A Comparative Study of Computer-Assisted Instruction Versus Classroom Training of Naval Technicians of Varying Aptitude Levels

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A COMPARATIVE STUDY OF COMPUTER-ASSISTED INSTRUCTION VERSUS CLASSROOM TRAINING OF NAVAL TECHNICIANS OF VARYING APTITUDE LEVELS

BY

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B.S., State University of New York at Cortland, 1977

THESIS

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Summer Quarter
1979
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A COMPARATIVE STUDY OF COMPUTER-ASSISTED INSTRUCTION VERSUS CLASSROOM TRAINING OF NAVAL TECHNICIANS OF VARYING APTITUDE LEVELS

INTRODUCTION

Programmed Instruction

Any discussion of computer-assisted instruction (CAI) cannot proceed very far without first examining the issue of programmed instruction (PI). CAI is a relatively recent development in the area of education and training, whereas PI enjoys a somewhat longer history. Nonetheless, PI lies at the very heart of CAI and forms the base on which CAI exists. CAI then, may be viewed as a mode or type of PI.

B. F. Skinner's work in the 1940's with the principles of operant conditioning laid the groundwork for the concept of PI (Garner, 1966). Operant conditioning is a type of conditioning whereby an emitted response is reinforced. The reinforcement should increase the strength of the response and presumably increase the chances that the response will occur again (Munn, Fernald, & Fernald, 1972). Operant conditioning, in which an individual is conditioned to behave in the direction of a predetermined goal, is achieved through the contingent reinforcement of a series of steps. These steps of action are linked together in a chain of successive approximations.
Each link of the chain approximates the end goal slightly more than the previous link. This chain of successive approximations is followed until the end behavior is achieved (Garner, 1966).

In this respect, PI makes use of the sequencing of small successive steps and contingent reinforcement to achieve some desired end goal, namely, achieving the lesson objective. This "Skinnerian" or linear form of PI requires the student to proceed through a forward moving chain in a step-by-step fashion until the end behavior is achieved.

The step-by-step sequence, as it pertains to PI, refers to the individual segments or frames of a PI lesson. Each frame might be considered one step of the entire PI lesson. These frames, which should flow logically from one to the next, should build upon each other and approximate the lesson objective.

Periodically, progress should be monitored in order to assure that the student is comprehending the lesson material (Wilson & Tosti, 1972). Typically, this is accomplished by incorporating multiple choice or true/false questions within the PI lesson itself. By so doing, student performances can be checked and appropriate actions taken within the concept of reinforcement.

Deterline (1962) argues that all learned behavior is based on reinforcement. Individuals learn by acting on their environment and, in turn, are influenced by the consequences of their actions (Deterline, 1962). When consequences strengthen behavior, reinforcement is said to have taken place.
Reinforcement need not always be in the form of material rewards (Garner, 1966). Reinforcement for most individuals may simply be feedback or knowledge of the results of a response. Most individuals are content to learn they have responded correctly (Garner, 1966).

In PI, reinforcement typically occurs in the performance monitoring section of the lesson. When the student is quizzed on comprehension of the lesson content (via multiple choice or true/false questions), the responses can be reinforced by using appropriate feedback. The student must respond accurately to criterion items before being reinforced and before proceeding to the next frame (Garner, 1966). Acceptable performance can be reinforced by using terms such as "that's right" or "excellent" or any other phrase with positive connotations (Deterline, 1962). Failure to respond accurately to criterion items results in the student being "washed back" to repeat material that was not understood the first time (Garner, 1966).

In addition to the operant principles of reinforcement and successive approximations found in PI, Skinner (1958) noted additional characteristics of PI. Continuous student-program interaction and student self-pacing along with successive approximations and reinforcement are all present, or at least desired in PI lessons. These characteristics are what separate PI from traditional teaching methods.

According to this "old" concept of PI, the student must proceed through the lesson in a fixed sequence (linear path) through every frame regardless of ability (Garner, 1966). If this were the case, Stolurow (1968) believed that PI was not truly individualized since
linear programs do not take into account different student abilities (i.e., the stimuli were not contingent on the student's response).

Crowder (1964), recognizing the limitations of linear programming and using basic PI principles, developed what he labeled intrinsic or branched programming. A branched program uses multiple choice questions for diagnostic purposes to periodically monitor student progress (as does a linear program). If the student demonstrates adequate performance, reinforcement occurs (e.g., "excellent") and the lesson continues. However, if the student commits an error, the program "branches" to another pathway and provides remedial instruction. By using various pathways for remediation, students with different abilities may achieve the lesson objective since additional help is available. The pathway is contingent on the nature and/or number of errors. The ability to branch to adaptive remedial instruction is the distinguishing factor between Skinnerian, or linear PI, and branched PI.

Whether or not it was recognized as PI, the first successful individualized plans of instruction on a large scale were the Winnetka Plan and the Dalton Plan (Garner, 1966). In 1919, under the Winnetka Plan, students proceeded through a lesson in a self-paced fashion, using self-instructional materials and self-administered tests. The students were required to master a particular unit before they could proceed to the next. Similarly, in 1920, the Dalton Plan provided individualized instruction in which students learned in a self-paced manner, and mastery of a unit had to be demonstrated before continuing.
Several reviews of the PI literature were presented throughout the 1960's and early 1970's. Before examining CAI, a brief overview of these surveys is presented in order to set the general theme of past research on PI.

Silberman (1962) reviewed 15 studies which dealt with the comparison of PI lessons and traditional teacher (classroom) instruction. In general, it was found that students using PI took less time to complete lessons than did the students trained via traditional classroom instruction. In nine of the studies, PI students outperformed their counterparts, while in the six other studies, no significant differences were found between the two methods. Unfortunately, the review makes no reference as to the source of the data, to the criterion measures, nor to the lesson content used.

Schramm (1964) reviewed 36 studies which also compared PI with conventional teacher instruction. Lesson content in the studies reviewed was typically school related subject matter (e.g., mathematics, foreign language, reading, etc.), but occasionally military related subject matter (e.g., electronics training). Criterion measures ranged from immediate posttest examination scores as measured by existing examinations, to retention scores taken several weeks later as measured by final examinations.

In 17 of the studies, PI was significantly superior to the teacher instruction; 18 studies showed no significant differences, and only one study revealed a teacher instruction superiority.

More recently, Lange (1972) examined 112 studies concerned with PI versus teacher instruction. Of the studies examined, 46 indicated
that PI was superior to teacher instruction, 55 revealed no significant differences, and 11 indicated a classroom instruction superiority. Again, as in the Silberman (1962) review, no mention is made with regard to the source, the criterion measures, nor the lesson content.

Despite the lack of thoroughness in the reviews by Silberman (1962) and Lange (1972), a basic theme still emerges from the literature comparing PI with traditional classroom training. In general, it appears that PI can be at least as effective as, and often more effective than, classroom training. According to Deterline (1962), PI "works" and has great promise in the areas of education and training.

Due to certain attributes of PI, it seems logical that low ability (aptitude) students might benefit more from PI than from traditional classroom training. There are several reasons for this belief. The pace of conventional classroom training is typically geared toward the class average (Ford & Slough, 1970). Lower ability students may have a difficult time keeping up with this pace. On the other hand, higher ability students may be held back by the pace. PI takes into account differences in student abilities by using a self-paced format. It should be noted that the terms "ability" and "aptitude" are being used interchangeably since ability is typically measured in terms of aptitude.

The branching capability of PI lessons provides remedial instruction for students who may need additional help in understanding a particular concept (Garner, 1966). Typically, lower ability students
require more help in understanding certain concepts and branched programs provide this capability.

The principle of successive approximations allow the lesson content to be subdivided such that each "step" is easy enough to grasp.

Also, reinforcement is possible on an individual basis when a PI lesson is used. It is virtually impossible for a classroom teacher to provide every student with individual reinforcement, but due to the student-program interaction in a PI lesson, it is possible to use reinforcement for every student (Deterline, 1962).

**Computer-Assisted Instruction**

With advancements in technology, the computer entered the field of PI and offered the potential of some of the "most highly individualized interaction between student and curriculum" (Jamison, Suppes, & Wells, 1974, p. 42). The use of CAI became one of the major educational developments of the 1960's, with promise of continued benefits (Feldhusen & Szabo, 1969).

The literature reviewed thus far concerns PI formats presented via paper media (e.g., programmed texts). Certain qualities of PI have enabled adaptation of this formatting technique to automated media (e.g., CAI). Characteristics such as branching, remediation, testing and scoring can be facilitated by CAI. The more sophisticated CAI systems provide additional enhancement of PI through animated graphics, color, slides, and increased student-lesson interaction.
The following is a review of the evolution of PI within the context of CAI.

CAI can be conceived of as a mode or type of PI presentation. It can be defined as "a form of human-machine interaction whose goal is the efficient learning of a desired outcome" (Hansen, 1970, p. 3).

Research on CAI has examined a number of variables. Early research compared branched and linear programs of CAI (Silberman, Coulson, Melaragno, & Estavan, 1960; Coulson, Estavan, Melaragno, & Silberman, 1962; Gilman & Gargula, 1967). Also investigated was the subject matter of classroom courses such as mathematics (Grubb & Selfridge, 1962; Fisher, 1973), foreign languages (Adams, 1967; Morrison & Adams, 1967), reading (Caldwell, 1974) and chemistry (Rigney & Lutz, 1976a, 1976b).

Research in the military has also examined the usefulness of CAI in electronics training (Lahey, Crawford, & Hurlock, 1975; Stern, 1975), radar systems training (McGuirk & Pieper, 1975), troubleshooting procedures training (Rigney, Bond, Mason, & Macaruso, 1966) and interpersonal skills training (Hausser, Blaiwes, Weller, & Spencer, 1976).

The usefulness of CAI has also been investigated for low ability students such as semi-literates (Caldwell, 1974) and learning disability students (Deboer, 1975), as well as comparisons of students with differential ability (Ford & Slough, 1970; Silberman et al., 1960).

Research in CAI then, has covered a broad spectrum. Some of the earliest research on CAI (Silberman et al., 1960) examined branched
and linear methods of CAI presentations. College students, in the branching condition, followed a sequence or path through the lesson which was dependent on the errors they made. A yoked control group, matched on ability, received a linear program (fixed sequence) on the same instructional sequence (or pathway) as their matched partners. Performance on a criterion test revealed no significant differences between the two groups. Student ability (aptitude) was significantly and positively correlated with posttest scores in both methods of instruction, and negatively correlated with time to complete the lesson and number of errors.

Coulson et al. (1962), also compared fixed-sequence versus branched programs of CAI. The branched group significantly outperformed the fixed-sequence group on a criterion achievement test. No significant differences were found between the groups with regard to time to complete the lesson.

The research dealing with branched versus fixed-sequence presentations is sparse. The findings (for both PI/CAI mode and PI/paper mode) tend to favor branched programs over fixed-sequence programs of presentation. The nature of branched programs affords the student adaptive "pathways" within the lesson which maximizes individualized instruction.

Grubb and Selfridge (1962) studied the use of CAI to teach psychological statistics. Students were divided into three groups; one was taught using a CAI format, the second was taught using a classroom lecture method, and the third used a programmed text. Course content was the same for all three groups. The CAI group
performed better on posttest measure than did the classroom lecture group and, took significantly less time than the other two groups to complete the lesson.

College students in a first year German language course received either traditional language laboratory training or a CAI lesson on reading and writing of the German language (Adams, 1967; Morrison & Adams, 1967). Experimental subjects (CAI group) outperformed the controls (language laboratory group) on a test of reading and writing achievement despite the fact that the two groups were matched on ability. A questionnaire revealed favorable student attitudes toward CAI.

Hansen, Dick, and Lippert (1968) administered a college physics course to one group of students via CAI alone, one group via CAI with classroom instruction, and one group with classroom instruction only. The CAI alone group's performance was significantly superior to the other two groups on midterm and final examination scores, while no significant differences were found between the CAI/classroom group and the classroom only group.

In a study which compared the effects on student achievement of a computer aided geometry course versus conventional instruction, Fisher (1973) also examined the variable of aptitude. The findings revealed that both methods were equally effective in teaching basic geometry skills. Also, low to average ability students were more likely to score at their predicted levels of performance when using the CAI lesson, whereas students of high ability were more likely to score at their predicted levels of performance when using the conventional
curricula. Perhaps this is due to the fact that classroom training is typically geared toward the class average (Ford & Slough, 1970). Lower ability students may have trouble keeping up with the pace of the average student, in the classroom. Since CAI is self-paced and individualized, and therefore takes into account differences in student abilities, the lower ability students may benefit more by using a CAI format. The low ability student using a CAI format can proceed through the lesson at whatever pace is necessary for understanding the content and therefore, perform better by using this method than traditional classroom training.

Caldwell (1974) compared reading achievement scores between two groups of semi-literate adolescents when taught either by programmed text or by a computer-based display. Students ranged in age from 14-18 years and had reading skills below the 5th grade level. Results showed that each method of teaching was successful. However, neither medium had a significantly superior effect on achievement. Also, attitudes of those using CAI were more positive than of those using the programmed text.

Rigney and Lutz (1976a) designed a CAI lesson explaining the functioning of a battery. Using a CAI device known as PLATO, experimental subjects proceeded through a lesson by interacting with the plasma panel to construct a graphic simulation of a battery. The control group also used a CAI lesson on the functioning of a battery, but only verbal information was given in response. The experimental group significantly outperformed the control group on a posttest measure of knowledge, comprehension, and application items. An
attitude and opinion questionnaire indicated that the subjects found the graphic CAI lesson to be interesting and that the lesson provided them the opportunity to visualize how a battery works. Control subjects did not believe that mental imagery was induced by their lesson and did not consider the lesson to be interesting. The authors concluded that since the graphic CAI lesson format was responsible for the higher level of interest, it is reasonable to assume that the subjects attended to these components and they possessed a greater ability to organize structural information due to the graphic simulation.

In a similar study, Rigney and Lutz (1976b) found additional support for their argument that interactive graphics apparently have the greatest effectiveness during initial acquisition. The graphic simulations allowed the students to focus their attention on various components of the simulation at will, and as a result, comprehend the concept. They cautioned, however, that using animated graphics may require a plasma panel with the capability of writing and erasing at higher rates of speed than was available at that time.

Other areas in academia that have benefited from CAI include elementary school mathematics, reading, junior high school science, and teacher training (Hansen, 1970). It has been estimated that over half of the colleges and universities in the United States are actively studying the potential use of CAI (Hansen, 1970).

The academic field, then, has shown some of the potential benefits of CAI. However, an often overlooked variable appeared evident in the literature. When subject matter such as psychological
statistics (Grubb & Selfridge, 1962), foreign languages (Adams, 1967; Morrison & Adams, 1967), and physics courses (Hansen et al., 1968) are used as the lesson material, particularly with college students, a restricted range of subject intelligence may have biased results.

A broader range of subject intelligence may be more desirable in studies of this type. The literature suggests that an aptitude by medium (mode of presentation) interaction may exist. This effect would not be revealed in a study using a homogenous subject pool.

The military has also devoted considerable attention to CAI research. Rigney et al. (1966), taught military trainees corrective maintenance procedures for electronics equipment via CAI. The CAI lesson used a troubleshooting flowchart to guide the student through a set-up and fault localization procedure. The results indicated that learning from CAI practice in troubleshooting procedures does transfer to troubleshooting performance. Relatively simple CAI lessons held student interest for several hours and led to effective troubleshooting training.

Ford and Slough (1970) cited several limitations of classroom training such as inadequate mastery of all training objectives, waste of student time due to the pace of average students, and variations in the quality of instruction. The researchers replaced a classroom training course (on alternating currents in electronics) with a CAI lesson on the same module, in an attempt to overcome these limitations. The usefulness of CAI versus classroom training was compared and the usefulness of CAI for students of different abilities was examined. Following the treatment (CAI or classroom training),
both groups took a regular school examination. For students of all ability levels, achievement was better when trained via CAI than when trained via classroom instruction. CAI subjects in the four different ability levels examined, had significantly higher average scores than did the corresponding classroom subjects.

In other research on military electronics training using CAI, Lahey et al. (1975) trained electronics students from the Basic Electronics and Electricity school (Naval Training Center, San Diego) on the uses of a multimeter. One group received the lesson on a PLATO terminal (CAI device) while a control group received traditional classroom training. The students in the CAI group were presented the lesson materials on a plasma screen which used graphics to simulate the multimeter. Performance measures were examination scores on the lesson content and time required to complete the lesson. No significant differences were found in overall test performance between the two groups. The CAI group, however, took significantly more time to learn the lesson content, but the authors point out that this may be partly due to the time needed to accustom the student to the computer system. Student reaction to the CAI lesson was enthusiastic.

Stern (1975) taught basic oscilloscope procedures to naval recruits either by using a CAI format (PLATO) or a programmed text (workbook). Results indicated that the overall skill levels of the two groups were similar, but the CAI group was better able to interpret display information whereas the programmed text group was more proficient in control manipulation. Following the posttest
measure (school examination), both groups were given additional training which consisted of hands-on experience. Following this additional training, the subskill differences (display information and control manipulation) disappeared.

Crawford, Hurlock, Padillo, and Sassano (1976) examined training and cost effectiveness of teaching co-pilots on the uses of an operational panel. Two instructional methods were used. The traditional method required the student to study a workbook for eight hours, then receive a one hour hands-on practice lesson using a high fidelity, three-dimensional simulator. The CAI group used a two-dimensional graphic simulation which consisted of three hours of practice. The CAI lesson was presented on a PLATO terminal. Results indicated that the necessary skills could be taught using the CAI format and that cost reduction could be achieved.

Thus far, the research has indicated that CAI can be at least as effective as classroom training in many areas. For example, Grubb and Selfridge (1962), Adams (1967), Morrison and Adams (1967), and Ford and Slough (1970) all found CAI to be more effective in training than traditional classroom methods. On the other hand, Fisher (1973), Lahey et al. (1975), and Stern (1975) found no significant differences between groups trained by CAI and groups trained by classroom instruction. Although many of the findings are inconsistent with regard to the advantages of CAI versus traditional classroom instruction, it is evident from the literature that CAI can be used at least as effectively as classroom instruction.
In the studies reviewed previously (concerned with the academic setting) homogeneity of intelligence was discussed. Colleges normally select the top applicants for openings in their schools and this may result in a restriction. The studies reviewed in the military setting, however, seem to suggest a broader range of student intelligence.

The issue of an interaction between an individual ability (aptitude) and method of training is not clearly resolved from the literature reviewed. For example, Silberman et al. (1960) found that aptitude was positively and significantly correlated with performance in CAI lessons. The findings suggest that higher aptitude students should score higher on performance measures than their low aptitude counterparts simply because they possess greater aptitude.

Ford and Slough (1970) showed that CAI subjects in four different aptitude levels scored significantly higher on posttest measures of performance than did a corresponding classroom group.

Hansen (1970) provided daily reading instruction via CAI to low aptitude students. Substantial gains were found for all students, more so in the lower aged children. The subjects used in the study were all low aptitude students and no comparison was made with students of high aptitude.

Using PI lessons, Dick and Latta (1969), presented mathematical concepts to two groups of low and high aptitude students. The media contrast was that of PI format, i.e., PI presented via a paper and pencil medium versus PI presented via a CAI medium. Criterion measures were an examination following the training procedure and a
retention test given three weeks following the lesson. For the high aptitude group, no significant differences were found for media contrast on either the posttest or retention measures. The low-aptitude group, on the other hand, performed significantly better on the posttest when trained via the PI/paper and pencil medium, than when trained via the PI/CAI medium. The same results were again evident on the retention test given three weeks later. The authors concluded that aptitude must be taken into account when deciding which training medium is to be used.

It is not clear from the available literature, just how aptitude is related to different methods of training and various measures of training effectiveness. Because of the inconsistencies in the literature, it is difficult to draw conclusions concerning interactions between training method and aptitude. Further, it is not apparent that any of these lessons were specifically tailored to enhance learning by low aptitude students.

Traditionally, PI presented in a paper mode has produced mixed results. The characteristics inherent in PI (PI in general) such as self-pacing, branching, individualization, and feedback and reinforcement, might not be sufficient to differentially affect low aptitude students. PI presented in a CAI mode can provide additional characteristics such as graphics, animation, increased student/curriculum interaction, and possibly even motivation, which may readily facilitate learning in low aptitude students.

Boyd (1973) points out that computers can be powerful motivators with some students and that motivation is often a major problem with
many low achieving students. Rigney and Lutz (1976a) believed that the utilization of interactive graphics (in a CAI mode) resulted in a more interesting presentation of concepts, and therefore received more attention during acquisition than did a verbal method of presentation.

On the basis of the literature reviewed, it is expected that using a CAI lesson format will provide at least as effective training as traditional classroom training.

It is also hypothesized that higher aptitude students will outperform lower aptitude students in their respective training groups simply because they do possess greater ability.

Finally, it seems logical that if the additional capabilities of PI presented in a CAI mode (graphic features, animation, etc.) are combined with the best features of PI in general, then the lower aptitude students will benefit more from the CAI training than from the classroom training, whereas higher aptitude students will perform fairly consistently across both methods of training as measured by performance on the multiple choice items following the training.
Subjects

Seventy-two male naval trainees (non-fleet experienced) enrolled in the Steering and Diving Systems course (number A652-0043) at the United States Naval Submarine School, Groton, Connecticut, served as participants in the study. Thirty-six experimental subjects were matched on aptitude with thirty-six controls selected from a pool of students who were enrolled in the same course either prior to or subsequent to four consecutive experimental classes. Matching was based on combined Work Knowledge (WK) and Arithmetic Reasoning (AR) subtest scores of the Armed Services Vocational Aptitude Battery (ASVAB), such that the combined score of each experimental subject was matched within ± 2 points of the matched control. The scores ranged from 96 to 135 and had a mean of 115.64 for the experimental group and from 98 to 133 with a mean of 115.69 for the control group.

Experimental subjects received their training using the CAI lesson sequence while control subjects were trained by traditional classroom lecture instruction.

Apparatus

The General Electric Training System (GETS) was the CAI device used for training the experimental subjects. The GETS is a stand-alone CAI device consisting of a plasma display for lesson
presentation, a 128 character ASCII II keyboard and sonic graf-pen for student interaction, and a random access 35 mm slide projector for auxiliary graphics. The slides are rear projected through the plasma panel.

An actual Sanders servo valve (model SV 438-11P) with cut-away sections, and an overhead projector with transparencies were used in the classroom training as supplements to the lecture.

Procedure

A particular segment of the Steering and Diving Systems course, steering and diving hydraulics, was selected for study by Navy personnel. The module dealing with the Sanders servo valve was chosen as the content area for the study. Behavioral objectives of this module, consistent with those of the classroom training, were incorporated into a CAI format and a training lesson was developed.

The CAI lesson was developed in conjunction with General Electric personnel (Pittsfield, Mass.). The lesson was then programmed into the GETS by the author. General Electric personnel also provided GETS familiarization and uniform instructions to experimental subjects.

Experimental subjects received the CAI lesson on the Sanders servo valve in lieu of traditional classroom training. Time to complete the CAI lesson ranged from 33 to 100 minutes with a mean of 57.67 minutes, the variation being due to the self pacing nature of CAI.
The control group received traditional classroom training, lasting an average of approximately one hour with a range of 30 to 90 minutes. The classroom training consisted primarily of lecture, which was accompanied by transparencies presented on an overhead projector and a cut-away version of an actual Sanders servo valve. All experimental also received hands-on experience of an actual servo valve at another point in the Steering and Diving Systems course.

The performance measure was a comprehensive examination given at the end of the Steering and Diving Systems course. This examination was given one day after the training sequence. The test consisted of 50 multiple choice questions, 12 of which dealt directly with the Sanders servo valve. Performance on these 12 questions was the dependent variable.
RESULTS

In order to test the hypotheses that: (a) CAI is at least as effective as classroom training, (b) higher aptitude students will outperform lower aptitude students across training methods, and (c) lower aptitude students will benefit more from the CAI training than from the classroom training, while higher aptitude students will perform fairly consistently across both methods of training, the data were analyzed using a 2 x 3 fixed effects analysis of variance. The mean number of correct responses to the 12 questions for both training groups are presented by aptitude level in Table 1.

Table 1
Mean Number of Correct Responses on the 12 Question Criterion Test (n = 12/cell)

<table>
<thead>
<tr>
<th>Aptitude Level</th>
<th>CAI Group Mean</th>
<th>SD</th>
<th>Classroom Group Mean</th>
<th>SD</th>
<th>Total Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>9.67</td>
<td>1.30</td>
<td>10.33</td>
<td>1.07</td>
<td>10.58</td>
<td>1.08</td>
</tr>
<tr>
<td>Medium</td>
<td>9.67</td>
<td>1.30</td>
<td>9.83</td>
<td>1.47</td>
<td>9.42</td>
<td>1.73</td>
</tr>
<tr>
<td>High</td>
<td>9.67</td>
<td>1.30</td>
<td>10.08</td>
<td>1.28</td>
<td>10.00</td>
<td>1.53</td>
</tr>
</tbody>
</table>

The analysis yielded no main effect for training method, \( F(1,66) = 3.07, \ p > .05 \), supporting the hypothesis that the CAI lesson was at
least as effective as classroom training. Although performance on the 12 questions was slightly superior for the CAI trained group than for the classroom trained group, this difference was not significant. This suggests that both training methods were equally effective in teaching the lesson material.

No main effect for aptitude was found in the analysis, thereby refuting the hypothesis that higher aptitude students would outperform lower aptitude students across training methods. $F(2, 66) = 0.65$, $p > .05$. The analysis revealed that, across training conditions, lower aptitude students tended to perform at the same level on the criterion test as their higher aptitude counterparts.

No interaction between method and aptitude was found in the analysis, failing to support the final hypothesis which stated that lower aptitude students would benefit more from the CAI training than from the classroom training, whereas higher aptitude students would perform consistently across both methods of training, $F(2, 66) = 1.14$, $p > .05$. No one particular aptitude group performed significantly better than any other group in either training condition. The results of these analyses are summarized in Table 2.

Table 2
Analysis of Variance--High, Medium, and Low Aptitude Students (12-Item Criterion Test)

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>5.56</td>
<td>1</td>
<td>5.56</td>
<td>3.07</td>
</tr>
<tr>
<td>Aptitude</td>
<td>2.33</td>
<td>2</td>
<td>1.17</td>
<td>0.65</td>
</tr>
<tr>
<td>Method x Aptitude</td>
<td>4.11</td>
<td>2</td>
<td>2.06</td>
<td>1.14</td>
</tr>
<tr>
<td>Within</td>
<td>119.50</td>
<td>66</td>
<td>1.81</td>
<td></td>
</tr>
</tbody>
</table>
In order to examine the performance of subjects at the extreme ends of the aptitude distribution, performance data of those subjects with a mean aptitude falling between ± .5 standard deviation of the mean were removed. The mean aptitude score was 115.64 with a standard deviation of 8.85. The subsequent analysis was a 2 x 2 fixed effects analysis of variance with 10 subjects per cell. The subjects represented the lowest and highest extremes in the distribution. The mean number of correct responses to the 12 questions for both training groups and for both extreme low and extreme high aptitude subjects are presented in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>CAI Group</td>
<td>9.80</td>
<td>1.32</td>
<td>10.70</td>
</tr>
<tr>
<td>Classroom Group</td>
<td>9.50</td>
<td>1.35</td>
<td>9.70</td>
</tr>
<tr>
<td>Total (All Subjects)</td>
<td>9.65</td>
<td>1.31</td>
<td>10.20</td>
</tr>
</tbody>
</table>

The analysis yielded no main effect for training method $F_{(1,36)} = 2.23, p > .05$. Again, the results indicate that the CAI trained group performed slightly better than the classroom trained group, however, the difference was not significant.

No main effect was found for aptitude, $F_{(1,36)} = 1.59, p > .05$. Although the scores were slightly superior for the higher aptitude
group, the scores between the extreme low and extreme high aptitude
groups were not significantly different. Apparently, students at the
extreme low end of the distribution performed just as effectively as
students at the extreme high end of the distribution on the criterion
test.

No method by aptitude interaction was revealed in the analysis,
\[ F (1,36) = 0.65, p > .05. \] Neither low nor high aptitude subjects per-
formed significantly different from the other regardless of training
method used. The results of these analyses are summarized in Table 4.

Table 4
Analysis of Variance—High and Low Aptitude Students
(12-Item Criterion Test)

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>4.23</td>
<td>1</td>
<td>4.23</td>
<td>2.23</td>
</tr>
<tr>
<td>Aptitude</td>
<td>3.03</td>
<td>1</td>
<td>3.03</td>
<td>1.59</td>
</tr>
<tr>
<td>Method x Aptitude</td>
<td>1.23</td>
<td>1</td>
<td>1.23</td>
<td>0.65</td>
</tr>
<tr>
<td>Within</td>
<td>68.30</td>
<td>36</td>
<td>1.90</td>
<td></td>
</tr>
</tbody>
</table>

During the prior analyses the lack of a main effect of aptitude
suggested that the twelve examination questions might not be of suf-
ficient difficulty to discriminate across ability. An item analysis
was performed to explore this possibility. The results are presented
in Table 5.

It can be seen from Table 5 that the majority of the 12 exami-
nation questions did not possess item difficulty levels which were
sufficient to justify their use as discriminating items. A percentage
<table>
<thead>
<tr>
<th>Item #</th>
<th>CAI</th>
<th>Classroom</th>
<th>CAI</th>
<th>Classroom</th>
<th>CAI</th>
<th>Classroom</th>
<th>CAI</th>
<th>Classroom</th>
<th>CAI</th>
<th>Classroom</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>100.0</td>
<td>100.0</td>
<td>91.7</td>
<td>100.0</td>
<td>100.0</td>
<td>83.3</td>
<td>97.2</td>
<td>94.4</td>
<td>95.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>91.7</td>
<td>91.7</td>
<td>100.0</td>
<td>100.0</td>
<td>91.7</td>
<td>100.0</td>
<td>94.5</td>
<td>97.2</td>
<td>98.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>91.7</td>
<td>91.7</td>
<td>100.0</td>
<td>75.0</td>
<td>100.0</td>
<td>83.3</td>
<td>97.2</td>
<td>83.3</td>
<td>90.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>83.3</td>
<td>83.3</td>
<td>91.7</td>
<td>91.7</td>
<td>83.3</td>
<td>91.7</td>
<td>86.1</td>
<td>88.9</td>
<td>87.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>08.3</td>
<td>33.3</td>
<td>33.3</td>
<td>50.0</td>
<td>50.0</td>
<td>41.7</td>
<td>30.5</td>
<td>41.7</td>
<td>36.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>91.7</td>
<td>100.0</td>
<td>75.0</td>
<td>100.0</td>
<td>88.9</td>
<td>94.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>83.3</td>
<td>91.7</td>
<td>91.7</td>
<td>75.0</td>
<td>100.0</td>
<td>83.3</td>
<td>91.7</td>
<td>83.3</td>
<td>87.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>91.7</td>
<td>75.0</td>
<td>75.0</td>
<td>75.0</td>
<td>100.0</td>
<td>91.7</td>
<td>88.9</td>
<td>80.6</td>
<td>84.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>66.7</td>
<td>33.3</td>
<td>91.7</td>
<td>58.3</td>
<td>66.7</td>
<td>41.7</td>
<td>75.0</td>
<td>44.4</td>
<td>59.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>75.0</td>
<td>83.3</td>
<td>83.3</td>
<td>91.7</td>
<td>66.7</td>
<td>91.7</td>
<td>75.0</td>
<td>88.9</td>
<td>82.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>91.7</td>
<td>100.0</td>
<td>75.0</td>
<td>91.7</td>
<td>91.7</td>
<td>83.3</td>
<td>86.1</td>
<td>91.7</td>
<td>88.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>83.3</td>
<td>83.3</td>
<td>100.0</td>
<td>83.3</td>
<td>100.0</td>
<td>75.0</td>
<td>94.4</td>
<td>80.5</td>
<td>87.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of 90 was arbitrarily chosen as a cutoff point and all items which were answered correctly with an overall frequency greater than this cutoff were eliminated. As a result of the item analysis, 4 of the 12 questions were removed, leaving the remaining 8 most discriminating questions for subsequent analyses.

Using the 8 most discriminating questions, the data were again analyzed using a 2 x 3 fixed effects analysis of variance. The mean number of correct responses to the 8 questions for both training groups are presented by aptitude level in Table 6.

Table 6
Mean Number of Correct Responses on the 8 Most Discriminating Questions
(n = 12/cell)

<table>
<thead>
<tr>
<th>Aptitude</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>CAI Group</td>
<td>5.83</td>
<td>1.34</td>
<td>6.42</td>
<td>0.90</td>
</tr>
<tr>
<td>Classroom Group</td>
<td>5.83</td>
<td>1.27</td>
<td>6.17</td>
<td>1.53</td>
</tr>
<tr>
<td>Total (All Subjects)</td>
<td>5.83</td>
<td>1.27</td>
<td>6.30</td>
<td>1.23</td>
</tr>
</tbody>
</table>

The analysis yielded no main effect for training method, \( F(1,66) = 1.02, p > .05 \). Once again, the results indicated that there were no significant differences between the CAI trained group and the classroom trained group.

No main effect for aptitude was found, \( F(2,66) = 1.12, p > .05 \). This is, again, in accord with the previous analyses whereby the
findings indicated that no one aptitude group performed significantly better than any other aptitude group across training conditions.

The method by aptitude interaction hypothesis also was not supported, $F(2,66) = 0.41, p > .05$. Again, the findings indicated that no one particular aptitude group outperformed any other group in either training method. The results of these analyses are summarized in Table 7.

```
Table 7

Analysis of Variance--High, Medium, and Low Aptitude Students
(8 Most Discriminating Items)

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1.68</td>
<td>1</td>
<td>1.68</td>
<td>1.02</td>
</tr>
<tr>
<td>Aptitude</td>
<td>3.70</td>
<td>2</td>
<td>1.85</td>
<td>1.12</td>
</tr>
<tr>
<td>Method x Aptitude</td>
<td>1.36</td>
<td>2</td>
<td>0.68</td>
<td>0.41</td>
</tr>
<tr>
<td>Within</td>
<td>108.58</td>
<td>66</td>
<td>1.65</td>
<td></td>
</tr>
</tbody>
</table>
```

Performance data of subjects at both ends of the aptitude distribution were reexamined, based on the 8 most discriminating items. The mean number of correct responses to these 8 questions for both training groups and for both extreme low and extreme high aptitude students are presented in Table 8.
Table 8
Mean Number of Correct Responses on the 8 Most Discriminating Questions by Extreme Low and Extreme High Aptitude Levels (n = 10/cell)

<table>
<thead>
<tr>
<th>Source</th>
<th>Low Mean</th>
<th>Low SD</th>
<th>High Mean</th>
<th>High SD</th>
<th>Total Mean</th>
<th>Total SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI Group</td>
<td>5.90</td>
<td>1.29</td>
<td>6.80</td>
<td>0.92</td>
<td>6.35</td>
<td>1.18</td>
</tr>
<tr>
<td>Classroom Group</td>
<td>5.70</td>
<td>1.34</td>
<td>6.30</td>
<td>1.34</td>
<td>6.00</td>
<td>1.33</td>
</tr>
<tr>
<td>Total (All Subjects)</td>
<td>5.80</td>
<td>1.28</td>
<td>6.55</td>
<td>1.15</td>
<td>6.18</td>
<td>1.26</td>
</tr>
</tbody>
</table>

The analysis yielded results which were in accord with the previous analyses. No main effect was found for training method, $F(1,36) = 0.81$, $p > .05$, nor for aptitude, $F(1,36) = 3.70$, $p > .05$. No method by aptitude interaction was evident in the analysis, $F(1,36) = 0.15$, $p > .05$. The results of the analysis are summarized in Table 9.

Table 9
Analysis of Variance—High and Low Aptitude Students (8 Most Discriminating Items)

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1.23</td>
<td>1</td>
<td>1.23</td>
<td>0.81</td>
</tr>
<tr>
<td>Aptitude</td>
<td>5.63</td>
<td>1</td>
<td>5.63</td>
<td>3.70</td>
</tr>
<tr>
<td>Method x Aptitude</td>
<td>0.23</td>
<td>1</td>
<td>0.23</td>
<td>0.15</td>
</tr>
<tr>
<td>Within</td>
<td>54.71</td>
<td>36</td>
<td>1.52</td>
<td></td>
</tr>
</tbody>
</table>

In order to investigate the relationship between time, aptitude, and performance, correlational analyses were performed. The results are presented in Table 10.
Table 10
Summary Table of Correlational Analyses

<table>
<thead>
<tr>
<th>Group</th>
<th>Variables</th>
<th>Pearson r</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI</td>
<td>Time to complete lesson and Performance on the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 Questions</td>
<td>.028</td>
</tr>
<tr>
<td>CAI</td>
<td>Time to complete lesson and Performance on the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 Questions</td>
<td>.062</td>
</tr>
<tr>
<td>CAI</td>
<td>Aptitude and Performance on the 12 Questions</td>
<td>.351*</td>
</tr>
<tr>
<td>CAI</td>
<td>Aptitude and Performance on the 8 Questions</td>
<td>.347*</td>
</tr>
<tr>
<td>Classroom</td>
<td>Aptitude and Performance on the 12 Questions</td>
<td>.058</td>
</tr>
<tr>
<td>Classroom</td>
<td>Aptitude and Performance on the 8 Questions</td>
<td>.147</td>
</tr>
</tbody>
</table>

*p < .05

Significant relationships were found between aptitude and performance on both the 12 item criterion test and the 8 most discriminating items for the CAI trained group. This correlation was not significant for the classroom trained group.

No significant correlation between time to complete the lesson and performance was found for the CAI trained group.
DISCUSSION

Of the three hypotheses examined, only one (CAI is at least as effective as classroom training) was supported. The hypotheses that higher aptitude students would outperform lower aptitude students across training conditions, and that lower aptitude students would benefit more from the CAI training than from the classroom training while higher aptitude students would perform consistently across both training conditions were not supported.

Support for the first hypothesis suggests that both training methods provide equally effective training. Overall, students demonstrated the same level of performance on the criterion test for both training methods. This finding is generally consistent with those of past studies which compared CAI training with classroom training. Grubb and Selfridge (1962), Ford and Slough (1970), Fisher (1973), Lahey et al. (1975), and Stern (1975) all found CAI to be at least as effective as classroom training.

The second hypothesis stated that across training conditions, the performance of higher aptitude students would be superior to that of lower aptitude students. This hypothesis however, was not supported. Contrary to expectation, no differences were found between low and high aptitude students on criterion test performance.
Whereas Ford and Slough (1970) argued that classroom training is typically geared toward the "average" student, this does not appear to be the case in the present study. The aiming of classroom training toward the class average may be appropriate for an academic setting (e.g., universities) where it is desirable to "weed-out" the weak students. However, in the military, reduction in training attrition rates is a major concern, and commonly results in technical training which is directed toward the slower learner. In this manner, students at all aptitude levels can grasp the material, adequately demonstrate their comprehension, and thereby reduce the number of failures. This may partially account for the lack of an expected relationship between aptitude and performance.

The failure to find a method by aptitude interaction went counter to the third and final hypothesis which stated that low aptitude students would benefit more from CAI training whereas high aptitude students would perform fairly consistently across both methods of training. No one particular aptitude group performed significantly better than any other in either training condition. This suggests that technical training of this sort can be accomplished by either mode of presentation regardless of student aptitude level. It should be noted however, that the present findings may be due to the lack of discrimination in the criterion measure.

The significant correlation between aptitude and performance for the CAI group (but not for the classroom group) suggests that the self paced nature of CAI training may have moderated the results.
The low aptitude CAI trained group scored higher on the criterion test than did the high aptitude classroom trained group. If it is true that military classroom training is oriented toward the lower aptitude student, the higher aptitude student may be inhibited from achieving his full potential. Higher aptitude students in the classroom trained group may become disinterested and unmotivated because training is aimed at the slower learner. Because of the self paced nature of CAI however, students at all aptitude levels can proceed at whatever pace is necessary for comprehension. By proceeding at his own pace, the student can in effect, match the training to his own particular needs. This may serve to maintain greater interest and motivation.

It might be desirable to add a third training condition consisting of a programmed text (PI/paper) to examine the effects of self paced PI, independent of CAI. It is suggested from the results of this study that self pacing and the PI format may aid learning. The automation of these features in the form of CAI must be carefully considered due to the economic considerations.

Several variables were identified which may have contributed to the outcome of this and antecedent studies of this type. Variables such as PI lesson content, adaptive scheme (e.g., branching, remediation), uniformity of classroom instruction, and the ability of the criterion measure to discriminate differential performance should be considered when interpreting inferences from the research literature. These are some of the factors which might be controlled and/or manipulated in designing subsequent studies of this type.
REFERENCES


Dick, W., & Latta, R. F. Comparative effects of ability and presentation mode in computer-assisted instruction (Tech. Memo No. 5). Tallahassee: CAI Center, Florida State University, 1969.


