

INCREASING THE INSTRUCTIONAL AND COST EFFECTIVENESS OF COMPUTER-BASED TRAINING BY GROUPING STUDENTS

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ABSTRACT

Computer-based training, already well established as a means to improve primary training while reducing its overall cost, may be made significantly more cost effective by training students in small groups of two to four at a terminal rather than one per terminal. In studies performed at Fort Knox's Training Technology Field Activity, grouping led to better retention, better training of low ability students, decreased times for completion of training, and reduced instructor/proctor intervention, without any reduction in achievement. Grouping can relieve scheduling difficulties when terminals are limited. Grouping can help instructors deal with high ability students, who help their peers instead of finishing early and making further demands on the instructors. These studies involved the learning of procedures common to military training, for both acquisition and sustainment training. Special preparation of materials or student assignments is not required. Therefore, grouping can be applied immediately to existing training systems.

INTRODUCTION

Computer-based training (CBT) has become well established in the military as a means to provide improved primary training while reducing its overall cost. In the face of current and predicted cuts in the military budget, a major challenge to the military is to provide even more effective training while using fewer training resources. Based on the results of studies being performed at Fort Knox's Training Technology Field Activity (TTFA), a promising new approach to CBT is grouping students--having students in small groups of two to four work together at a terminal. This paper reports some of the latest research being conducted in this area.

MEETING THE NEED: MORE TRAINING FOR LESS COST

The effectiveness of a training system can be measured in many ways. As a result there are many ways to describe how to increase its effectiveness. Among these are the following:

- o Increase the number of students being graduated without increasing the instructional resources required to train them.
- o Increase the acquisition and the retention of skills so that graduates may be immediately effective when they arrive in the field and so that less retraining is required later.
- o Increase the training of low ability students so that they may be put to better use in the field.

CBT has been an effective training medium because of its use of individualized, interactive training. Students could learn more in the same amount of time or less time, with less instructor resources needed, compared with more conventional training. However, there are some problems with traditional CBT, one being that training

organizations often are not able to acquire sufficient terminals to meet their needs despite dramatic decreases in the cost of hardware over the years. Also, the amount of students to be trained can expand over time to exceed initial planning figures. Whatever the reason, the limits of CBT effectiveness are reached when terminal availability becomes a bottleneck. Another drawback of traditional CBT in the military environment has been the variable rate at which students complete instruction. Faster learners have sometimes been penalized for finishing early because there is no provision for them. This places a burden on the instructor as well.

GROUPING STUDENTS AT CBT TERMINALS

Grouping students at CBT terminals involves having two to four students work together on the same courseware at a single terminal. Potentially, if these small groups could finish the instruction in the same time as individual students, then there would be an immediate increase in student throughput equal to the size of the small group. This would help alleviate scheduling problems when there was a shortage of terminals, which is a common problem in military training.

Initial results of studies carried out at the TTFA at Fort Knox were positive for small group CBT. Small groups were found to complete the instruction in less time while at the same learning rates as individual students. Further, grouped students required significantly less instructor intervention. It is important to note that these studies used the same courseware for both the grouped and individual students and that no attempt was made to encourage or discourage cooperation within the small groups. In other words, the experimenter was trying to see what might happen in a normal military application of grouping; that is, an instructor simply assigns groups to each terminal without structuring the makeup of each group nor providing courseware modified for group presentation.

The problem of faster students finishing early was also alleviated by grouping. The experimenter observed that nearly all of the more advanced students took a lead role within their groups by helping the other group members. The experimenter also observed that the responses to the practical exercises made by the group were not limited to particular students. In most cases answers were provided by the majority of the group members during the course of instruction.

It seems then that the grouping of students leads to cooperation among group members. This can provide additional benefits in the areas of training low ability students and in increasing retention. As students take on the role of instructors themselves by explaining what they understand to other members of their group, they reinforce their own knowledge by increasing their comprehension of the material. This also helps compensate for any shortcomings in the instruction when students with different perspectives may be better able to understand what the author intended. The significant lowering of instructor intervention seems to support this. Also, since learning times decreased rather than increased, there seems to be no problem with the group holding back individual members.

THE PRESENT RESEARCH

The goal of the present research was to examine some of the previously mentioned issues about small group CBT, the following areas in particular:

- o Its effectiveness when training new skills and relearning old skills
- o Its effectiveness for promoting retention of skills
- o Its effectiveness when training low ability students
- o The optimum size of a small group

Two experiments were carried out, which are described below. [For a more detailed discussion of these experiments, see Shlechter (in preparation).]

Experiment 1

The first experiment was designed primarily to investigate the applicability of grouping to the procedural training typically found in the military and the effects of grouping on students' retention of information. Past research had shown positive effects for cognitive learning but had not investigated procedural learning.

Experimental Design and Implementation. The subject matter chosen dealt with training noncommissioned officers to use the Communications-Electronics Operation Instruction (CEOI) extracts. This is a U.S. Army system developed to ensure the reliability and security of tactical communications. It provides information about the proper codes for various interactions such as radio frequencies, call signs, encoding and decoding messages, and encrypting grid coordinates. Soldiers must be trained in how to locate the information they need within the CEOI.

The CBT courseware for this CEOI training was previously found by the researchers to be effective

in training the required tasks. It consists of six units of instruction. Each unit presents textual information and practical exercises on the procedures required for each task. The students use a light-pen interface with the CBT terminal to perform the procedural exercises. Passing criterion is three correct responses per exercise. For each wrong response, an additional question is presented. The CBT hardware was Fort Knox's four terminal MicroTICCIT® CBT system.

To measure training and retention effectiveness, the students were issued a paper-and-pencil pretest, immediate posttest, and (two week) delayed posttest. These were modifications of the standard Army end-of-course CEOI training tests, which were not available for use in the experiment. The experiment's tests were carefully constructed to cover various aspects of the material taught and to be uniform in difficulty across the three tests. In all cases these tests were administered individually, whether the student had participated in the experiment as part of a small group or as an individual.

A questionnaire was created for gathering background information on the soldiers. Along with other data, the students were asked how much previous CEOI experience they had, if any. A second part of the questionnaire, issued later, asked how much practice they had using the CEOI between the immediate and delayed posttests to see if this might be a factor in retention results.

Twenty-four soldiers from the Armor Advanced Individual Training program at Fort Knox were used as subjects. They had no previous experience with the tasks to be trained. The subjects were randomly divided into three groups of eight. One group was then trained in two groups of four per terminal. Another group was trained in pairs, two students per terminal. The last group was trained individually, one per terminal.

In an attempt to replicate actual classroom conditions, subjects were neither discouraged from nor encouraged to discuss the courseware as they worked, and group rewards were not given for completing the material.

Four trained observers participated in the experiment. They were carefully briefed and given mock training until they all reached the same level of competency. During the experiment they recorded the following:

- o The frequency of responses to the practical exercises (including individual responses and group responses by two or more students)
- o The frequency of wrong answers (more wrong answers meant more practice exercises were presented)
- o The frequency of proctor prompting
- o The frequency of helping by group members, as well as the nature of the discussions that took place within the groups
- o The time necessary to complete the CEOI instruction

The observers were careful not to interact with the subjects. A knowledgeable proctor was available to provide help in understanding and completing the material, but only when requested to do so by the subjects.

Scoring of the test results and the observers' data was performed by independent judges using a predetermined set of criteria. Discrepancies between the judges' scoring were rare. When they occurred they were settled by the proctor.

Statistical tests were applied to the data to help interpret the results and to look for significant correlations. Figures 1 and 2 present the recorded data on test scores and time to complete the courseware, respectively.

Retention Results. The students trained in groups of two and groups of four were found to have statistically significant better retention than the individually trained students. This seems to have resulted from the interactions that took place within the groups, including frequent discussions, many cases of helping, and multiple student responses to the practical exercises (over 55 percent by two or more students). The groups of four students did not show a significant difference in retention over the paired students.

Increased practice through the practical exercises did not seem to be a factor in increased retention. In fact, the individual students saw more exercises because they made more wrong responses, on average receiving twelve more exercises than the group training students. Neither was the amount of previous CEOI use nor the amount of practice that occurred between testing sessions a factor. Further, the analysis of the data ruled out the increased retention by group members being a result of any preexisting differences among the students.

Learning Efficiency Results. To measure learning efficiency among the various training conditions--individual, paired, and groups of four--the following criteria were studied:

1. Time in minutes to complete the lesson
2. Achievement scores (immediate posttest scores)
3. Wrong responses to the practical exercises
4. Amount of proctor assistance

A learning efficiency index was determined for each condition based on the average time for completion and the achievement scores. This is one measure of the cost effectiveness of the training. The higher the index, the more efficient the learning. The group training resulted in a higher index (17.88) than the individual training (3.65).

The learning times, both range and mean, were statistically significantly different, as shown in Figure 2. The average time for a soldier trained in a group of four being 55 minutes less than for an individually trained soldier: 156.5 minutes for the group training and 222.38 minutes for the individual training; pair training mean time was close to the group of four time at 172 minutes. In addition, the spread of learning times (slowest soldier's time minus the fastest soldier's time) was much less for

the group-trained soldiers (paired or groups of four) than for the individually trained soldiers: 19 minutes for paired, 37 minutes for groups of four, and 101 minutes for individuals. This is an important factor for proctors having to deal with students who finish early. When grouped, most groups will finish within a short time of one another.

The learning rate, a significant indicator of achievement, appeared to be the same for the individual students compared with the groups of four: 4.63 and 4.59, respectively. (The learning rate is the difference between the pretest and posttest scores.) Therefore, we can conclude that immediate mastery is not degraded by grouping.

Another significant result was the amount of proctor intervention required by the different conditions: 37 incidents for the individually trained students compared with two for the students in groups of four. Further, the average number of wrong responses was higher for the individually trained students: 17.5 compared with 5.5 for the groups of four.

The groups of four subjects did significantly better than the paired subjects in several categories. The former's learning efficiency index was 17.88 compared with the latter's of 8.70. The average time for completion was 16 minutes less for the groups of four than for the pairs. The paired students made statistically significantly more wrong responses (12.25 average compared to 5.5 average) and required more proctor assistance (10 requests compared to two) than the groups of four students.

Summary of Experiment 1 Results. This experiment supported Shlechter's (1987) earlier results showing that grouping four students to a terminal provides more cost effective CBT training than individually training CBT students, in this case nearly five times more cost effective. It also indicates that groups of four are more cost effective than pairs of students. Also, groups of four required significantly less proctor intervention.

Experiment 2

After Experiment 1, questions still remained about the effectiveness of grouping on the training of low ability students and the effectiveness of grouping on training experienced students (sustainment training). Experiment 2 was designed to investigate these two areas.

Experimental Design and Implementation. Thirty-six experienced armor noncommissioned officers from an operational Armor Brigade at Fort Knox were selected to take part in the second experiment. Nearly all these soldiers had previous CEOI, tank, and tank commander experience. In addition, they were selected because they had either the highest or lowest GT scores in their units.

Twelve subjects were assigned to pairs, twelve to groups of four, and twelve to be trained individually. (Two of the paired subjects were not able to complete the instruction.) The three training conditions--individuals, pairs, and groups of four--each had a nearly identical distribution of subjects with high, medium, and low GT scores. Among the three groups of four, subjects were equally distributed according to their GT scores.

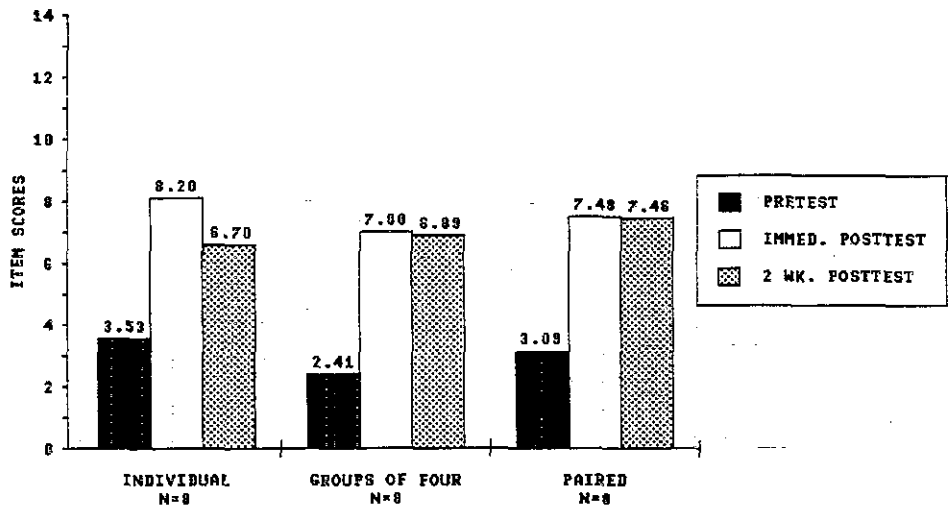


Figure 1. Experiment 1 mean scores on each test for the different testing conditions.

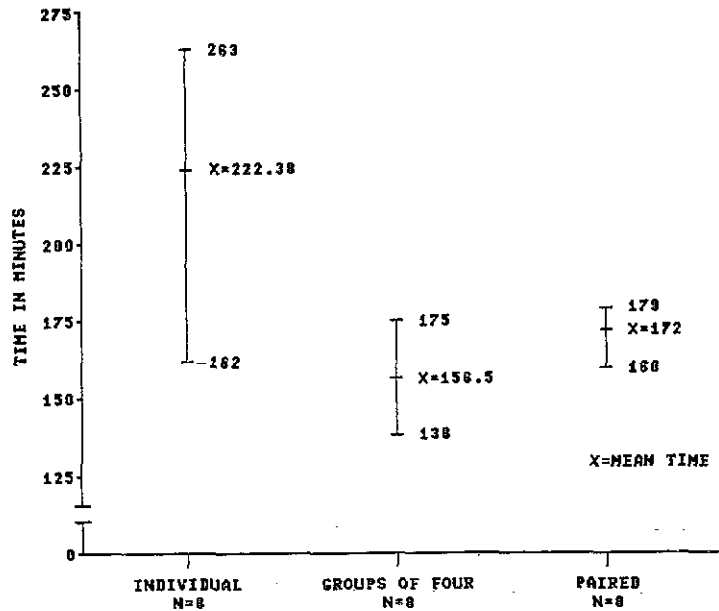


Figure 2. Experiment 1 range of times and mean times in minutes to complete the courseware.

Among the pairs were three pairs of high and low score subjects, one pair of medium score subjects, and a medium and low score pair.

The same courseware was used for both experiments. Experiment 2 was conducted the same as Experiment 1 except that two delayed posttests were administered instead of one, the first two weeks after completion of the lesson and the second two months after completion. Background information then also included the amount of practice that occurred between the two posttests.

Because of transfers from Fort Knox, eight soldiers were unable to complete the retention tasks, leaving nine, nine, and ten subjects for the groups of four, paired, and individual training conditions, respectively. Figure 3 presents the test and posttest data for these 28 subjects.

The instructional efficiency and low ability data were gathered for the 34 students who completed the courseware. Their pretest and immediate posttest scores are presented in Figure 4 and their times for completion in Figure 5. Figure 6 presents the pretest and immediate posttest results for the low ability students who completed the courseware.

Statistical analyses were performed on the various data gathered. A significant correlation was found between the subjects' GT scores and their performance on the pretest, but not between GT scores and the immediate or delayed posttest results or the time to complete the lessons.

Retention Results. The retention rates for the subjects trained in groups of four were not significantly higher after two weeks than for the individually trained subjects. Six weeks later the group results were significantly higher than those for individuals. It appeared that taking the immediate and first delayed posttest had helped the soldiers relearn the material and that this effect was more pronounced for the group-trained soldiers. These results seemed to be a function of the interaction that took place within the groups as well. There were many observations of helping within the groups, and more than 40 percent of the groups' responses to practice exercises were by two or more subjects.

As in Experiment 1, the increased retention by group members did not appear to be a result of any preexisting differences among the students. Nor did it appear to result from the amount of practice during or after the administration of the courseware. In fact, the individually trained subjects averaged 8.67 more practical exercises than did the group-trained subjects.

Learning Efficiency Results. The respective learning efficiency indexes for the groups of four and the individual subjects were 28.69 and 5.89. The average time for completion of the subjects in the groups of four was 33 minutes faster than for the individually trained subjects (145.67 minutes compared with 178.5 minutes). Also, the individually trained subjects' range of learning times was greater than for the groups of four.

The need for proctor assistance and the average number of wrong responses were again greater for the individually trained subjects than for those trained in groups of four: 34 proctor interventions compared with two, and an average of 9.75 wrong responses compared with 5.33.

Low Ability Training Results. The learning rate for low ability subjects within the groups of four was statistically greater than for their counterparts in the individual training: 3.54 compared with 2.30. (See Figure 6.) Also, the grouped subjects needed less proctor assistance and finished faster than the individual subjects: 0.33 requests compared with 3.75, and 145.66 minutes compared with 189.25 minutes.

The low ability students among the pairs had a statistically higher learning rate than those in the groups of four--6.27 compared with 3.43--indicating that pairing might be more effective for low ability students. However, because of the small sample, care should be taken when drawing that conclusion.

Summary of Experiment 2 Results. The learning efficiency results of Experiment 2 paralleled those of Experiment 1, this time for sustainment training instead of initial acquisition training: Training in groups of four was nearly five times more cost efficient and required less additional instructor (proctor) resources than did individual training. It was also about twice as cost effective as pairing students. However, pairing might be the best way to train low ability students.

CONCLUSIONS

It appears that the grouping of students in small groups per terminal for CBT instruction can provide a significant increase in cost effectiveness, as well as an increase in retention over the individual training of students. Groups of four are more cost effective than pairs, but pairing may be better for teaching low ability students, with heterogeneous pairing of high and low ability students at the same terminal.

It also appears that cooperation among group members occurs naturally without the need for group performance rewards, which has further benefits: All students within the group seem to benefit from the discussions that take place, which further reinforces their comprehension and increases their retention. In addition, grouping appears to aid overall training effectiveness by reducing the amount of instructor/proctor intervention needed, as well as the amount of relearning needed. Grouping can further benefit the Army by easing scheduling problems when CBT terminal availability is limited.

It should be noted that these experiments were designed to require a minimum of instructor intervention: The courseware used was not modified for group use, and in one case, no systematic assignment of students to groups was made. This parallels the classroom situation where instructors probably would not be likely to make any special arrangements. Therefore, grouping appears to be of even greater potential benefit to military training, with immediate application possible.

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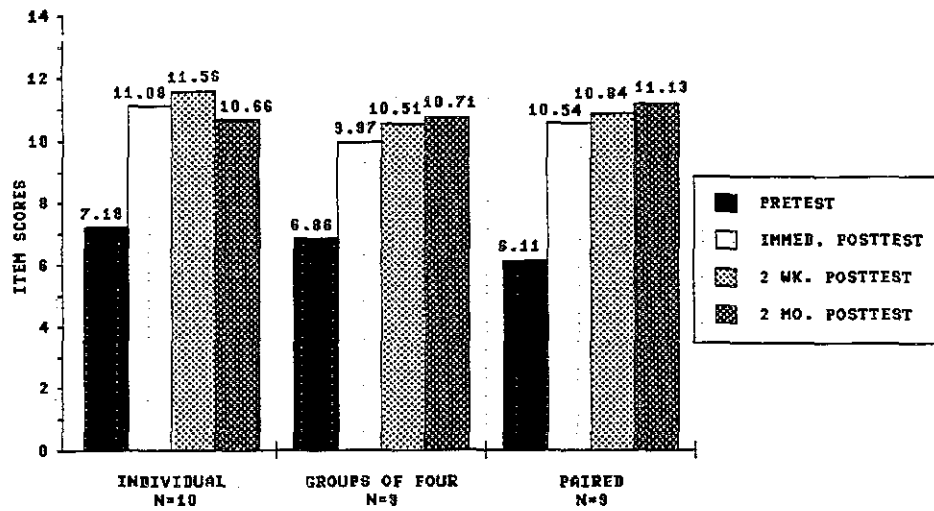


Figure 3. Experiment 2 mean scores on each test for the different testing conditions for the sample of 28 soldiers.

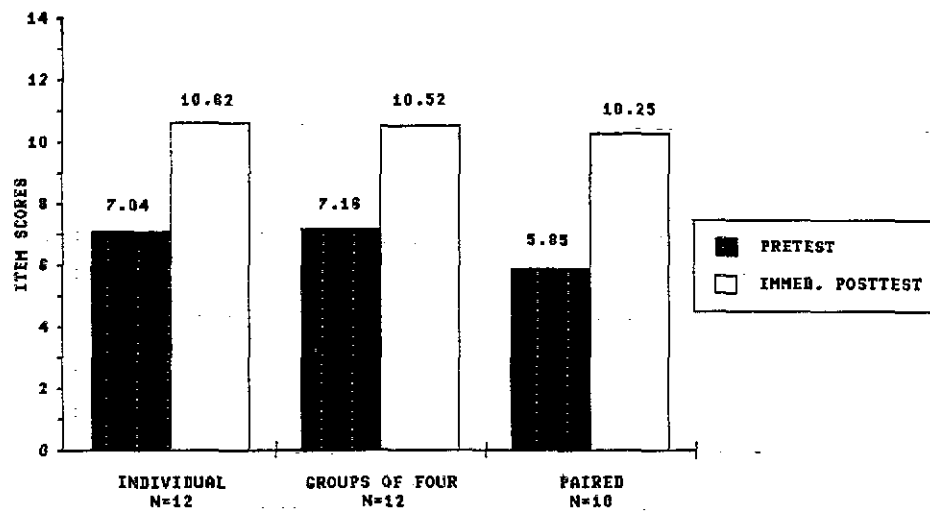


Figure 4. Experiment 2 mean pretest and immediate posttest scores for the 34 soldiers who completed the courseware.

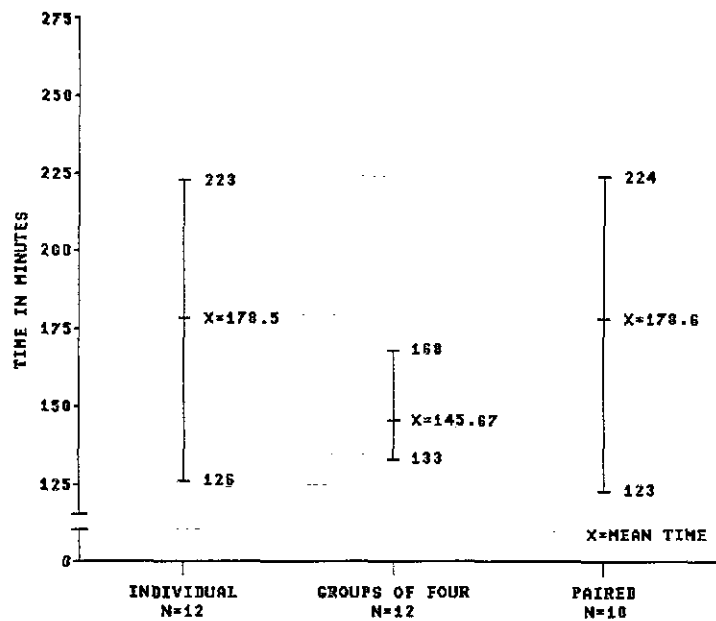


Figure 5. Experiment 2 range of times and mean times in minutes for the 34 soldiers to complete the courseware.

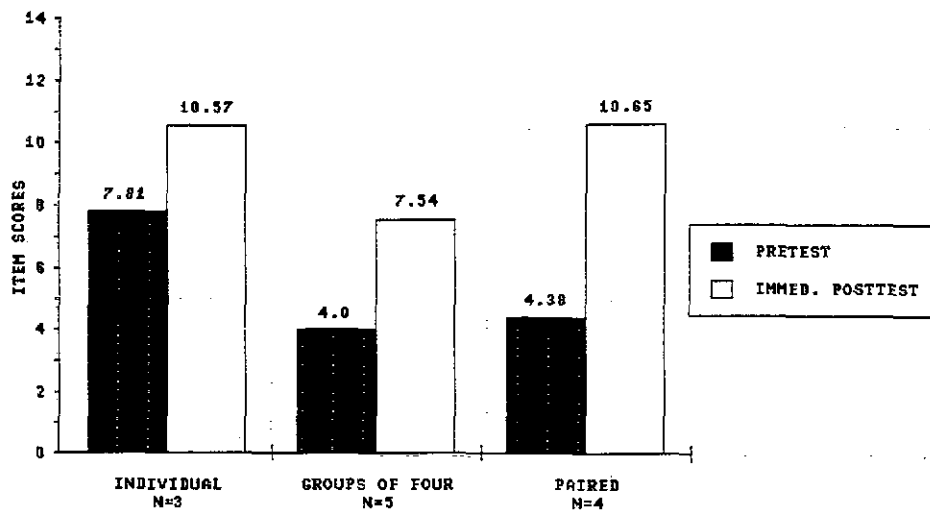


Figure 6. Experiment 2 mean pretest and immediate posttest scores for the low ability soldiers.

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