Technical Report 453

THE USE OF TACTICAL COMPUTERS TO PROVIDE WEAPONS AND TACTICS TRAINING TO COMBAT NCOs: RESULTS OF A FIELD TEST

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A pilot field test in 1974 demonstrated the effectiveness of using an Army tactical data system for computer-assisted instruction (CAI) of soldiers when the system was not being used for tactical operations.

Courseware was written in the existing author language PLANIT to run on the Army's Developmental Tactical Operations System (DEVTOS), at Fort Hood, Tex. Lessons were developed in two proficiency test areas, Crew Served Weapons and

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Tactics, and the 120 participating noncommissioned officers (NCOs) were chosen for their previous low scores in these subjects. After a pretest, half the group studied with CAI, a fourth studied from Army manuals, and a fourth served as a control group by studying unrelated material. A posttest measured learning, and interviews with the CAI group recorded their enthusiastic comments.

The CAI group learned significantly more than the others did. The automated instruction also worked equally well for fast and slow learners and across differences in age, education, and paygrade. Slow learners seemed to use the same strategy as fast learners but to take more time. The results, therefore, demonstrated the feasibility and benefits of the project.

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Command Systems

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FOREWORD

The Manpower and Educational Technology Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts ongoing research on computer-based educational systems (Army Project 2Q162722A791, FY 80) and training simulation (Army Project 2Q163744A795, FY 80). The forerunner of the current research is described in this report.

An effort in the Command Systems Work Unit of ARI had been designed to optimize commanders' use of Army tactical data systems for command and staff information processing and decisionmaking, by developing software packages that would use the actual system as the instructional vehicle for training users and maintaining their proficiency. The research reported here stemmed from that effort and from earlier in-house laboratory independent research (ILIR) efforts.

This research used tactical data systems in a computer-assisted instruction (CAI) mode to support MOS 11B40 infantry training at the combat unit level. The particular problem area was selected when the training of 11B40 soldiers came up as a critical item in the report of the Board for Dynamic Training in 1971 and in the Continental Army Command (CONARC) Task Group Report on Computer-Assisted Instruction in 1972.

ARI programs are conducted as in-house research augmented by contracts with organizations having unique capabilities in the area. Much of this experiment was conducted by personnel of the System Development Corporation (SDC) under contract DAHC19-73-C-0029. The entire effort responded to requirements of Project 2Q062106A721, Human Performance in Military Systems, FY 1973 Work Program, and to special requirements levied by what were then the Assistant Chief of Staff for Force Development and the Director of Army Research, Office of the Chief of Research and Development. Current programs are responsive to requirements of the Army Training and Doctrine Command (TRADOC), the successor to CONARC.

The essential contents of this paper were presented at the 16th Annual Conference of the Military Testing Association (MTA), 21-25 October 1974 at Oklahoma City, Okla. and appear in the Proceedings of that meeting.

Joseph Zeidner

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THE USE OF TACTICAL COMPUTERS TO PROVIDE WEAPONS AND TACTICS TRAINING TO COMBAT NCOs: RESULTS OF A FIELD TEST

BRIEF

Requirement:

To determine in a field test whether Army tactical data systems can be used for the secondary purpose of computer-assisted instruction (CAI) to support unit training requirements when the systems are not needed for tactical operations.

Procedure:

Subject matter was chosen from areas that light-weapons infantry in military occupational specialty (MOS) 11B40 must know to pass their proficiency tests. Courseware was written in the existing Programming Language for Interactive Teaching (PLANIT) authoring language, to be run on the Developmental Tactical Operations System (DEVTOS) installed at Fort Hood, Tex. Participants were 120 NCOs in MOS 11B40 at Fort Hood, who were chosen because they had scored low on their last MOS proficiency test.

All participants were given a pretest and assigned to one of three groups. One group received CAI on either Crew Served Weapons or Tactics; the second studied the same material from Army publications and manuals in a structured setting; and the third (control) group studied an unrelated assignment. After about 4 hours all participants were given a posttest, and the computer-instructed group were interviewed to obtain their reactions.

Findings:

Four major findings came out of this effort:

1. Statistically significant evidence showed that learning did take place when tactical data systems were used in a secondary role for automated instruction (AI) and that AI was more effective than self-study.

2. The AI method of training was equally effective in providing weapons and tactics training to 11B0 personnel with high or low general technical (GT) scores across the range of 11B40 GT scores.

3. Automated instruction appeared to be effective across age groups, across education levels, and across the paygrade of the 11B40 population.

4. The slower learners used the same strategy and essentially the same paths through the AI course as the faster learners, but they required more time to read and comprehend the material.

Utilization of Findings:

The results from the U.S. Army's MASSTER Test FM 122, IBCS: Automated Instruction demonstrated the feasibility of using these systems in a stand-alone mode in support of soft-skills (nontechnical) unit training requirements and paved the way for the current variety of systems.

THE USE OF TACTICAL COMPUTERS TO PROVIDE WEAPONS AND TACTICS TRAINING TO COMBAT NCOs: RESULTS OF A FIELD TEST

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INTRODUCTION

Anticipating the smaller all-volunteer force, the decentralization of training, and the added emphasis on individual and group instructional activities at the unit level, the Office of the Chief of Research and Development of the U.S. Army undertook an investigation in 1973 to determine whether the Army Tactical Data Systems' (ARTADS) projected network of computerized systems could be used to support combat unit training activities. The study reported here supported that effort. The objective of this research was to determine the extext to which Army tactical data systems could be used in a secondary, automated instruction (AI) role directed toward satisfying training requirements in a tactical unit environment. The systems measurement bed (Uhlaner, 1972) used for this assessment was the U.S. Army's Developmental Tactical Operations System (DEVTOS), located at Fort Hood, Tex. Detailed descriptions of DEVTOS have been presented elsewhere (Baker, 1968, 1972, 1973); it is a mobile automatic data processing (ADP) system intended to aid commanders and their staffs in conducting tactical operations by collecting, processing, and summarizing the information they need for command decisions and staff actions. Given the requirement and the system, it was necessary to identify the subject matter to be taught, select the individuals who would take part in the study, develop the courseware necessary to teach it, develop a test plan for conducting the field test (designated as MASSTER Test FM 122, IBCS: Automated Instruction), conduct the field test, and analyze the results. This report details that undertaking.

APPROACH

Subject Matter and Courseware Considerations

The maintenance of proficiency by noncommissioned officers (NCOs) in military occupational specialty (MOS) 11B40, Light Weapons Infantry, had been identified by the Combat Arms Training Board and the Continental Army Command (CONARC)[1] as a significant unit training problem. Among the four subject matter areas that 11B40 personnel were required to know, Tactics and Crew Served Weapons accounted for most of the proficiency test failures; therefore these subject matter areas were selected for AI courseware development. Another area, General Educational Development (GED), was also examined during the study, but the results of that aspect of the research are reported elsewhere (Hoyt, Butler, Bennik, & Baker, 1980). The training analysis (and subsequent recording of results) followed the principles and concepts contained in CONARC Regulation 350-100-1, Systems Engineering of Training. The data forms used to structure the AI courseware included training analysis information sheets, criterion and enabling objectives, test items, and course outlines. For crew-served weapons, subject matter experts from the Weapons Committee of the Infantry School reviewed the training analysis results page by page, concurred

[1] Now the U.S. Army Training and Doctrine Command (TRADOC).

(or non-concurred) in the topic selection, and ranked each weapon as to its relative importance in the Crew Served Weapons Course. Three weapons ranked highest: LAW (light antitank weapon), 90mm recoilless rifle, and M60 machine gun. The resultant materials provided a basis for developing 12 hours of AI Crew Served Weapons courseware, although only 4 hours of the material was subsequently used in MASSTER Test 122. A similar procedure was used to provide 12 hours of AI Tactics courseware.

AI Authoring Considerations

The first task was to analyze the DEVTOS hardware and software to determine whether or not it could support computer-aided instruction (CAI) and to survey and analyze existing CAI programs and procedures to determine their availability and feasibility for use within DEVTOS. The results of this phase are documended elsewhere (Hoyt, Butler, Bennik, & Baker, 1975, 1980). Essentially it was found that the PLANIT CAI system (PLANIT stands for Programming Language for Interactive Teaching) would best satisfy the requirements (Frye, 1968; Feingold, 1968; Frederick, 1974; Atkinson & Wilson, 1969). Consequently, the courseware was written to run on the PLANIT/DEVTOS system.

In the development of course materials, every attempt was made to capitalize on PLANIT capabilities that assist the author preparing the instructional material and the student receiving it. The most elementary of the presentation strategies was a straight instructional path. In addition, as the complexity of the topic warranted, an accelerated or a remedial instructional path was included. Courseware was written at a level designed to reduce reading difficulties. Military terms were included, and if it appeared that these terms might introduce comprehension problems, synonyms or examples were added. To the extent possible, on-line representations (on the computer) of situations or examples were used (basically, if you can put it on a typewriter, you can put it on the scope). When this was impossible or infeasible, pictures and diagrams were prepared for student use.

Answer-matching in frames requiring constructed responses (PLANIT accepts certain misspellings), and the alternative selected in multiple-choice questions constituted the student response data-base. Correct as well as incorrect responses provided a basis for selective remedial material and for making decisions for subsequent actions. When an 11B40 answered incorrectly, he was told not only that he was wrong, but why he was wrong. The student received feedback for each response entered. The feedback took a positive, negative, or neutral form. Additional prompts and cues were also included. Another PLANIT feature provides a course reentry capability to restart students where they stopped for breaks.

Materials for preassessment and postassessment of student performance were prepared to balance the assignment of students among three treatment groups and to assess extent of learning (gain score) among students. From an Infantry School-approved list of criterion and enabling test items, two test versions for each courseware module were prepared (LAW, M90, M60, tactics, patrolling). Each version contained a comparable number of items, about 25 to 30. Versions were created by scrambling the order of multiple-choice alternatives, while leaving content the same; selecting different steps for items consisting of a series of steps; and adjusting the relative position in the test of constructed-response items which did not lend themselves to alteration.

The PLANIT structured AI courseware content was reviewed by the Infantry School in July 1973. The subject matter experts comments ranged from "Can go into practical application with little additional training (LAW)," to "This program looked good, the exercises on sighting and engaging targets were quite good and probably of the most value (90mm Rifle)." After a field tryout with 10 11B40 NCOs, course materials were finalized in August 1973.

Subject Selection

The test plan (experimental design) called for 11B40 NCOs who had relatively low scores on their MOS proficiency test; therefore, they needed the training. To choose them, a run was made on the personnel tapes at Fort Hood, Tex., and the 11B40 files were extracted from it. Card decks containing names and Social Security numbers of 11B40 personnel were sent to the Enlisted Evaluation Center, Fort Benjamin Harrison, Ind., and the 1972 MOS Proficiency Test scores were obtained. A month before MASSTER Test 122, the card decks were again run against the personnel tapes to determine whether or not the 11B40s were still at Fort Hood. On the basis of this information, listings of the subject pool of 11B40s were prepared and delivered to Headquarters MASSTER. For each 11B40 on the list the background data included GT (general technical) score, MOS proficiency test scores, education, age, and paygrade on a student record form.

Conduct of the Field Test

MASSTER Test FM 122 began in September 1973. An outline of the test design in terms of the treatment of participants is shown in Table 1. Briefly, 120 male participants were tested--60 in the AI Group, 30 in the Study Group, and 30 in the Control Group. One-half of the participants in each of the AI and Study Groups participated in one of the two subject-matter areas: Crew Served Weapons or Tactics.

Table 1

Test Design--Treatment of Participants

AI group (N = 60)	Study group (N = 30)	Control group (N = 30)
Pretest	Pretest	Pretest
Automated instruction	Self-study	Activity unrelated to subject matter
Posttest	Posttest	Posttest
Structured interview		

The procedure called for a maximum of 12 11B40 participants each day to fill out an introductory form on arrival and to be briefed on the purpose of MASSTER Test FM 122. While the briefing was conducted, student records were pulled and assignments made to either Crew Served Weapons or Tactics, based upon MOS proficiency test score. For a given participant, his past scores were compared, and he was assigned to that treatment group which corresponded to his lowest previous proficiency test score. Participants then took their pretest (half on Form A and half on Form B) and were assigned at random to the AI, Study or Control Groups. The AI Group took their course (e.g., Tactics) on the computer; the Study Group studied the same material from Army publications, and the Control Group had an unrelated assignment (learning the ALPHA-DOT System of communication) (Sidorsky, 1974a, 1974b). Each group averaged approximately 4 hours on their activity. The posttest (the alternate form of the pretest) followed, and then the AI Group was interviewed.

RESULTS

In discussing results, there is always a question about favoritism of one or more groups (bias) in regard to background variables or pretest scores and pretest time. Table 2 shows the means and standard deviations for the AI, Study, and Control Groups for the LAW (light antitank weapon). The data show that the three groups are about the same, which indicates that the effects of these variables were virtually canceled out by the random assignment of test subjects to the AI, Study, and Control Groups. The one variable that shows the greatest difference is GT score, in which the Control Group has a mean of 108 and the AI and Study Groups have means near 100. This difference is not regarded as having a serious effect, since the correlation of GT score and pretest score was low (.26), and the difference was in favor of the Control Group. Table 2 also shows a fairly wide range of 11B40 personnel. In the AI Group, for example, ages were from 21 to 45, education from 8th to 13th grade, GT scores from 88 to 119, and paygrade from E5 to E7.

Although the mean pretest times for the three groups were within one-half a minute of each other, the mean posttest time differed considerably (Table 2). The Study Group took 8 minutes or 53% longer to complete the posttest than did the AI Group. [This ability of the AI Group to answer the test questions more quickly than the Study Group was highly significant at the .01 level of confidence, as evidenced by a _t_-test (_t_ = 4.70) with 44 degrees of freedom) computed from an _F_ ration.] Feedback obtained during the interview indicates that the AI Group was more confident of their knowledge and skills than the Study Group and could answer the test questions more quickly and more accurately.

Between-Groups Comparison

The two critical comparisons for the study are between (a) the AI and Control Groups and (b) the AI and Study Groups. The AI Group had a mean gain score of 8.394, an 82% increase over their pretest score. The Control Group had a mean gain score of 2.154, a 21% increase. The difference between the two mean gain scores is 6.240, which, using the _t_-test of statistical significance, produces a _t_ ratio of 6.23--highly significant at the .01 level (.01 - 2.69). The _t_ ratio shows that the possibility of a mean difference 6.240 occurring by

Table 2

Crew Served Weapons: Group Means and Standard Deviations

Variable name	AI group (N = 33)		Study group (N = 13)		Control group (N = 13)	
	M	SD	M	SD	M	SD
GT score	100.2	8.9	100.7	11.0	108.3	12.8
Education	12.3	1.6	12.1	1.8	12.1	2.1
Age	28.4	5.6	30.9	6.0	29.6	5.3
Paygrade	5.7	0.6	5.9	0.5	5.8	0.6
MOS Test 2	13.5	2.8	14.2	2.6	12.7	2.9
MOS Test total	65.9	8.6	66.1	8.4	64.2	10.5
Pretest score	10.3	2.7	10.1	2.5	10.4	3.1
Pretest time	25.6	6.3	26.2	4.9	25.6	7.6
Posttest score	18.7	3.5	15.6	3.1	12.6	3.1
Posttest times	15.0	5.2	22.9	4.9	20.5	8.3
Gain score	8.4	3.1	5.5	3.8	2.2	3.0

chance is remote. Consequently, this difference can be attributed to the automated instruction given the AI Group. The significant *t* ratio and the 82% increase in proficiency are positive statistical and practical evidence that learning takes place when tactical data systems are employed in a secondary (automated instruction) role.

The same comparisons were made between the AI and Study Groups. The difference was statistically significant at the .05 level, producing a *t* ratio of 2.66 in favor of the AI Group. The significant *t* ratio and a 52% increase in proficiency over the Study Group ($\frac{82\% - 54\%}{54\%} = 52\%$) are positive statistical and practical evidence that--within the limits of this study--learning by means of automated instruction is more effective than study group methods of training. For purposes of completeness, note that the differences between the Study Group and Control Group produced a *t* ratio of 2.54, which is significant at the .05 level. Thus the Study Group also had a significant gain in learning when compared with the Control Group, although not as great as that of the AI Group. Figure 1 shows the relationships of these between group findings.

The Study Group situation was better in this experiment than the 11B40 NCOs normally encounter. They were given a pretest, and although they did not know their pretest scores, they had some idea of how well they did on the test. They had field manuals to work with, plus an instruction sheet telling them what topics to cover and in what order, and on what pages and paragraphs the topics were located. Finally, they had supplemental material available in this structured-study situation.

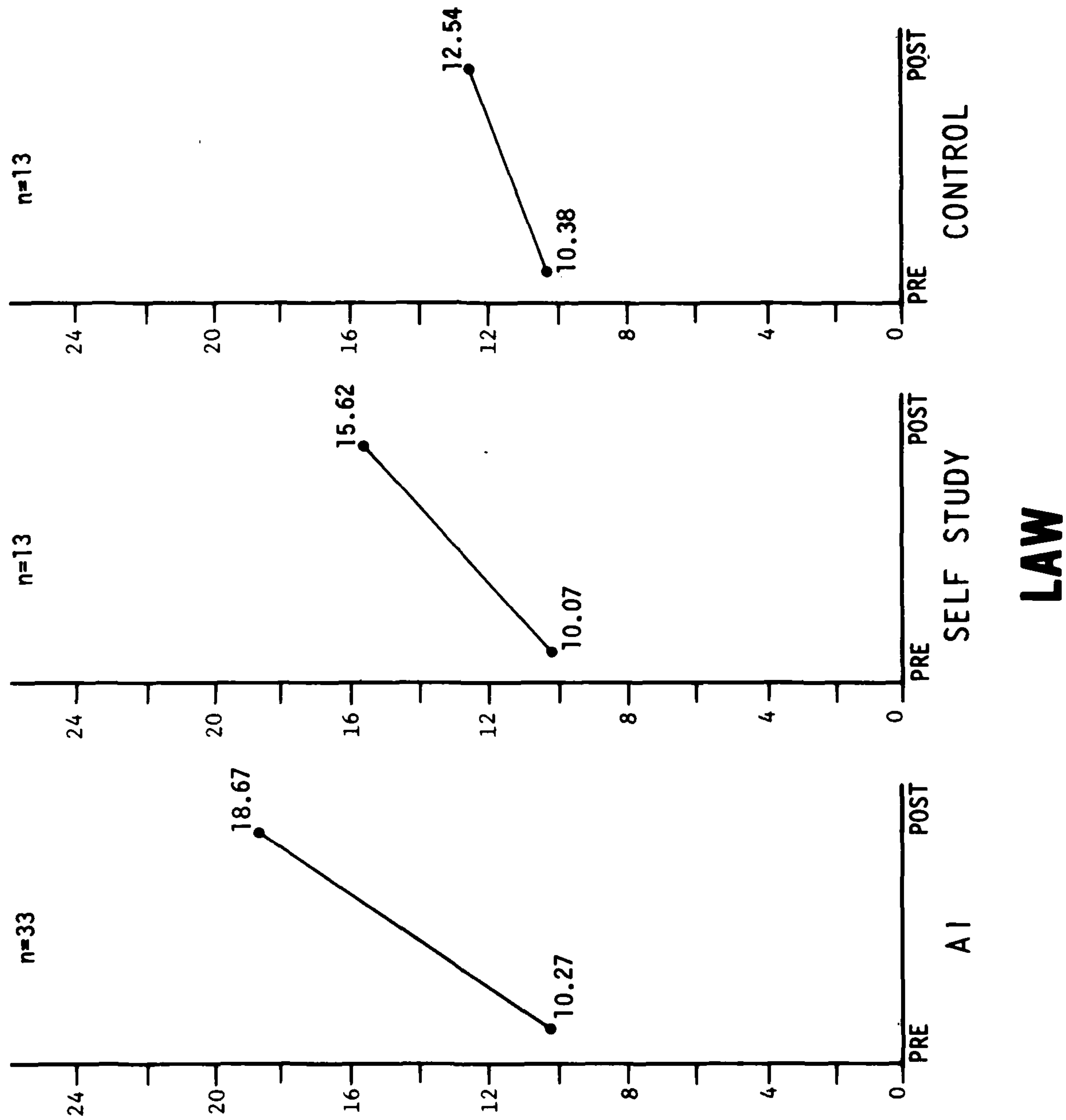

Figure 1. Relationship of between-groups findings for the LAW.

The results for Tactics were quite similar to those for LAW, as evidenced by the data presented in Figure 2. There is some difference in the slope of the control group curve from that obtained for the LAW group. But this pretest and posttest difference shown for the LAW control group was not statistically significant and appears to reflect the variability between the alternative forms of the test. Also, the "idealized" equal-cell entries sought in the original test plan design (Table 1) were not fully obtained in reality. These differences in "idealized" and "actual" may be obtained by comparing the Ns of Figures 1 and 2 with those in Table 1. Such deviations from plan (or how the field test differs from the laboratory) are to be expected in this type of setting (Johnson & Baker, 1974; "Field Testing," 1974).

Relationship of Data to GT (General Technical) Score

Data were analyzed on 77 variables for the 33 NCOs in the Crew Served Weapons AI Group, and for 34 NCOs in the Tactics AI Group. The statistics included the frequency distributions, means, standard deviations, and range of scores for each variable, and the intercorrelation matrix for all 77. The relationships of three specific variables to GT score are shown in Figure 3.

Of particular interest to the training community is GT score, which is considered a measure of general aptitude or ability to learn. Combat arms personnel, many of whom are in the lower ranges of GT score, present special problems in training for the military services. As shown here, GT scores for the 33 11B40s in the Crew Served Weapons AI Group ranged from 88 to 119, with 55% of them below 100. These results show that the automated instruction method of training applies equally well to 11B40 personnel with high or low GT scores. The 10 AI subjects with the lowest GT scores had an average posttest score of 18.7 and the 10 highest, an average of 19.5, less than a point difference. Similar results were obtained for the Tactics AI Group.

Even when the entire N of 33 is considered, a distinct observational trend shows that students at lower GT levels improved more than those at higher GT levels. The Pearson r between GT and pretest score was .38, while the Pearson r for GT and posttest score was .17. This shows a trend for all GT levels to learn and do better on the posttest, with those in the lower GT band showing the most improvement. It appears that the posttest had a ceiling sufficient to accommodate both the higher and lower GT levels; however, an exhaustive psychometric analysis of posttest ceilings was not made. Because of the practical significance of this conclusion, further corroboration of this phenomenon in AI field experiments is warranted.

Taken overall, these results indicate that automated instruction is an effective method of providing weapons and tactics training across the range of 11B40 GT scores. Automated instruction apparently has the effect of reducing or overcoming the verbal handicaps usually associated with lower GT scores.

Other Variables Examined

Three other variables--Paygrade, Education, and Age--were examined and showed a low negative correlation with gain score. Thus, automated instruction

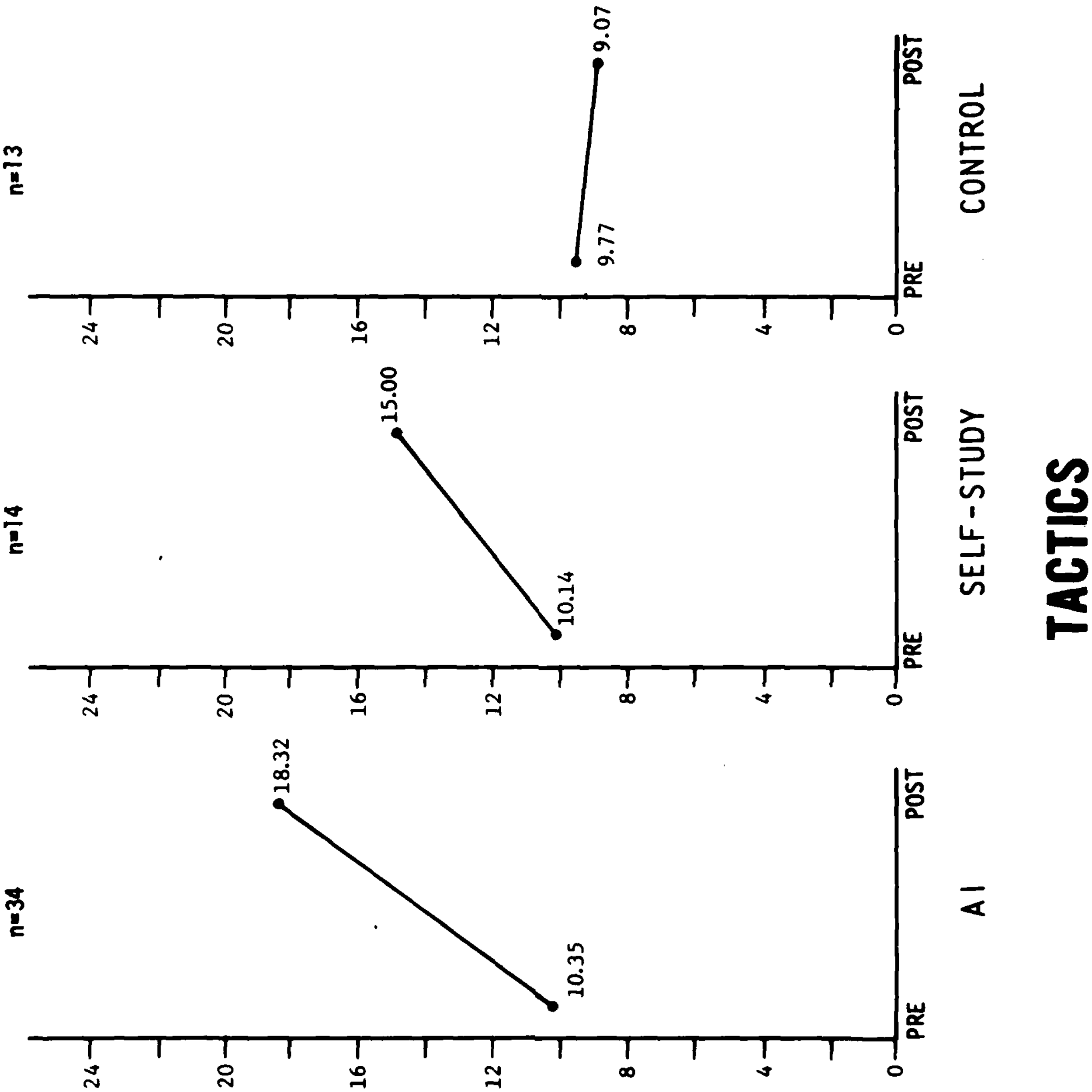

Figure 2. Relationship of between-groups findings for tactics.

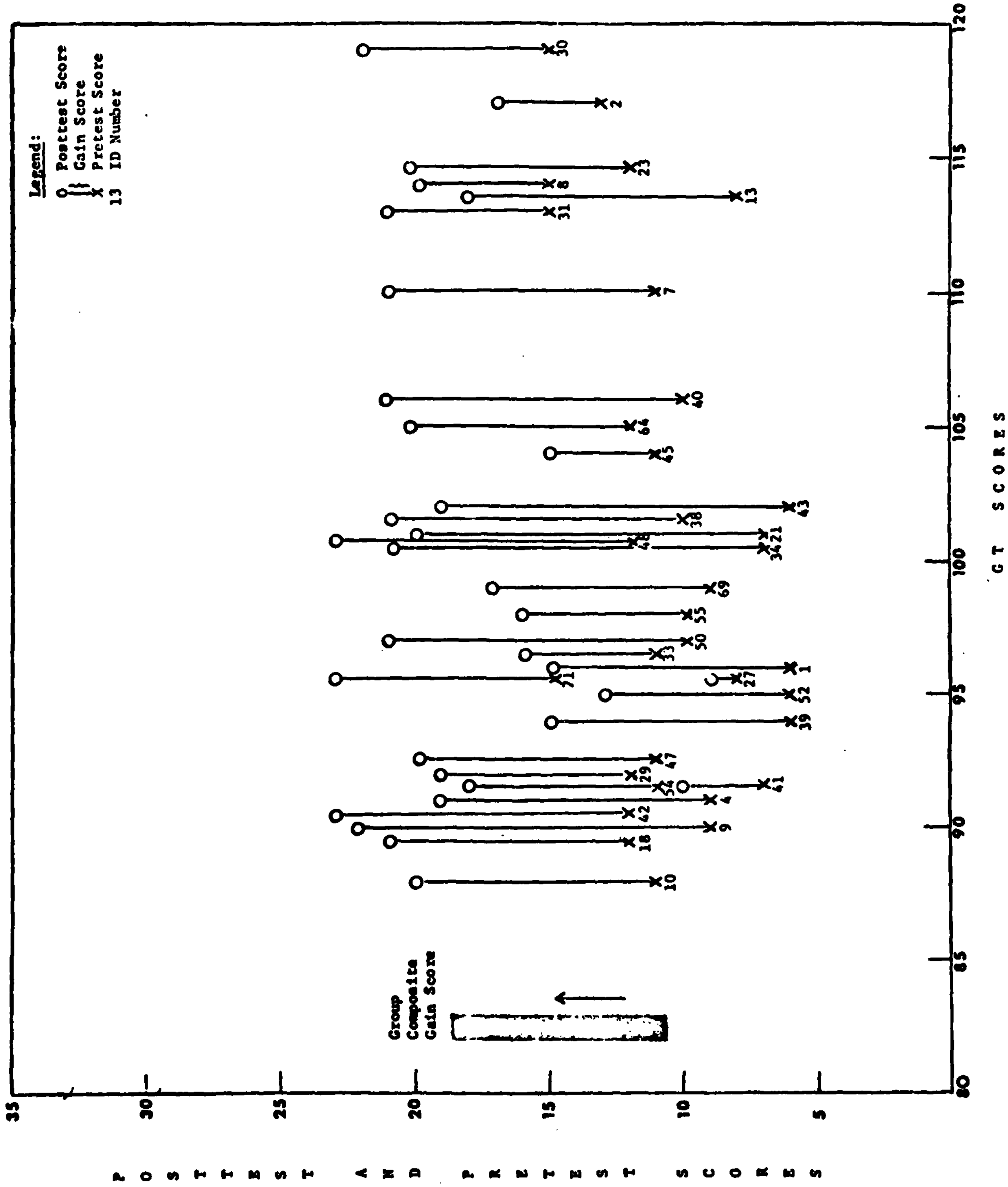

Figure 3. Relationship of pretest, posttest, and gain scores (var. 25) to GT scores (var. 26) for CSW AI subjects (n = 33) (correlation between gain and GT is -.14)

appears to be effective across age groups, across education level, and across the paygrade of the 11B40 population.

The total course time for the 33 subjects in the LAW course averaged 224 minutes and ranged from 158 minutes to 300 minutes. There were four lessons in the LAW course. Of the 33 participants, 24 completed the entire LAW course, 1 was in lesson 4 at the time the test period ended, and 8 had completed or were in lesson 3.

A ratio score was obtained to determine whether slow learners, in taking the AI course, used a different strategy than the faster learners did. Total entries that each slow learner made were divided by total FL Frames (the minimum path to the point the slow learner reached in the course). This ratio is the number of entries made for each FL frame. The results showed that the slowest 16 made only one additional entry more than the fastest 16 per every nine FL frames reached. This relatively small difference would indicate that the slow learners went through the AI course in the same way as the fast learners and simply required more time to read and comprehend the material.

Qualitative Results

After the posttest, AI Group participants were interviewed in depth about their experience with automated instruction. The interviewer filled out a form as the participant responded. Some questions were open-ended, and others required a specific answer. The interviews were also taped, with participants' permission. The response to and acceptance of automated instruction by 11B40s was striking: combat infantry NCOs, who usually start fidgeting after an hour in the classroom, sat down at a scope for 4 or 5 hours and became completely absorbed in the learning process. As one qualified NCO drill instructor aptly put it: "It covered the whole weapon. When you come out of there, you knew a hell of a lot more than you did when you went in." Another NCO expressed it this way: "Makes you confident because when you walk out, you know the subject."

Responses to the interview questions were virtually unanimous. In terms of the expected, and widely touted, positive features of CAI, these participants also remarked on the quiet atmosphere, the self-pacing features, immediate feedback, individual attention, and nonthreatening interactions between the student and the computer. The last point was a key feature, since these NCOs repeatedly remarked that they were reluctant to ask questions or make mistakes in a classroom for fear of "looking stupid" in the eyes of those they command. Regarding the course materials and technique of presentation, the participants commented that the items were easy to understand, were obviously built on each preceding item, were accurate, and "got at the facts without the B.S." The students found the situation to be challenging (but nonthreatening) and rewarding, "because you always know immediately where you stand." They believed that new methods of training such as AI would make Army instruction better and more interesting.

SUMMARY AND CONCLUSIONS

With the efforts in the Army to develop and field tactical data systems, there will be a considerable data processing capability at the tactical unit level. A potential secondary role for these systems, when they are not required for tactical operations, is that of supporting unit and individual training. The results from the U.S. Army's MASSTER Test FM 122, IBCS: Automated Instruction, have demonstrated the feasibility of using these systems in a stand-alone mode in support of unit training requirements--in this case MOS and GED training of infantry personnel.

This project has validated one of the objectives of the National Science Foundation's effort in the development of PLANIT--maximum portability. A DEVTOS tactical data system using PLANIT is installed on a next-generation, militarized, more rugged tactical data system. Several diverse courseware packages have been developed and successfully executed on a tactical computer, using this CAI language.

We may conclude that automated instruction in a field setting is effective, is enthusiastically accepted by NCOs, and is more efficient than the traditional study method of training. Efficiency refers here to time spent in taking the posttest and observed concentration and focus on the learning task (attentiveness) when comparing AI and Study Groups. Also, using a computer for training during scheduled periods of inactivity may indeed be more efficient (productive) than letting it sit idle, in terms of amortizing the dollars already spent on the computer, software, peripherals, and assigned Army manpower. AI training has the advantage of reducing or overcoming the verbal handicaps usually associated with lower GT scores. For these participants, automated instruction held their attention, required them to think about what they were doing, and provided them time in which to ponder and learn. Further, AI provided a positive learning experience in a nonthreatening environment.

Further research seems warranted. The LAW students believed they could have left the console and gone out and fired the weapon with accuracy. Thus there is considerable interest in restructuring the criteria against which tests are designed and constructed, that is developing criterion-referenced tests (Carver, 1974). Criterion-referenced tests are designed "to yield measurements that are directly interpretable in terms of specified performance standards" (Glaser & Nitko, 1971). Traditionally developed tests (such as achievement scored, norm-referenced proficiency tests) are usually the methods used for assessing such things as the efficacy of using AI as the instructional media. Such was the case in the present study. But the real experimental question remains: Does CAI teach effectively enough in the abstract to affect performance measured in the real world? The U.S. Army has a major stake in the answer.

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