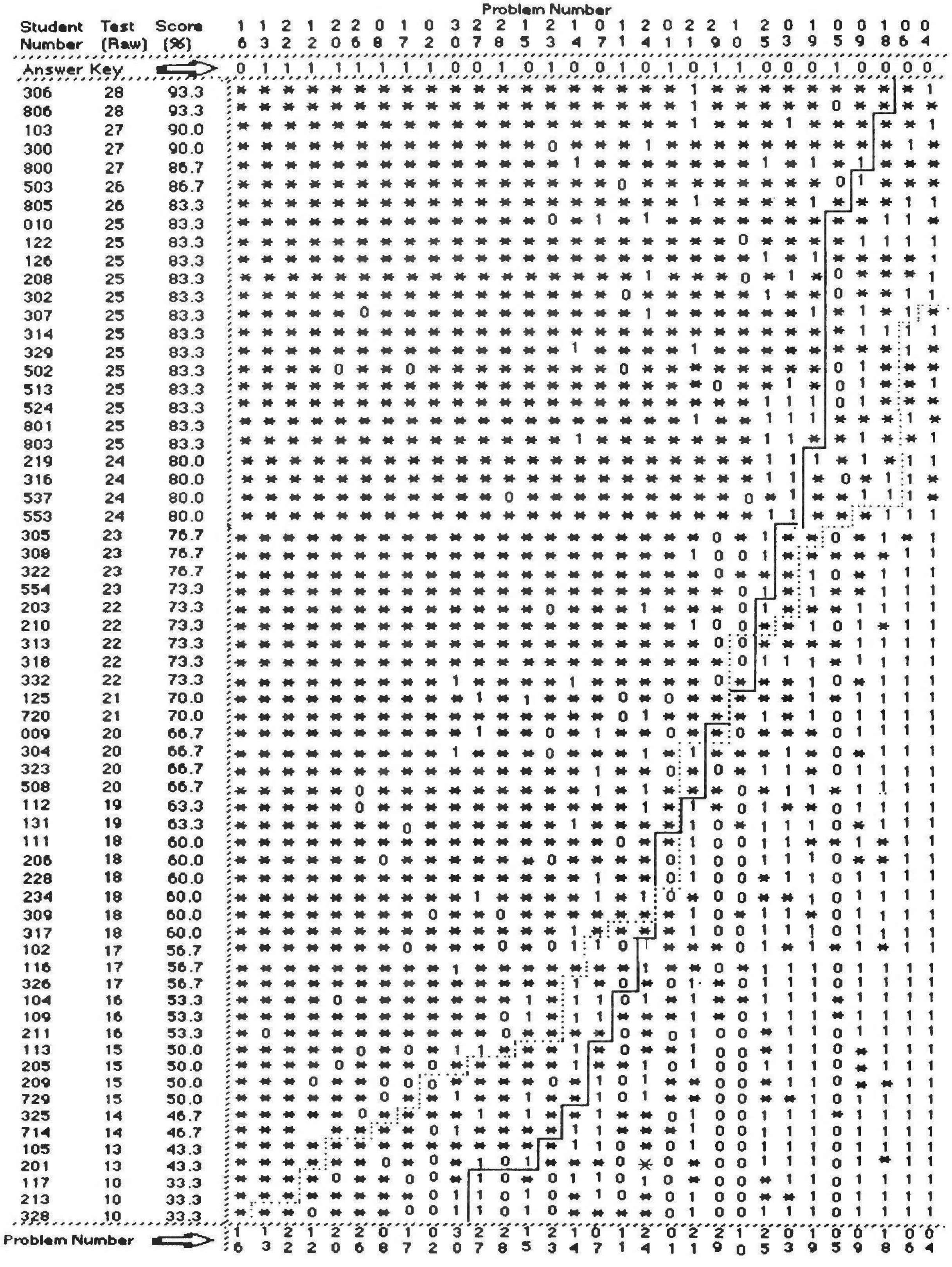

Figure C1. SP Chart.

APPENDIX D:

QUESTIONNAIRE

ID NUMBER____________ **QUESTIONNAIRE**

RESPOND TO THE FOLLOWING STATEMENTS BY CHECKING THE AGREE OR DISAGREE COLUMN.

PLEASE DO NOT OMIT ANY ITEMS, PICK THE ONE THAT BEST APPLIES.

	AGREE	DISAGREE
1. I feel generally competent with the AutoCAD concepts covered in the computerized lessons.		
2. I like AutoCAD.		
3. Having previous experience in drawing and/or drafting is necessary before attempting the AutoCAD instruction.		
4. A manual covering the lessons is necessary.		
5. The lessons helped me learn more quickly than I do from classrooms or textbooks.		
6. In order to use AutoCAD productively, I need more coursework.		
7. The computer won't allow me to express my design ideas as well as I can manually.		
8. I believe that I could use AutoCAD in my work projects.		
9. I had trouble following the directions in the lessons.		
10. I feel capable of teaching AutoCAD to others.		
11. The first lesson was easy enough that I didn't feel frustrated.		
12. I like working with computers.		
13. Trying the AutoCAD commands helped me learn.		
14. Most of the lessons were too long for a single session.		
15. The lessons were too difficult for me.		

		AGREE	DISAGREE
16.	Computers are not helpful in the design process.		
17.	The time I used for the lessons was well spent.		
18.	I needed more feedback from the computer program.		
19.	A teacher should be present during the computerized lessons.		
20.	The use of various colors for text (not the drawings) throughout the lessons was useful.		
21.	I need a time schedule to keep myself working on the computer-based instruction.		
22.	I liked being able to page back and use an index.		
23.	The computer helps me consider different possibilities in my design.		
24.	The reminder pages were annoying.		
25.	Having previous computer experience is necessary before using the embedded AutoCAD instruction.		
26.	I expected to like doing the computerized instruction.		
27.	I don't understand much about AutoCAD.		
28.	I usually knew when I did things wrong in the lessons.		
29.	I like walk-in training better than scheduled classes and labs.		
30.	I don't like computer-based instruction.		
31.	I prefer micro CADD to mainframe CADD.		
32.	I would like to see more advanced lessons made available.		

Please use the back of this sheet for additional comments or suggestions about the computer-based instruction.

APPENDIX E:

RAW DATA

Table E1

Demographic Data

ID	Sex	Age	Background	CompExp	ACADExp	GraphExp	Time on Less	Drawing scor	Raw Score
9	m	28	1	1	3	3	540	93	20
10	m	22	4	3	2	3	270	90	25
40	m							78	
41	m							97	
42	m							97	
80	m	22	1	1	1	2		90	
101	m	46	4	3	3	3	480	67	
102	f	26	2	1	3	2		78	17
103	m	43	2	2	2	2		45	27
104	m	26	12	1	1	2	660	70	16
105	f		2	2	3	3	1440	84	13
106	m	52	2	2	3	3	2870	87	
109	m	37		3	3	3	1620	66	16
111	m	39	2	1	2	2	415	85	18
112	m	45	2	3	3	3	570	73	19
113	m	23	2	1	3	3	570	86	15
116	m	18		2	3	2	360	88	17
117	m	42	1	2	3	2	900	75	10
119	m							80	
122	m	48	4	3	3	3	1980	67	24
125	m	34	2	2	3	3	570	93	21
126	f	27	2	1	3	2	405	88	25
127	f	37	4	3	3	3	3300	79	
128	m	61	4	3	3	3	360	63	
131	m	22	2	1	2	1	315	84	19
201	m	34	2	1	3	2		100	13
202	m	60	2	3	3	3		68	
203	m	34	4	3	3	3		68	22
205	m	27	2	1	3	2	565	90	15
206	m	26	2	1	3	2	240	51	18
207	f	55	1	3	3	3		97	
208	m	42	1	1	3	1		97	25
209	m	50	4	1	3	1		92	15
210	m	53	2	1	3	1	695	87	22
211	m	36	2	1	3	3	320	83	16
212	m	60	2	3	3	3		97	
213	f	28	1	3	3	3	570	79	10
214	m	40	2	3	3	3		84	
217	m	40	2	3	3	3		96	
219	m	36	2	1	3	1		85	24
220	m	38	4	1	3	1		94	
221	m	41	4	1	3	3		97	
224	m	46	2	1	3	2		95	
226	m	40	4	3	3	1		35	
228	f	38	4	1	3	2	420	85	18
234	m	32	4	1	3	1	445	78	18
237	f	40	4	1	3	1			
300	m	40	4	2	3	3			
302	m	21	4	2	2	2		80	25
304	m	30	4	3	3	3		76	20
305	m	33	4	1	3	1		87	23
306	m	27	1	2	3	3	720	65	28
307	m	25	4	3	3	3		70	25
308	f	43	1	3	3	3	1635	67	23
309	f	24	2	1	2	1		88	18
313	m	30	1	1	3	2			22
314	m	20	4	1	3	2			25
316	m	28	4	2	3	3		95	24
317	m	35	2	3	3	3		75	18
318	m	33	2	2	3	3	435	65	22
322	f	35	2	1	3	3	370	91	23
323	m	30	4	1	3	3		79	20
325	m	44	1	3	3	3	1454	88	14
326	m	40	1	3	3	3	1650	97	17
328	m	42	4	3	3	3		88	10
329	m	30	4	1	3	3			
332	f	32	4	1	3	3		90	22
502	m	31	2		2	3	390	93	25
503	m	27	2	1	3	3	475	97	26
508	m	44	1	1	2	1	195	88	20
513	m	50	2	3	1	3	390	87	25
524	m		4	1	2	2	210	83	18
537	f	25	2	3	2	1	140	99	24
553	m	36	2	1	3	2		79	24
554	f	44	4	1	3	1	325	75	23
714	m	40	4	3	3	2	720	90	14
720	m	23	2	1	3	3	600	80	21
729	m	53	2	2	3	2		78	15
800	m	35	2	1	2	1	238	95	27
801	f	34	3	1	2	3	605	94	25
803	m	56		1	3	1	1575	97	
804	m	60	2	2	3	3	510	83	
805	f	34	2	1	3	2	385	80	26
806	m	34	2	3	1	2	374	84	28

Table E2

Results of Questions 1 Through 10

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
9	0	1	0	1	0	1	1	1	1	0
10	1	1	0	0	1	1	1	1	0	1
40										
41										
42										
80										
101										
102	1	1	0	1	1	1	1	1	1	0
103	1	1	1	1	1	0	0	1	0	1
104	1	1	1	1	1	1	1	1	1	1
105	0	1	1	1	0	1	1		1	0
106										
109	1	1	1	1	1	1	1	1	1	0
111		1	1	1		1	0	1	1	0
112	0	1	0	1	0	1	0	1	1	0
113	1	1	1	1	0	1	0	1	0	0
116	1	1	1	1	0	1	0	1	1	1
117	0	0	1	1	0	1	1	1	1	0
119										
122	1	1	0	1	1	1	0	1	1	0
125	0	1	0	1	1	1	0	1	1	1
126	1	1	0	1		0	0	1	0	1
127										
128										
131	1	1	1	1	0	1	0	1	0	1
201	0	0	1	1	0	0	0	0	1	0
202										
203	1	1	0	1	1	1	0	1	1	0
205	0	0	1	1	0	1	0	1	0	0
206	0	1	1	1	0	1	0	0	0	0
207										
208	1	1	1	1	0	0	0	1	0	0
209	1	0	1	1	0	1	1	0	0	0
210	1	1	0	1	0	1	0	1	1	0
211	0	1	1	1	0	1	0	1	1	0
212										
213	- 0	0	0	1	0	1	1	0	1	0
214										
217										
219	1	1	1	1	1	1	0	1	1	1
220										
221										
224										
226										
228	0	1	1	1	0	1	1	1	1	0
234	0	1	0	1	0	1	1	1	1	0
237										
300	1	1	0	0	1	1	0	1	0	1
302	1	1	0	1	0	1	0	1	0	1
304		1	1	1	0	1	0	1	0	1
305	0	1	1	1	0	0	0	1	0	1
306	1	1	0	1	1	0	0	1	0	1
307	1	1	0	0	1	1	0	1	1	1
308	1	1	0	1	1	1		1	0	0
309	1	0	1	1	0	1	0	1	1	1
313		1	0	1	1	1	0	1	1	0
314	1	1	0	1	1	1	0	1	1	1
316	1	1	1	0	0	1	0	1	0	0
317	1	1	1	1	0	1	0	1	1	0
318	1	1	1	1	1	1	0	1	1	0
322	1	1	0	1	0	1	0	1	0	1
323	0	1	1	1	0	1	1	1	1	1
325	0		1	1	1	1	1	1	1	0
326	0	1	1	1	0	1	0	1	1	0
328	0	0	1	1	0	1	0	1	1	0
329	1	1	0	0	0	1	0	1	0	1
332	1	1	0	1	0	1	0	1	0	1
502	1	1	0	0	0	0	0	1	1	1
503	1	1	0	0	0	0	0	1	1	1
508	1	1	1	1	1	1	1	1	1	0
513	1	1	1	1	0	0	0	1	1	1
524	1	1	1	0	0	0	0	1	1	1
537	1	1	1	0	1	1	0	1	1	0
553	1	1	1	1	1	1	0	1	0	0
554	1	1	0	1	1	1	0	1		0
714	1	0	1	1	0	1	1	1	1	0
720	1	1	0	1	0	1	0	1	1	1
729	1	1	0	1	0	1	1	0	1	0
800	1	1	0	0	1	0	0	1	1	1
801	1	1	1	0	1	1	0	1	0	1
803	1	1	1	1	1	0	0	1	1	1
804	1	1	1	1	1	1	0	1	1	0
805	1	1	0	1	1	1	0	1	0	1
806	1	1	0	0	0	0	0	1	0	1

Table E3

Results of Questions 11 Through 20

ID	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
9	1	1	1	0	0	0	1	1	0	1
10	1	1	1	0	0	0	1	1	0	1
40										
41										
42										
80										
101										
102	0	1	1	1	0	0	0	0	1	1
103	1	1	1	0	0	0	1	0	0	1
104	0	1	1	1	1	0	1	1	1	0
105	0	1	1	1		0	1	1	1	1
106										
109	1	1	1	1	1	0	1	1	1	1
111	0	1	1	0	0	0	1		0	1
112	1	1	1	0	0	0	1	1	0	1
113	0	1	1	1	0	0	0	1	1	1
116	1	1	1	0		0	1		1	1
117	0	1	1	1	0	0	0	1	1	0
119										
122	1	1	1	0	0	0	1	1	0	1
125	0	1	1	0	1	0	1	1	1	1
126	1	1	1	0		0	1	0	1	1
127										
128										
131	1	1	1	1	0	0	0	1	1	1
201	0	1	1	0	1	0	1	1	1	1
202										
203	1	1	1	0	0	0	1	1	0	1
205	1	1	1	1	0	0	1	1	1	0
206	1	1	1	0	0	0	1	0	1	1
207										
208	1	1	1	0	0	0	1	0	0	1
209	0	0	1	0	0	0	0	0	1	1
210	1	1	1	0	0	0	1	0	1	1
211	0	1	0	0	0	0	1	1	1	1
212										
213	0	1	1	0	1	0	1	1	1	1
214										
217										
219	1	1	1	0	0	0	1	0	1	1
220										
221										
224										
226										
228	1	1	1	0	0	0	1	1	1	1
234	1	1	1	0	0	0	1	1	1	1
237										
300	1	1	1	0	0	0	1	0	0	1
302	0	1	1	0	0	0	1	0	0	1
304	1	1	1	0	0	0	1	1	0	1
305	1	1	1	0	0	0	1	1	0	1
306	1	1	1	0	0	0	1	0	0	1
307	1	1	1	0	0	0	1	0	1	1
308	1	1	1	0	0	0	1	0	0	1
309	1	1	1	0	0	0	1	1	0	1
313		1	1	0	0	0	1	1	0	1
314	1	1	1	0	0	0	1	1	0	1
316	1	1	1	0	0	0	1	1	0	1
317	1	1	1	1	0	0	1	1	1	1
318	1	1	1	0	0	0	1	1	1	1
322	1	1	1	0	0	0	1	1	1	1
323	1	1	1	0	0	0	1	1	0	1
325	1	1	1	0	1	0	11	1	1	1
326	0	1	1	1	0	0	11	1	1	1
328	1	0	1	0	1	0	0	1	1	1
329	1	1	1	1	0	0	1	0	1	1
332	1	1	1	1	0	0	1	1	1	1
502	0	1	1	0	0	0	0	0	0	0
503	0	1	1	1	0	0	1	0	0	1
508	1	1	1	0	0	0	1	1	1	1
513	1	1	1	0	0	0	1	0	0	1
524	1	1	1	0	0	0	1	0	1	1
537	1	1	1	0	0	0	1	1	0	1
553	1	1	1	0	0	0	1	1	0	1
554	1	1	1	0	0	0	1	1	1	1
714	1	0	1	1	0	0	1	1	1	1
720	0	1	1	0	0	0	1	1	1	1
729	0		1	0	1	0	1	1	1	0
800	1	1	1	0	0	0	1	0	1	1
801	1	1	1	0	0	0	1	0	1	1
803	1	1	1	1	0	0	1	0	0	1
804	1	1	1	1	0	0	1	1	1	1
805	1	1	1	0	0	0	1	0	1	1
806	1	1	1	0	0	0	1	0	0	1

Table E4

Results of Questions 21 Through 30

ID	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
9	0	1	0	0	0	1	1	1	1	0
10	0	1	0	1	0	1	0	1	1	0
40										
41										
42										
80										
101										
102	0	1	0	1	1	1	0	0	1	0
103	1	1	1	0	0	1	0	1	1	0
104	1	1	1	1	1	1	0	1	1	0
105	1	1	1	0	1	1	0	1	0	0
106										
109	1	1	1	0	1	1	1	0	1	0
111	1	1	1	0	1	1	0	1	0	0
112	1	1	1	1	1	0	0	1	1	0
113	1	1	1	0	0	0	1	1	0	1
116		1	1	1	1	1	0	1	0	1
117	0	1	0	1	0	1	1	0	0	0
119										
122	0	1	1	0	0	1	0	1	1	
125	0	1	1	0	0	1	1	1	1	0
126	0	1	1	0	1	1	0	1	1	0
127										
128										
131	1	1	1	0	1	1	0	1	0	0
201	0	1	1	1	1	1	1	0	0	0
202										
203	0	1	0	1	1	1	0	1	1	0
205	1	1	1	1	1	1	0	1	0	0
206	1	1	0	0	1	1	0	1	0	0
207										
208	0	1	1	1	0	1	0	1	1	0
209	0	1	0	1	0	1	0	1	0	0
210	1	1	1	0	0	1	0	1	0	0
211	1	1	1	0	0	1	0	0	0	0
212										
213	1	1	0	0	1	1	1	0	0	1
214										
217										
219	0	1	1	0	1	1	0	1	1	0
220										
221										
224										
226										
228	1	1	1	0	0	1	0	1	0	0
234	0	1	1	1	0	1	1	1	0	0
237										
300	0	1	0	1	0	1	0	1	1	0
302	0	1	1	0	1	1	0	1	1	0
304	1	1	0	1	0	1	0	1	1	1
305	0	1	1	0	1	1	0	1	0	0
306	1	1	1	0	0	1	0	1	1	0
307	0	1	1	1	0	0	0	1	1	0
308	1	1	1	0	1	1	0	1	0	0
309	1	0	1	0	1	1	0	0	0	0
313	0	1	1	0	0	1	0	1	0	0
314	0	1	1	0	0	1	0		1	0
316	0	1	1	0	1	1	0	1	1	0
317	1	1	1	0	1	1	0	1	0	0
318	0	1	1	0	1	1	0	1	1	0
322	0	1	1	0	0	1	0	1	0	1
323	0	1	1	0	1	1	0	1	0	0
325	1	1	1	0	1	0	1	1	0	0
326	1	1	1	0	1	1	0	1	1	0
328	1	1	0	0	1	1	1	0	0	1
329	1	1	1	0	0	1	0	1	1	0
332	0	1	1	0	0	1	0	1	1	0
502	0	1	1	0	0	1	0	1	1	0
503	0	1	1	0	0	1	0	1	1	0
508	0	1	1	1	0	0	0	1	1	0
513	0	1	1	0	0	1	0	1	0	0
524	0	1	1	0	1	1	0	1	1	0
537	0	1	1	0	0	1	0	0	1	0
553	0	1	1	0	1	1	0	1	1	0
554	0	1	1	0	1	1	0	1	1	0
714	1	1	1	0	1	1	0	1	0	1
720	0	1	1	1	1	1	0	1	1	0
729	0	1	1	1	0	1	0	1	0	1
800	0	1	1	0	1	1	0	1	1	0
801	1	1	1	0	1	1	0	1	1	0
803	0	1	1	0	1	1	0	1	1	0
804	1	1	1	0	0	1	1	1	0	0
805	1	1	1	0	0	1	0	1	1	0
806	1	1	1	0	0	1	0	1	1	0

USA-CERL DISTRIBUTION

Chief of Engineers
ATTN: CEIM-SL (2)
ATTN: CEIM-S
ATTN: CECC-P
ATTN: CECW
ATTN: CECW-O
ATTN: CECW-P
ATTN: CECW-RR
ATTN: CEEC
ATTN: CEEC-C
ATTN: CEEC-E
ATTN: CEEC-ED
ATTN: CEEC-ES
ATTN: CEEC-EC
ATTN: CERD
ATTN: CERD-C
ATTN: CERD-M
ATTN: CERM
ATTN: DAEN-ECE-M
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM
ATTN: DAEN-ZCZ

USAEHSC, ATTN: Library 22060
ATTN: CEHSC-FM
ATTN: CEHSC-FB-S

US Army Engineer Districts
Alaska 99506
ATTN: CENPA-EN-BB-A
Charleston 29402
ATTN: CESAC
ATTN: CESAC-EN-DF
ATTN: CESAC-EN-DA
Fort Worth 76107
ATTN: CESWF-ED-DA
Kansas City 64106
ATTN: CEMRKED-P
Memphis 98103
ATTN: CELMM
ATTN: CELMN-IM-R
Mobile 36628
ATTN: CESAM
Nashville 37202
ATTN: CEORN
Norfolk 23510
ATTN: CENAD-IMO
Philadelphia 19106
ATTN: CENAP
Sacramento 95814
ATTN: SPKED-A (2)
ATTN: CESPK
ATTN: CESPK-PB
ATTN: CESPK-CO-C
Saint Louis 63101
ATTN: CELMSED-D
Saint Paul 55101
ATTN: CENCS
Savannah 31402 (3)
ATTN: CESAS-EN-DA
Vicksburg 39180
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