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ABSTRACT

In continuing research into the technology of training, a study was undertaken to devise guidelines for applying programed instruction to training courses that involve the learning of principles and rules for use in problem solving. As a research vehicle, a portion of the material in the Army's Programing Specialist Course was programed to explore several different factors in using automated instruction to teach computer programing. Experimental versions of the course were administered to over 900 subjects in various experimental groups. Criterion and retention tests based on actual job problems were used to measure subject's performance, along with in-training measures. Results in a series of prompting/confirmation variations indicated that giving subjects extensive stimulus support during training helps motivate them and improves scores during training, but hampers them in using what they have learned. Requiring subjects to fully write out rules during training hindered them in developing problem-solving skills applying these rules; however, using mnemonics during training aided subjects in retaining what they had learned. (Author)

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Technical Report 68-4

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The Application of Theoretical Factors in Teaching Problem Solving by Programed Instruction

by

Robert J. Seidel and Harold G. Hunter

HumRRO Division No. 1 (System Operations)

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Office, Chief of
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The George Washington University
HUMAN RESOURCES RESEARCH OFFICE

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Technical Report 68-4
Work Unit METHOD
Sub-Unit II

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FOREWORD

The research described in this report was performed by the Human Resources Research Office under Work Unit METHOD, Research for Programed Instruction in Military Training. The objectives of Sub-Unit II of that Work Unit were to develop guidelines for applying programed instruction to military tasks requiring the learning of principles and rules, especially those applying to computer programming.

The vehicle for the research was the development of an automated instructional package for teaching basic computer programming instructions in the FIELDATA symbolic coding language. The final version of the course is entitled, Basic Computer Programming: A Self-Instructional Course (with Answer Booklet), June 1967.

The research was conducted at HumRRO Division No. 1 (System Operations). The present Director of Research of the Division is Dr. J. Daniel Lyons; Dr. Arthur J. Hoehn was Director of Research when METHOD II was initiated; Dr. Robert J. Seidel was Work Unit Leader.

HumRRO staff members who contributed to the research include Dr. Iris C. Rotberg, in the early stages; Dr. Eugene F. MacCaslin, task analysis; Dr. Donald Reynolds, Dr. Harold Wagner, and Dr. Richard D. Behringer, data collection; Dr. Harold G. Hunter, course preparation and report preparation; and SP 4 Wayne S. Carpenter, course preparation.

The superintendents of the school systems in the metropolitan Washington, D.C., area who provided facilities and students for the administration of the experimental programed instructional course were: Dr. J.C. Albohm, Alexandria, Virginia; Dr. H. Wilson, Associate Superintendent for Instruction, Arlington County, Virginia; Dr. C.F. Hansen, Washington, D.C.; Mr. E.C. Funderburk, Fairfax County, Virginia; Dr. H. Elseroad, Montgomery County, Maryland; and Mr. W.S. Schmidt, Prince Georges County, Maryland.

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Meredith P. Crawford
Director
Human Resources Research Office

SUMMARY AND CONCLUSIONS

Military Problem

The military problem to which this study was addressed is primarily that of the need for research in the technology of training, with development of a potentially useful course serving both as the research vehicle and as a secondary objective.

In recognition of the need for more efficient training of military personnel to meet the increasing demands for more complex knowledge and skills, research and development on automated instruction is continuing on a widespread scale. While solution of training problems for a particular course represents an important activity, contributions that have broader application can be made by establishing general guidelines for developing automated instruction for a *class* of instructional content. Toward this end, the principal objective of METHOD II research has been to develop general guidelines for the application of programed instruction to tasks requiring the use of *principles and rules* in problem solving.

Increasing complexities in military systems have created a need for faster and more efficient methods of information processing and a consequent increase in the importance of training for computer programmers, whose work involves the application of principles and rules. The activity chosen for the research, therefore, was the development of an automated instructional package for a portion of the Automatic Data Processing Specialist (ADPS) programming course (MOS 745.1). The instructional content was concerned with the basic computer programming instructions and FIELDATA symbolic coding language, pertinent to the MOBIDIC computer. Emergence of a usable military course of instruction would be a desirable by-product of the research.

Research Problem

Although programed instruction is beginning to find application in full-length operational courses, much of the research on the technique has been restricted to short-course laboratory studies, using material requiring simple memorization. Most operational training, on the other hand, requires learning complex material—"connecting" a set of stimuli (concepts) and symbolic "mediating" responses, in contrast to "connecting" a *single* stimulus and a *single* overt response. Further, for training, a distinction must be made between *learning* per se (i.e., developing a base knowledge of and ability to use what was learned to solve problems.

To help bridge the gap between laboratory research and training, the METHOD II research was planned as a large-scale experimental study to explore a variety of factors in using automated instruction to teach fundamentals of computer programming. The study provided "real" training content, an environment more like a school than a laboratory, and complex material to be learned.

Variables studied experimentally in presenting programed instruction were (a) degrees of *prompting*—providing correct answers to the student before he responds, (b) degrees of *confirmation*—providing correct answers for the student after he responds, (c) effects of *verbalization*—requiring students to write or name rules, and (d) effects of *variety of practice*.

Since prompting and confirmation affect the smallest unit of a program, the individual instruction frame, study of these variables deals with the fundamental aspects of preparing programed instruction. Verbalization which has been used in other research to indicate whether the student understands the material, was used in this study to explore the relationship between the student's ability to verbalize rules and principles and his ability to actually use them in problem-solving performance on realistic materials.

Approach

The research involved four major types of activities:

(1) **Literature review.** The literature on programed instruction and learning principles was reviewed to select concepts and techniques for experimental study.

(2) **Program development.** After attending military and industrial computer programmer classes, researchers analyzed the programmer's work, with the aid of operational military personnel. Portions of the ADPS programming course were selected for experimentation, and training content for an experimental course was developed jointly by military instructors and research personnel.

(3) **Experimentation.** Materials for the experimental course were divided into five parts of increasing difficulty. Training content was translated into programed instruction format and then prepared to reflect varying degrees of the experimental variables. Training experiments, factorial in design, were then conducted: a relatively small experiment using the first two parts of the course, and a larger-scale effort using all five parts of the course.

(4) **Course revision.** The principal research findings were applied in developing a revised version of the course in programed instruction format.

The experimentation phase of the research may be summarized as follows:

Experiment 1A—The prompting/confirmation and the verbalization variables were studied during a three-day period of training and testing, using 60 high school students. The first two portions of the five-part course were the subject matter. As the prompting/confirmation training condition, one-half the subjects wrote answers after being given the needed information, and the other half wrote answers before receiving the information. Alternative versions of verbalization were used; during training, one group of subjects was required to write the entire rule applicable to the computer programming problems they were solving, a second group wrote the appropriate mnemonics (name) for the rule, and a third group neither wrote nor named the rule during their instructional work.

Experiment 1B—This experiment was the first portion of the large-scale study. It initially involved 805 volunteer subjects from local high schools, about half of whom remained in the program at the close of the 1B portion of the training. It covered Parts I and II of the course and the materials used were identical to those in Experiment 1A. The same prompting/confirmation conditions also applied; study of the use of mnemonics was continued with groups that named the rule or did not name the rule in training, but the treatment requiring writing of the entire rule was omitted. This experiment and Experiment 2, together, covered 10 weeks, with instruction given once a week.

Experiment 2—This experiment was the second portion of the large-scale study, following Experiment 1B in time and covering the more complex content of the course (Parts III, IV, and V). The students who had completed Experiment 1B continued into Experiment 2; a total of 345 completed the whole five-part program. The treatments included expanded variations of the prompting/confirmation conditions. They also included a variety-of-practice variable; during learning one group of subjects practiced solving problems in a single context while a second group was given three different variations of problems.

For all of the experimentation, the performance tests used as final criterion measures (and also as retention tests given at periods of one day to four weeks after training) represented the kinds of computer programming problems typically encountered on the job by programmers

with a comparable amount and kind of training. Work on similar practice problems within the course provided error rate data on learning during training.

Following the experimental administrations, the course was revised to incorporate findings from the research and apply experience gained. This revision included simplifying the content and improving the format. The course was then administered to seven college freshmen and six high school seniors, all of whom completed it.

Results

Experimental Effects

(1) The results of Experiment 1A showed that:

(a) Writing out rules of computer programming during training hindered students on the performance tests, despite the fact that they learned to write the rules better than the other students.

(b) Prompting was associated with significantly better learning than was confirmation, as measured by error rates during training. However, a reverse tendency appeared on the *application* of learning to problem solving in the criterion performance test.

(c) Practice in *naming* the rules of computer programming (rather than writing them out) appeared to aid criterion performance.

(2) Experiment 1B added to the reliability and generalizability of Experiment 1A results by duplicating them under different administrative procedures.

(3) The results of Experiment 2 showed that:

(a) The more information (either prompting or confirmation) the students received during training, the more likely they were to complete the course.

(b) For those who completed the course, more prompting or confirmation reduced error during learning, but increased error on the criterion tests.

(c) Students who dropped out had performed much more poorly than they had thought they would. Students who finished the course had expected to perform only slightly better than they did.

(d) Variety in practice problems led to better criterion scores than did no-variety.

(e) Results on the final retention test four weeks later yielded the same pattern as the criterion tests.

Course Effectiveness

(1) Taking into consideration the differences in administration conditions between the Army school situation and an experimental setting aimed primarily toward comparing techniques rather than maximizing scores, the course seemed to be effective in certain of the experimental conditions. Specifically, the average scores on criterion tests in the first two parts of the course were approximately 80-85% correct. Under the optimal experimental conditions in the most complex portion of the course, the scores dropped to approximately 50% correct. Average time for completion of the full five-part course (Experiments 1A and 2) was about 27 hours.

(2) In the pilot administration of the final revision of the course, four of the seven college freshmen given the course had scores of 90% or better on the final criterion test and the lowest score was in the high 70s; median completion time was 26 hours. The high school students' scores averaged slightly lower, in the 80s, with a median completion time of 31 hours. The two

high school students who obtained the highest scores were in the bottom third of their senior class.

Conclusions

(1) Results suggest the following guidelines for preparing programed instruction for learning rules and principles:

(a) A large amount of prompting and confirmation is important as a motivational device to keep students interested in continuing training. However, a smaller amount of prompting and confirmation, while producing more errors during learning and lowering motivation, appears to foster better ability to use the results of training. The advantage of less prompting/confirmation for ability to use learning seems consistent and long-lasting.

(b) Requiring students to write out rules during their training hinders the development of problem-solving skills using these rules.

(c) Variety in practice problems facilitates the learning of problem-solving skills.

(d) Early training using mnemonics (naming the rules) aids later learning and retention, particularly as material becomes more complex.

(2) Because of the nature of the course content, it would appear to be useful for either officer or enlisted personnel who need some introduction to computer programming, whether for administrative or supervisory activities, or for some allied operational activity.

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The Application of Theoretical Factors in Teaching Problem Solving by Programed Instruction

Chapter 1

RATIONALE

MILITARY PROBLEM

As present and future defense systems continue to increase in size and complexity, greater demands for information and skills are being placed on military personnel. Besides the requirements of learning new weapons systems, changes in current equipment and tactics impose broad, continuing requirements for adaptation of skills already learned. Taken together, these conditions demand the continuing development of methods for constructing shorter, more effective training programs.

Much necessary training research has been directed toward solving problems in specific courses of instruction. Less research has been aimed at establishing a body of knowledge, sets of principles, and effective guidelines for training development in general, or for specific categories of training content. Besides the need for more effective individual training programs, then, there is a need to develop a body of training technology. Specific findings need to be brought together in a systematic way, so that they may be more readily applied to future Army training programs.

A category of training content that has both great importance and broad application is the learning of principles and rules for use in problem solving. It was therefore decided that the METHOD II research would deal with guidelines for applying programed instruction (PI) to Army training courses that involve the learning of principles and rules.

The use of principles and rules is typified in the task of programming for automatic data processing systems. The programmer's job is problem solution, that is, he analyzes information given and prepares a solution to the problem in a form acceptable to a computer. For the Army, training computer programmers is a matter of considerable urgency because the increasing complexity of weapons and operations systems requires highly effective information processing possible only with computers. Therefore, the vehicle chosen for METHOD II research was an automated instructional package for selected portions of the Automatic Data Processing Specialist (ADPS) (FIELDATA) programming course.

From work with such materials, it was hoped that the experimental findings of METHOD II would provide a beginning toward the establishment of guidelines for programing training content that consists of rules and principles. A secondary research goal would be development, as a research by-product, of course material that could be used for military instruction.

SCIENTIFIC BACKGROUND FOR THE RESEARCH

Several facets of theory and exploration which led to the current set of experiments are summarized in this section:

(1) The area of programed instruction is examined from theoretical aspects, as well as for its practical value as a controlled environmental setting in which to do training research.

(2) The role of errors in training and training research is discussed.

(3) The range, difficulty, and variety of instructional content are considered in terms of concept formation processes, as contrasted with simple learning such as rote memorization.

(4) The distinction between learning concepts and using them in solving problems is given emphasis.

These factors are considered against a backdrop of the various kinds of content that have been used in the laboratory setting. Traditional psychological research (generally using isolated bits of verbal material) is contrasted with the kinds of material that must be dealt with in the everyday teaching and training situation, that is, connected discourse, hierarchically ordered and related conceptual material. Research pertinent to the specific studies undertaken in Work Unit METHOD is discussed in order to bring into focus the particular experimental hypotheses to be investigated.

Programed Instruction: Value as Theory and Technique

Because of its potential for applying Skinnerian experimental techniques to the area of education, programed instruction has been viewed as a panacea for problems of teaching; it is not that. On the other hand, programed instruction has also been termed merely another teaching aid; it is not that either. It is a medium of instruction that can readily provide for the application of psychological principles to teaching. It can also provide a testing ground for uncovering laws of learning, using as a laboratory the highly controlled educational environment that PI makes possible.

Ironically, the advances in programed instruction to date have come not from applications of theoretical developments but rather from a technique incidental to programed instruction per se—that of task analysis, which has existed in the field of military and industrial psychology for many years. With this tool a curriculum developer who is planning instruction is directed to a focus on the behavioral end-products of training (or education). There is no doubt that this analytic tool has been helpful in improving curricula through the development of programed instruction; however, it provides marked improvement in conventional teaching as well. Curriculum improvement deriving from this technique is best considered an engineering improvement, to distinguish it from advances that might be due to the development of learning theory.

The advent of programed instruction has also resulted in a focus upon the individual student. This represents an administrative breakthrough rather than a development from the psychology of individual differences. For years teachers have been aware of the importance of a student's individual characteristics in instruction, but crowded classrooms and the need to serve the "average" student have interfered with teachers' attempts to take advantage of individual capacities. The teaching machine and the programed booklet have provided a distinct step forward in this regard.

Educational research literature is rife with studies showing no differences between the so-called "conventional" and the programed instructional technique (cf., Schramm, 1). Usually, the data indicate that one can teach the same amount in less time using programed instruction than using conventional instruction, or else the development of proper behavioral objectives for a course results in improvement for both programed instruction and conventional teaching.

Existing courses in programed instructional format represent constellations of learning factors such as frequency of reinforcement, amount of information per presentation unit, and activity of the student. No PI product truly represents a particular learning theory. The intent in the present research has been to try

to examine some of the training factors (e.g., amount of information given prior to requiring a response) without attempting to label the program according to whether it is related to one or another or some combination of PI viewpoints.

To date, simple devices (the programed booklet and small teaching machines) have been the primary vehicles for PI. Such devices, in turn, have been quite adaptable to the techniques of operant conditioning—learning a response by being rewarded as a "consequence" of the response. These techniques (developed mostly with rats and pigeons) for increasing the likelihood of a response have become more or less the modus operandi of the curriculum developer in the field of programed instruction. They include the training procedure of successive approximation (with minimal, if any, errors), particular reinforcement schedules, immediate feedback, and active participation by the student.

Cook and associates (e.g., 2) and Angell and Lumsdaine (3), and others as well, have found that prompting (giving the student specific information before asking him to respond) is significantly more effective than confirmation (giving him correct information after he responds) for serial learning. Gagné and Brown (4), in a study dealing with conceptual material, compared several combinations of prompting and confirmation (although they did not use those terms) in the learning of principles for generating number series. Their guided discovery (confirmation) group, medium difficulty condition, appeared to be most effective, while the rule and example (prompting) condition, low difficulty level, was least effective.

Thus, the results obtained by Angell and Lumsdaine suggest that the subjects should be given substantial information before being required to respond, while the findings of Gagné and Brown suggest that subjects should be required to discover the answers themselves. The precise factor that caused these experimental differences cannot be determined because of the differences in the research paradigms used and because of many other factors that were not comparable across the experiments or between conditions within an experiment.

Effects of Errors on Learning

The use of operant conditioning techniques, together with an insistence on a low error rate during learning have combined to produce PI materials characterized by low difficulty. Low error rate requires easy-to-understand material, and the operant maxim of high student participation encourages the breaking of the material into small (hence, low error rate) segments, with a student response after each segment.

Whether a low rate of error is desirable during learning may be questioned on the basis of data developed in studies dealing with level of aspiration. It has been found, for instance, that an individual performs to his maximum when the learning task is neither too easy (low error rate) nor too hard (high error rate). If the task is too easy the student refuses to set a level of aspiration, or personal goal, and will not perform the task, through lack of interest (inattentiveness) or lack of motivation. On the other hand, if the task is too difficult the student will refuse to try, because of frustration (Lewin, 5).

The emphasis on low error rates is based, for the most part, on studies of lower organisms (rats and pigeons) and, thereby, of simple types of learning. Human learning, particularly in education, tends to be much more complex—primarily in terms of concept formation and problem solving.

The focus of the present study with respect to error rate during learning has been to manipulate certain stimulus conditions that might produce greater or smaller error rate in a conceptual, hierarchically ordered setting. It was

expected that, unlike the effects obtained in rather simple discrimination learning, those conditions leading to greater difficulty during training (e.g., few hints) might well result in better overall criterion performance and retention.

Range of Instructional Content

In simple operant learning, the organism is taught to discriminate, or respond differently to different stimuli—for example, to perform in one way in the presence of A and a different way in the presence of B. In most types of human learning, however, the student not only must discriminate A from B, but must also learn that A and B each are to be treated as belonging to classes of As and Bs. For example, a child learns that the fork in his hand is but an example of forks in general, all of which have common properties; human beings tend to make such inductive leaps even if not told to.

Even in supposed rote learning, subjects structure the stimuli into groups, as shown by results of a number of studies in paired-associate learning (Battig, 6). Battig has proposed an interference-facilitation theory of learning—that high intra-task interference promotes inter-task facilitation. This view is consistent with the motivational ideas expressed above. That is, the dual assumption that error rate should be minimal during the teaching-learning process and that human learning is analogous to a simple discrimination problem is open to question, on the grounds of lowered motivation and of oversimplification.[1]

In general terms, most human learning requires that the student develop transformational behavior with respect to given stimuli. These transformations can be called mediating responses or hypotheses, which exist, as it were, in the student's "head" and allow him to apply his learning from one situation to another.

The wholesale adoption of operant conditioning principles can be viewed in another way. Skinner (9) has criticized the use in textbooks of materials he termed irrelevant—materials such as analogies and examples, which might confuse the student. Such materials are often included to challenge the student's thinking or to make the topic more interesting; similarly, an instructor, in translating a book and other course materials into analogies and examples, tries to make the student "understand" rather than memorize concepts. What is being accomplished in the teaching-learning process is the establishment of connections between a delimited set of stimulus elements and a delimited set of response elements. Instead of covering only narrowly defined "relevant" material, the instructor or textbook writer who makes use of materials such as analogies may teach a much more complex set of relations.

Three classes of stimulus elements can be considered: irrelevant, correct, and omitted. The same three classes exist for the response, but there is also an additional class, the incorrect response. The outcome of training experience may be viewed as a set of incorrect stimulus-response (S-R) tendencies competing with correct ones.

One prevalent approach to programed instruction limits content to only those stimuli that are relevant, and tries to limit responses, as much as is feasible only to those that are correct. Although this means that no competing response tendencies are established, the range of S-R coverage is considerably narrowed. In other words, a limited sample of appropriate elements becomes connected but the coverage is incomplete in terms of the total stimulus and response populations. The problem of defining what is "relevant" in instruction, to develop the appropriate concepts and to allow the person to discriminate "correct" from

[1] In fact, research with connected discourse has already produced data which raise a question as to the universal applicability of minimal error rate (Basic Systems Inc., 7; Seidel and Rotberg, 8).

"incorrect," is a crucial theoretical and practical problem for programed instruction, especially for that dealing with problem-solving behavior.

Once one considers a broad range of instructional content, and departs from operant conditioning concepts, new research questions unfold. One such question derives from Harlow's error factor theory (10). In learning set research, Harlow (11) inferred that the increased conceptual proficiency shown by subjects stemmed from eliminating erroneous hypotheses during training. His conclusion, and the essence of his theory, suggests that encouraging certain kinds of errors (i.e., incorrect S-Rs) during learning could result in more effective elimination of erroneous hypotheses.

Thus while concepts are being formed (as is the case in most education), variety of content probably facilitates the elimination of erroneous hypotheses during training. It also allows the individual student to abstract the appropriate mediating skills and responses more effectively than he could in a homogeneous context. The individual can then use these mediating skills and responses to generalize to other stimulus contexts after training.

Knowing and Using: Levels of Learning

The distinction between rote and problem-solving learning is made as follows. Rote learning involves connecting specific stimuli to specific responses during training, and the test of success in training is simply whether the connections have been made. Problem-solving learning, on the other hand, involves training the student to abstract a common (identity) response to a class of stimuli; while a test of success in such training consists of knowing (being able to name, state, or describe a concept), the main test rests in being able to use the concept effectively in solving problems (cf., Kendler, 12, and Gagné, 13).

A more detailed analysis of problem-solving learning heightens the difference between it and rote learning. For problem-solving learning, distinction is usefully made between (a) responding during training, (b) abstracting concepts from responses, (c) knowing a concept, (d) being able to use the concept.

Making this distinction is not new. For years, Gestalt psychologists have delivered polemics (and included some demonstrations of principle learning) on the distinction between rote and conceptual learning. The thrust of Katona's work on learning number series is another example. However, only recently has a study by Smith, Jones, and Thomas (14) clearly separated the two types of responding. Their experiment directly compared rote and conceptual learning where number of stimuli per response was varied from one to four. (Rote learning involved random grouping of stimuli, whereas conceptual organization included a meaningful link among stimuli within each grouping.) Increasing the number of stimuli per response improved concept learning but [illegible] rote learning, thus showing two distinct learning processes.

Added to the identity response in most human learning are the [illegible] solving responses; that is, the identity response is used in developing strategies to put concepts together in order to perform some task. Will the optimal techniques for teaching concept formation per se (identity responding) be the same as those for teaching problem solving? Gagné (13, p. 312) suggests that they may indeed be different forms (or at least levels) of learning. Concept learning consists of "establishment of mediating response to stimuli which differ from each other physically ('classifying')." Problem solving, he feels, is the 'establishment of a process which 'combines' two or more previously learned rules in a 'higher-order rule'." A study by Gagné and Smith (15) suggests that the verbalization of principles takes on importance as the problem becomes more complex.

The distinction between concepts and problem solving can be illustrated in electronics troubleshooting. The student must understand the concept of a schematic diagram which represents the wires, connectors, and other parts. He must know the color coding system for resistors and the system of naming pins on electronic vacuum tubes, as well as how one reads a multimeter. Superimposed on all of these is another requirement: the student must determine the likelihood that following a given path of potential defects will be successful in troubleshooting the overall system. The effects of each factor may be taught. So might the mechanical responses or a total task in isolation. Given the learning and isolated practice, the student may be asked to actually troubleshoot a malfunctioning piece of equipment; this activity comprises applying the complex of concepts to solve a problem.

Viewing the troubleshooting illustration from a theoretical point of view provides a more technical analysis. The student might learn (from making certain kinds of controlled errors during training) to recognize the effects of various kinds of errors in the system, and to abstract from his training experience an understanding (conceptual set of responses) for the task. Having learned the proper identity responses (concepts), the student must put these together into a strategy to perform the task of troubleshooting successfully (the problem-solving aspect of the process). Here, it seems, is a meaningful distinction between understanding (concepts) of a class of stimuli and their use (problem solving) in a series of acts required to turn out a useful solution.[1]

RESEARCH OBJECTIVES

Background for the Experimental Hypotheses

Unfortunately, much of the research that has been done concerning the effects of learning factors in programed instruction has been conducted with paired associates or serial learning. Little has been done where experimental treatments have been manipulated for hierarchically organized conceptual discourse.[2] Yet this type of discourse—meaningful course content—is precisely the medium for most, if not all, programed instructional applications. Paired-associate experiments generally require the subject to make a series of rote responses, and his learning is measured by his ability to give back these rote responses. Conceptual learning, however, requires the subject to abstract mediating responses, and learning is measured by his ability to apply these mediating skills to a variety of different situations.

As indicated earlier, the present study was undertaken to examine some of the psychological factors in programed instruction. The review of previous research led to selection of the following factors for exploration:

First, the value of a rule-giving or naming type of verbalization response was investigated. This factor deals with the distinction between rote learning and concept formation, and was intended to explore the efficacy of repeating or naming concepts in training, for the purpose of applying learning to problem-solving situations. Many current programed instruction programs are parallel to paired-associate learning situations in that they seem to emphasize reproducing material presented. Yet the program developers seem to be interested in teaching concepts (mediating skills). Does verbalizing a rule aid or hinder learning to use the rule in problem solving?

[1]This view of such a teaching problem has recently been implicitly expressed by Cronbach (16) in an excellent review of discovery experiments.

[2]A recent study by Hickey and Newton (17) is a welcomed attempt. Also, for an excellent discussion of problems in doing PI research on conceptual material, see Traub (18).

Second, the principle of minimal error rate as applied to learning complex, meaningful materials was questioned. Level of aspiration studies have shown that a certain amount of difficulty (e.g., error) during learning will lead to maximum motivation (and implicitly, high scores on a criterion test).

Third, the importance of varieties of examples in such human learning was examined to see whether this principle generalized from simpler concept (learning set) studies, in which variety of examples has been found to foster concept formation. It would be expected to aid subjects to generalize from training content to operational application.

Fourth, attention was given to another pair of factors of interest in programed instruction research—"prompting" (providing the student specific information prior to asking him to respond) and "confirmation" (giving him correct information after he responds). For a meaningful comparison of prompting and confirmation, the sole element manipulated should be the amount of information given to the subject prior to requiring him to respond; whatever is not given to him then should be given after he responds to make the total information each subject receives comparable for the confirmation and prompting conditions.

Experimental Treatments

In summary, the background for the METHOD II research rested on the need to study, using meaningful course content, those factors that seem most relevant to learning how to use rules and principles. The first experiment (1A) examined the influence of prompting vs. confirmation, and of alternate ways of verbalizing rules. The results of this experiment were taken into consideration in further exploration of the same variables in the second experiment (1B). In the third experiment (2) other aspects of these variables were explored, and, through work with a variety of practice problems, the development of connections between conceptual stimuli and mediating responses was considered.

With the training content (writing a computer program) put in the form of programed instruction, experiments were conducted with the following factors:

(1) Amount of information to be given to trainees prior to requiring responses (degrees of prompting vs. degrees of confirmation) (Experiments 1A, 1B, and 2). This factor was judged especially valuable to study since its influence is felt in the smallest unit of a program; namely, the frame itself.

(2) Value of written verbalization of rules during training (Experiments 1A and 1B). Verbalization of rules has been generally used in construction of programs to indicate understanding by the student of the material in the program. In this study, interest lay in the relationship between the student's ability to verbalize rules and principles and his use of them in problem-solving performance.

(3) Value of variety of context for practice problems during the training on problem solving (Experiment 2). The complexity in most learning demanded consideration of broad connections between conceptual stimuli and mediating responses. Variety of verbal contexts for the practical problems given during training provides the setting for establishing broad connections. Minimal variation of problem context should encourage only simple connections.

(4) The effects on a problem-solving criterion of different amounts of error during training, examined throughout the series of experiments.

As the final step in the research effort, an attempt was made to incorporate major findings from the experimental work into a revised self-instructional course in basic computer programming. The desired by-product was a usable military course of instruction.

Chapter 2

RESEARCH PROCEDURE

APPROACH

The major research activities—a literature review, program development, experimentation, and course revision—may be summarized as follows:

(1) The scientific literature on learning principles and programed instruction was reviewed as described in the preceding chapter, to provide a basis for selecting concepts and techniques for experimental study. Selection was based on importance for learning in a military training context, feasibility of manipulation for study, and potential for the advancement of training technology.

(2) As the first step in developing the instructional program, the researchers attended computer programmer classes at the U.S. Army Signal School, Fort Monmouth, New Jersey and at IBM. They then interviewed supervisory and computer instructor personnel, systems analysts, and computer programmers at Fort Huachuca, New Mexico. The nature of the tasks performed by the programmer was analyzed with the assistance of operational programmers. Portions of the Automatic Data Processing Specialist (MOS 745.1)[1] programming course were selected for experimentation. Final content was developed jointly by instructors from the Signal School and research personnel.

(3) The materials selected were divided into five parts of increasing complexity. Training content was translated into programed instruction format and then prepared to reflect varying degrees of the experimental variables. Three experiments were conducted; their major characteristics are summarized below and in Figure 1. In all three experiments, the final criterion and retention measures were performance tests representing the types of problems typically encountered on the job by computer programmers with a comparable amount and kind of training. The experiments were:

Experiment 1A—The prompting/confirmation and verbalization variables were first studied during a three-day training and test period in 1962, using 60 students from a local high school as subjects. Parts I and II of the five-part course were used as subject matter.

Experiment 1B—This experiment was the first part of a larger study conducted between September 1964 and January 1965, and initially involved 805 student volunteers from local high schools. The variables were the same prompting/confirmation conditions and part of the verbalization condition used in Experiment 1A, and the materials were also the same. Instruction was given once a week during the first part of a 10-week time frame which included Experiment 2.

Experiment 2—This portion of the larger study followed Experiment 1B in time and was applied in weekly instruction to the more complex course content of Parts III, IV, and V. Students who had completed the instruction in Experiment 1B were the subjects. The prompting/confirmation variable was expanded and a variety-of-practice variable was introduced.

[1]Under the current MOS structure, the ADPS Programing Specialist is MOS 74F.

Approach Used in the Method II Experiments

Experiment	N	Instructional Materials	Factors Studied	Criteria	Time Sequence
1A	60	Part I Part II	Verbalization of rules and principles a. Writing the Rule (Rules Group) b. Naming the Rule (Naming Group) c. Neither (CP-Only Group) Prompting/Confirmation a. Answer before response (Prompting Group) b. Answer after response (Confirmation Group)	Part I–Criterion performance test at end of instruction Criterion tests on writing and naming rules at end of instruction Retention performance test the next day Error rates during training Part II–Same as Part I	Daily Sessions 3 days
1B	805	Part I Part II	Verbalization a. Naming the Rule (Naming Group) b. Not Naming the Rule (No-Naming Group) Prompting/Confirmation a. Answer before response b. Answer after response	Same as in experiment 1A except that the retention test for each Part was given one week after instruction	Weekly Sessions 10 weeks
2	345 (at end of course)	Part III Part IV Part V	Prompting/Confirmation Exploration of various degrees of prompting and confirmation Variety of Practice a. Similar practice (No-Variety Group) b. Varied practice (Variety Group)	In addition, criterion performance test at end of instruction for each part. A final retention test was given four weeks after the close of instruction	

Figure 1

(4) A final version of the course in programed instruction format was developed by applying the principal research findings, and a pilot test was conducted, using 13 students as subjects.

OVERALL DESCRIPTION OF THE PROGRAMED COURSE

The experimental programed course was directed toward the level of high school seniors and first-year college students. This level was chosen because the content material was originally drawn from portions of the Army training course for the ADPS Programing Specialist, at the U.S. Army Signal School, in which the background of the Army trainees corresponds to a high school education.

The aim of the experimental course was to provide understanding of fundamental computer programming concepts and, more important, to produce proficiency in writing elementary computer programs. From the very beginning of the course, its entire context was oriented toward the writing of computer programs. That is, a concept was introduced, then a problem incorporating the concept was presented, and the student programmed the problem. The practice problems and the problems used in the criterion and retention tests were chosen from actual ADP job situations.

The repertoire of primary programming commands and the symbolic language in which the computer programs were written were chosen from material which had been used by the Army to teach trainees to program the MOBIDIC computer. The language is the FIELDATA Symbolic Language which, although representing a set of symbols interpretable by the MOBIDIC, is sufficiently general in form that it largely applies to almost any other computer and to the English language (the addresses).

As nearly as possible, the goals of all subjects were made comparable by orienting them with an overview of the concepts of computer programming in an Introduction to the course. Specific attention was paid to the concepts of command, address, the accumulator, memory locations, input, and output. Also included were a brief description of how a computer functions, and some sample mnemonics as they are used in computer commands. The coverage of these topics was interspersed with periodic review and with questions which students answered to themselves. The student was instructed to continue reviewing the material preceding each of the sets of questions until he could answer the material to his own satisfaction. As the last item in the introductory material, the student worked through a short sample program.

The five parts of the experimental course proceeded from the simple to the complex. Parts I and II dealt with primary programming; the student was introduced to storage locations, the concept of a central work area, the movement of numbers from place to place, and simple arithmetic operations, along with an introduction to elements of a symbolic data language. Part III covered basic looping concepts, including general transfer commands, counting the loops, leaving the loops, and program preparation. Parts IV and V dealt with data processing, covering address modification and address arithmetic (effective addressing), sorting and counting data into various categories, and multiple address modification.

The programed instruction materials were all prepared in the form of linear programs so that a student moved step-by-step straight through the course. It would not be correct to characterize the steps as frames, however, because the steps—rather than single sentences or two sentences at a time—constituted conceptual or functional units. Thus, there could have been as many as two or three paragraphs given to the student prior to questioning him on the content.

Details on the course materials and the variations for the experimental treatments are presented in the descriptions of the individual experiments. Content and presentation of the course are illustrated in samples in Appendix A.

The criterion tests at the end of each part of the course consisted of actual computer programming problems submitted by a programmer group from Fort Huachuca and by programming instructors from the Signal School. Where necessary, problems were simplified by removing aspects that would require techniques beyond the scope of the course.

EXPERIMENT 1A

Design

A 2x3 factorial design was used in Experiment 1A (illustrated schematically in Figure 2). Six independent groups of subjects in a PI environment learned to write increasingly complex computer programs (CPs). One-third of the subjects periodically wrote out the content of the rules used to guide the writing of computer programs (Rules Group), one-third periodically wrote down the names of

Design for Experiment 1A

Training Variation	Writes Computer Program and Rules	Writes Computer Program and Names of Rules	Writes Only Computer Program
Prompting	Computer Program	Computer Program	Computer Program
	Rules	Names of Rules	
	Answer given before student response	Answer given before student response	Answer given before student response
Confirmation	Computer Program	Computer Program	Computer Program
	Rules	Names of Rules	
	Answer given after student response	Answer given after student response	Answer given after student response

Figure 2

the rules (Naming Group), and one-third wrote CPs without any verbalization of the rules (CP-Only Group). Also during learning, one-half of the subjects were required to write their answers after being given explicit information needed in the response (prompting), and one-half were required to write their answers prior to receiving the information (confirmation). During learning, error rates were obtained on CP-writing for all groups and on rules and naming for the appropriate groups.

Treatments composed of various combinations of the training conditions were administered during the PI training, and their effects were evaluated on criterion and retention tests given at the end of each of the two parts of the instruction.

Subjects

The subjects were 60 volunteer high school students (juniors and seniors), who had been informed that they were to be paid between $1.50 and $2.00 per hour, depending upon the proficiency they exhibited in learning. They were assigned at random to one of the six training conditions. A combination of scores from the verbal and clerical tests of the Army Classification Battery (ACB) was used to measure intelligence level for the detailed evaluation of results.[1]

Training Materials

The training materials used in this experiment were Parts I and II, covering an introduction to symbolic language for computer programming and primary programming commands of a business-type digital computer. The learning task was writing computer programs of increasing complexity, with the additional requirements imposed by the experimental treatments. The treatments were applied as each new concept was introduced along with the attendant requirement of writing a computer program.

A different programed instructional booklet was used by each of the six groups of subjects (Figure 2), in accordance with the training conditions assigned to that group. The booklets used by the Rules and Naming (or mnemonics) Groups

[1]The intelligence measure was the same as that applied by the Army for entrance into the ADPS programming course.

consisted of 90 pages, including the criterion tests; booklets used by the CP-Only Groups had half that number of pages. The difference in treatment between the prompting and confirmation conditions did not affect the size of the booklets.

For all groups, the first step was the presentation of a concept. The next step varied according to the experimental treatment. The following sample rule can be used to illustrate the various treatments:

> The CLA SOCSEC instruction clears any material already in the accumulator and copies the number from location SOCSEC into it.

After the concept had been presented, the portion underlined above was given to the subjects in the Rules Groups, who were to fill in the rest; the portion not underlined was given to the subjects in the Naming Groups and they filled in the part underlined. Both groups were then given a problem illustrating the concept and they wrote a computer program on the problem. The CP-Only Group went directly from the presentation of the concept to the statement of the problem.

The prompting/confirmation variable was added to the above treatments by having subjects work on only one page at a time. The Prompting Groups saw the entire sentence first; the subjects in those groups turned the page and completed the blank before working on the computer programming problem. The subjects in the Confirmation Groups completed the blank, then turned the page and viewed the entire sentence after working on the problem.

The booklets included criterion tests at the end of each part of the course. As a secondary part of the criterion tests, the ability of all subjects to write t. e rules and the names of the rules used in writing the CPs was measured.

Procedures

On the first day students were given Part I, the section concerned with primary programming commands, and a criterion test for that material. On the second day they were first given a retention test (for Part I) consisting of four problems to be programmed, which all subjects finished within 30 minutes. Immediately following the retention test, they were given Part II of the course, on more complex computer programs, and the criterion test for that part. On the third day, they were given Retention Test II, consisting of four programming problems covering all the course material, followed by the ACB intelligence measure.

The students were allowed a maximum of four hours on each of the two days of training, but only one or two students required that much time on either day. Each student's booklets were checked at the end of his working day to ensure that he was actually working with the material. All students appeared highly motivated to perform; many stayed after hours to ask further questions about the course work. (No substantive questions were answered in order not to contaminate the experimental treatments.)

EXPERIMENTS 1B AND 2

Design

Taken together, Experiments 1B and 2 covered all five parts into which the course was divided. The first two parts (used in Experiment 1B) were identical in content to that of Experiment 1A; they provided subjects with the background necessary for the final three parts (Experiment 2), which dealt with looping principles. Each of the five parts had its own criterion test.

All variables in the two experiments were administered factorially during training. Experiment 1B involved the same conditions as Experiment 1A, except that the Rules Group was omitted. That is, in Experiment 1B comparisons were made between (a) prompting and confirmation; and (b) writing the names of rules and writing computer programs, and simply writing the computer programs.[1]

After completing Part II of Experiment 1B, students were reassigned randomly to treatment groups for Experiment 2, which included three variables:

(1) 0, 50, or 100% confirmation.
(2) 0, 33, 67, 100%, or progressive (67, 33, 0) prompting.
(3) No-variety vs. variety conditions on practice problems.

The No-Variety Group worked on practice problems having a verbal context of warehouse inventory for electronic vacuum tubes. The Variety Group, however, had three types of verbal contexts, the one on vacuum tubes just noted, and on military pay, and uniform selection.

The design of Experiment 2 is an incomplete three-factor study, composed of 29 cells (see Figure 3).[2] The practice problems were given in sets of three instead of singly. The confirmation variable was administered on a more molar level than that of the prompting variable, being applied across sets of problems; that is, either the entire set of three problems received confirmation or it did not, depending upon the confirmation applied. Both the prompting conditions and the variety vs. no-variety treatments were applied <u>within</u> the sets of three problems. Furthermore, the progressive prompting condition was administered as a diminishing prompt within each set of three problems; thus, the first problem received two-thirds prompting, the second one-third, and the third no prompting. A sample application of treatments is shown in Appendix A.

Design for Experiment 2

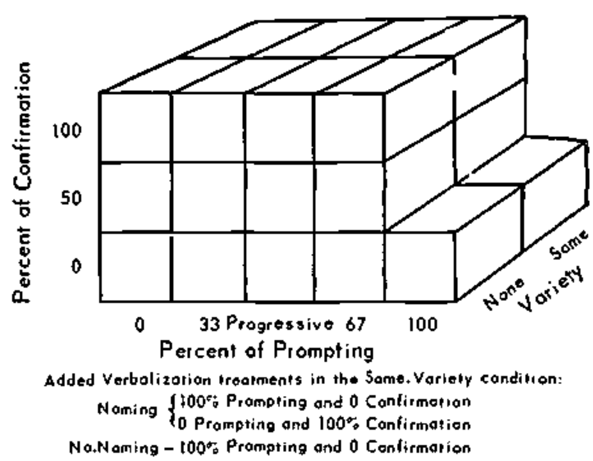

Figure 3

In addition, an attempt was made to obtain data on the relationship between the stage of training at which mnemonics are introduced and the improvement in criterion performance. This was done by continuing the use of mnemonics through the course for three additional groups of students.[3]

[1]The schedule of experiments did not provide true replicates between any of the parts or experiments. What is lost by not having replicates, however, is more than compensated for by the gain in generalizability of whatever findings are stable across materials differing in complexity.

[2]The four cells which would have combined 100% or 50% Confirmation with 100% Prompting (either Variety or No-Variety) were considered somewhat redundant and were to be omitted from the design.

[3]Three cells were added to the design to extend the comparisons of Naming No-Naming, and Confirmation Prompting to more complex materials. The cells were: 100% Confirmation plus Naming, 100% Prompting plus Naming, and 100% Prompting with the Naming content provided without any response requirement. A clerical error during preparation of the booklets resulted in 0% Confirmation - 100% Prompting (Variety and No-Variety) cells omitted instead of 100% Confirmation - 100% Prompting cells. Thus, Naming comparisons in Experiment 2 were quite limited.

Groups of 29 subjects or multiples thereof worked in a single experimental room with each student of a set of 29 in a different experimental treatment from those of his classmates. This design effectively eliminated experimenter differences and socioeconomic variability between school systems, and provided generally equivalent levels across cells. As a check on ability levels, the CL portion of the Army Classification Battery was administered to the students.[1]

Subjects

The original plan was to use Army subjects at the U.S. Army Signal School for Experiments 1B and 2. Because of difficulties in obtaining an adequate sample of Army subjects there, however, it was necessary to use a civilian population for the experimentation. Subjects were male volunteers recruited, without compensation, from the junior and senior grades of high schools in the metropolitan Washington, D.C., area. The schools participating represented all local area school systems, thus insuring a sizable range in socioeconomic status of the pupils attending. No systematic attempt was made, however, to take stratified samples either within or across schools on the basis of socioeconomic status. The school systems, and the number of participating schools per system, were: Alexandria, 1; Arlington, 1; District of Columbia, 3; Fairfax County, 2; Falls Church, 1; Montgomery County, 4; and Prince Georges County, 2.

The number of volunteer subjects beginning the course was 805; the dropout rate was high (57%), with the number of subjects who completed the entire course being 345. Approximately 75% of the attrition occurred prior to criterion testing for Part III, 21% prior to testing for Part IV, and 4% during Part V. The analyses of the experimental effects, reported in the next chapter, were made on the basis of the subjects who completed the entire course.

Training Materials

Parts I and II were contained in one booklet, the content of which was identical to that used in Experiment 1A. Parts III, IV, and V were also contained in a single booklet (186 pages). Part III introduced the technique of looping, Part IV dealt with address modification, and Part V had to do with address arithmetic (a more advanced technique of addressing).

The performance criterion tests were administered after the students completed each part of the program. A similar test was administered four weeks after the course was completed, as a measure of retention. Upon completion of each criterion test, the students were given a Level-of-Aspiration (LOA) Scale, divided into intervals of 5% (see Appendix B). They were asked to make two judgments: (a) how well they thought they had performed on the criterion test they had just taken, and (b) how well they thought they would perform on the next criterion test. These scales were used in computing discrepancy scores, obtained by subtracting the student's actual performance on the next test from his LOA or expected score. Such scores are traditionally used to obtain an indication of the degree of realism with which a student progresses through a course; for example, a small positive discrepancy score (expectation slightly above performance) exemplifies the realistic, positively adjusted student.

Procedures

Students were trained in a classroom at their own or a nearby high school after school hours (afternoon or evening sessions) or on Saturday. They attended

[1]No ACB test data were available for roughly one-fifth of the subjects.

one three-hour session a week. It should be noted that so long a time between sessions was not intended when the experimental course was constructed because the delay allows more time for forgetting. Daily sessions would be the most desirable schedule for the self-instructional course.

Halfway through the three-hour session the students were given a 10 to 15 minute break. Seats were spaced as far apart as room size would allow. The ratio of proctors to the students was approximately 1:15. The proctors insured that the students worked independently and tried to prevent review of materials.

Proctors were instructed to assist the students only with procedural or "structural" questions. (A "structural" question would be one about a suspected misprint or, in rare cases, a request to define an unfamiliar Army term such as KP.) Proctors did not answer substantive questions, those pertaining to understanding the content being taught. In response to those questions, the proctors simply told the students to do the best they could.

Before the course began, the students were given a brief outline along with a cautionary statement regarding the need for independent work and regular attendance. Students were informed that they would be given a final test, covering the complete experimental course, approximately four weeks after they completed the course, and that they would receive certifications of completion after the final test.

Chapter 3

RESULTS

Taken together, the three experiments generated a staggering amount of data. To provide a framework for viewing the results, without presenting an overwhelming amount of detail, it may be well to review the basic questions that were being asked. These questions took the form, "What is the effect of X on Y?" For example, "What is the effect of naming rules during training on ability to solve criterion problems?" The "Xs" and "Ys" are listed below, with an indication in parentheses of the experiment in which they were used:

Effects of . . .	As Measured by . . .
Level of prompting (all)	Errors during training (all)
Level of confirmation (all)	Errors on criterion tests:
Verbalization in training:	Problem solving (all)
Writing rules (1A)	Writing rules (1A)
Naming rules (1A and 1B)	Naming rules (1A and 1B)
Variety of practice (2)	Errors on retention tests (all)
Intelligence (all)	Time to complete (1A)
Combinations of the above	Level of aspiration (1B and 2)
	Combinations of the above

Results are presented separately for each experiment. After the evidence of learning has been presented, findings relative to the various treatments (left-hand column, above) and the effects of each treatment on the various measures (right-hand column, above) are discussed.[1]

EXPERIMENT 1A

Treatments studied were prompting/confirmation and verbalization. Instruction was divided into two parts (I and II). After instruction, proficiency measures were taken in the form of criterion tests (I and II) and retention tests (I and II). During instruction, measures were taken in each phase in the form of errors during training and time to complete.

Evidence for Learning. On the criterion test after Part I, nearly two-thirds of the students scored 80% or more correct, and more than a third scored 90% or higher. Results on Criterion Test II were comparable. Mean criterion and retention test scores are given in Table 1.

Time to Complete. For both Parts I and II, there were no significant differences between the prompting and confirmation treatments as to the length of time subjects took to complete the course. The three Verbalization Groups did differ significantly, however, on both parts. In Part I, the Rules Group was slower than the other two verbalization groups. In Part II, the Naming Group

[1]Unless otherwise indicated, the statistical test used was the Analysis of Variance.

Table 1

Mean Criterion and Retention Test Scores by Treatments: Experiment IA

(N 60)

Measure	Mean: Rules + CP Group	Mean: Naming + CP Group	Mean: CP-Only Group	Summary Mean	Percent Correct	Standard Deviation[a]: Rules + CP Group	Standard Deviation[a]: Naming + CP Group	Standard Deviation[a]: CP-Only Group
Criterion Test I[b]								
Prompting Group	39	43	47	43	83	15	9	7
Confirmation Group	43	49	44	45	87	10	4	8
Summary Mean	41	46	46					
% Correct	79	88	88					
Criterion Test II[c]								
Prompting Group	66	66	75	69	78	29	16	11
Confirmation Group	69	79	77	75	84	19	8	12
Summary Mean	68	73	76					
% Correct	76	82	85					
Retention Test I (%)	76	87	84		82			
Retention Test II (%)	70	80	68		73			

[a]For Criterion Test I, the groups differed significantly, $p < .01$ (Bartlett's test, $X^2(5) = 15.52$). For Criterion Test II, the groups differed significantly, $p < .01$ (Bartlett's test, $X^2(5) = 18.16$). For Retention Test I and Retention Test II, raw scores of the groups did not differ significantly.

[b]Maximum possible score: 52.

[c]Maximum possible score: 89.

was faster than the other two groups. The mean learning times for the verbalization conditions are shown in Table 2.

Table 2

Mean Learning Times for Verbalization Variable: Experiment IA

Part	Means (minutes): Rules + CP	Means (minutes): Naming + CP	Means (minutes): CP-Only
I[a]	135	116	115
II[b]	107	93	102

[a]$F(2,54) = 5.4$, $p < .01$.
[b]$F = 3.8$, $p < .05$.

As can be noted in Tables 1 and 2, achievement was positively related to speed of learning. To provide an indication of the efficiency of each treatment, a time-weighted score for each individual was computed by dividing the student's criterion (or retention) test score by his time to complete the course. These scores, which reflected the amount learned per unit of time, were used in the subsequent analyses of data for the various treatments.

Prompting and Confirmation Effects. During learning, as measured by error rates in computer programming, the Prompting Group scored significantly higher than the Confirmation Group. However, the groups did not differ significantly on the criterion tests (including the tests on writing and naming rules) or the retention tests. If anything, the Confirmation Group was superior, as shown in Table 3.

Verbalization Effects. Students required to write out the rules of computer programming during training did not do as well on the criterion tests as students in the other verbalization groups. The Rules Group also had the highest spread of scores on the criterion tests, as shown in Table 1. (Later supplementary analyses indicated that this effect was particularly evident in students of lower intelligence.)

Table 3

Mean Time-Weighted Criterion and Retention Test Scores for Prompting/Confirmation Variable: Experiment 1A[a]

Measure	Criterion Test I		Criterion Test II		Retention Test I		Retention Test II	
	Prompting	Confir-mation	Prompting	Confir-mation	Prompting	Confir-mation	Prompting	Confir-mation
CP-Writing	368	389	719	750	427	442	423	468
Naming the Rules	34	38	49	46	–	–	–	–
Writing the Rules	17	24	21	19	–	–	–	–

[a]Score = $\frac{\text{Achievement}}{\text{Time (Min.)}} \times 1{,}000$.

The mean score of the Rules Group on tests of computer programming (Criterion and Retention Tests I and II) was consistently lower than the mean of the Naming Group or the CP-Only Group (Table 4). Two-group comparisons (19) indicated that this difference was statistically significant in all four cases.

Table 4

Mean Time-Weighted Criterion and Retention Test Scores for Verbalization Variable: Experiment 1A[a]

Measure	Criterion Test I			Criterion Test II			Retention Test I			Retention Test II		
	Rules +CP	Naming +CP	CP-Only	Rules +CP	Naming +CP	CP-Only	Rules +CP	Naming +CP	CP-Only	Rules +CP	Naming +CP	CP-Only
CP-Writing	314	397	426	624	793	753	356	463	486	385	521	412
Naming the Rules	29	40	40	39	55	42	–	–	–	–	–	–
Writing the Rules	24	20	20	27	19	15	–	–	–	–	–	–

[a]Score = $\frac{\text{Achievement}}{\text{Time (Min.)}} \times 1{,}000$. All three-group comparisons except Writing the Rules, Criterion Test I, were significant ($p < .05$). For Naming the Rules, Criterion Test II, $p < .01$.

On the criterion and retention tests following Part I, the CP-Only Group made the highest scores, while on the tests after Part II the Naming Group seemed to be superior. However, this tendency was not statistically significant.

The inferior scores made by the subjects in the Rules Group in solving criterion problems did not seem to be due to poorer learning per se, since they scored higher on those criterion items specifically related to their training, namely, the writing out of rules. In Part I this difference in performance was not significant, but in Part II it was ($p < .05$). On the other hand, the Naming Group answered the naming questions on the Part II criterion test significantly better than the other two groups ($p < .05$), and also performed well on tests of computer programming. Thus, it appeared that both groups learned the additional materials presented during training, but that the subjects in the Rules Group were unable to apply their learning to problem solving.[7]

Intelligence. Intelligence, as measured by scores on parts of the Army Classification Battery, was significantly and positively related to criterion

[7]Criterion measures of problem solving were highly reliable by Hoyt's Test (20). Coefficients ranged from .79 to .89 ($p < .01$).

scores in all cases. No interactions appeared between intelligence scores and criterion scores related to the experimental variables.

EXPERIMENT 1B

The second experiment was basically a repeat of the first. Its primary functions were to confirm the earlier findings and provide the introductory instruction necessary for the more complex materials presented in Experiment 2.

Variables studied in Experiment 1B were the same as those for 1A except that the Rules Group was deleted from the verbalization variable. It was intended that the same measures would also be taken, with the addition of a Level-of-Aspiration measure. However, difficulties attending the administration of a large study over several months, using volunteers from many different school systems, resulted in the loss of the time scores, and a portion (20%) of the intelligence scores. The high dropout rate (57% for Experiments 1B and 2) also affected measurements.

Evidence for Learning. Mean performance on the Part I criterion dealing with problem solving averaged about 87% for students who completed all instruction (including Experiment 2) and 81% for all who took the test. On the Part II problem-solving criterion, the average was about 82% for finishers and 72% for all students. Thus, the program taught about as effectively as it had in Experiment 1A.

Since the mean performance scores suggested that the finishers were more homogeneous, the analyses of all experimental findings reported below are confined to them, in order to provide uniformity in the data base throughout the study. Mean criterion and retention test scores are shown in Tables 5 and 6.

Prompting and Confirmation Effects. The Prompting Group scored significantly higher than the Confirmation Group ($p < .001$) during training on both Part I (96.5% vs. 88.5%) and Part II (91% vs. 87%). The groups did not differ

Table 5

Mean Criterion and Retention Test Scores of Naming/No-Naming Groups: Experiment 1B

Measure	Mean: Naming Group	Mean: No-Naming Group	p	Summary Mean	Percent Correct	Standard Deviation: Naming Group	Standard Deviation: No-Naming Group
Criterion Test I	(N = 174)	(N = 171)					
CP-Writing[a]	86.8	84.8	NS	85.8	88	19.7	20.8
Naming the Rules[b]	11.2	9.6	< .001	10.4	87	1.8	2.4
Writing the Rules[c]	7.9	6.7	< .001	7.3	73	2.8	2.7
Criterion Test II	(N = 174)	(N = 171)					
CP-Writing[d]	145.2	135.9	NS	140.6	83	29.1	37.0
Naming the Rules[b]	10.7	9.1	< .001	9.9	83	1.8	2.1
Writing the Rules[c]	6.0	4.2	< .001	5.1	51	2.3	2.6
Retention Test I[e]	(N = 165)	(N = 151)					
	117.6	110.9	< .01	114.4	66	30.9	40.4
Retention Test II[f]	(N = 174)	(N = 159)					
	93.5	85.7	< .01	89.8	64	32.2	35.6

[a]Maximum: 98
[b]Maximum: 12
[c]Maximum: 10
[d]Maximum: 169
[e]Maximum: 172
[f]Maximum: 141

Table 6

Mean Criterion and Retention Test Scores of Prompting/Confirmation Groups: Experiment 1B

Measure	Mean: Prompting Group	Mean: Confirmation Group	p	Summary Mean	Percent Correct	Standard Deviation: Prompting Group	Standard Deviation: Confirmation Group
Criterion Test I CP-Writing[a]	(N 163) 85.8	(N 182) 85.8	NS	85.8	88	20.2	20.5
Criterion Test II CP-Writing[b]	(N 163) 141.3	(N 182) 139.8	NS	140.5	83	32.2	35.2
Retention Test I[c]	(N 152) 116.6	(N 161) 111.6	$< .01$	114.0	66	35.2	36.1
Retention Test II[d]	(N 157) 91.1	(N 176) 88.4	NS	89.7	64	33.4	34.4

[a]Maximum: 98
[b]Maximum: 169
[c]Maximum: 172
[d]Maximum: 141

significantly on the two criterion tests; however, when scores were adjusted for learning error the Confirmation Group was superior ($p < .005$ for Criterion Test I; $p < .10$ for Test II). This adjustment was made by means of an analysis of covariance, which provided an estimate of scores that would have been observed if performance during learning had been the same across conditions. The adjusted means for the Confirmation and Prompting Groups on both sets of criterion tests are shown in Table 7.

Table 7

Adjusted Mean Scores[a] of Naming/No-Naming and Prompting/Confirmation Groups on Criterion Tests: Experiment 1B

Part	Prompting	Confirmation	p	Naming	No-Naming	p
I	84.6	90.0	$< .005$	88.4	87.3	NS
II	84.4	84.9	$< .10$	84.9	84.3	$< .10$

[a]Adjusted for learning error by means of an analysis of covariance.

Verbalization Effects. Since the Rules Group was dropped from Experiments 1B and 2, the remaining groups were called the Naming (used mnemonics) and No-Naming Groups, depending upon whether they named rules and worked on practice problems, or simply worked problems during training.

The two groups did not differ on the Part I criterion items dealing with problem solving. However, on criterion items requiring students to name and write out rules, the Naming Group scored significantly higher. (The Naming Group had been given practice in naming rules but not in writing them out.) An analysis that took learning errors into account (analysis of covariance) showed that the superiority could be attributed in part to better performance during training (see Table 6). Retention tests reflected the same findings.

Level of aspiration and intelligence data are presented in the final section of this chapter.

EXPERIMENT 2

Experiments 1B and 2 were conducted in succession, Experiment 2 dealing with the new and more difficult materials of Parts III, IV, and V. The number of treatment combinations was quite high—29. Since attrition was also quite high—about half the students dropped out before the end of Part III—many of the groups in Experiment 2 were rather sparsely populated. Although this situation dampened the hopes of detecting statistically significant effects, those results which did prove reliable can be considered all the more powerful.

Evidence for Learning. Overall mean performance on the criterion test for Part III was about 70% correct; the median was about 78%. Thus, there was evidence of learning at a point three to five weeks after training had begun under Experiment 1B. Overall proficiency dropped to a median of 64% on Part IV and 35% on Part V. This drop was not unexpected since the purpose of the experiment was to obtain comparative data on teaching combinations; many of the less effective combinations were quite ineffectual at the more complex levels. One condition—zero confirmation—however, was effective and yielded medians of 81%, 73%, and 48% on Parts III, IV, and V.

A three-way factorial analysis was performed on Part III criterion data by randomly eliminating subjects to equate cell sizes. No interactions were revealed. Consequently, all subsequent comparisons considered the variables as independent and utilized all the data. The first set of analyses below treats Parts III, IV, and V separately. A second series was performed treating the three parts as replications.

Prompting and Confirmation Effects. Prompting and confirmation are similar in that they both present information pertaining to the correct answer. The amount of information presented will be called the degree of stimulus support, whether it comes from prompting or from confirmation. It had been hoped that errors during training could be manipulated by varying the percentage of stimulus support. An analysis of data from Part III indicated that this was accomplished. As shown in Figure 4, errors ranged from 10% for zero

Relations Between Learning Error and Criterion Test Error Under Prompting and Confirmation Conditions: Part III

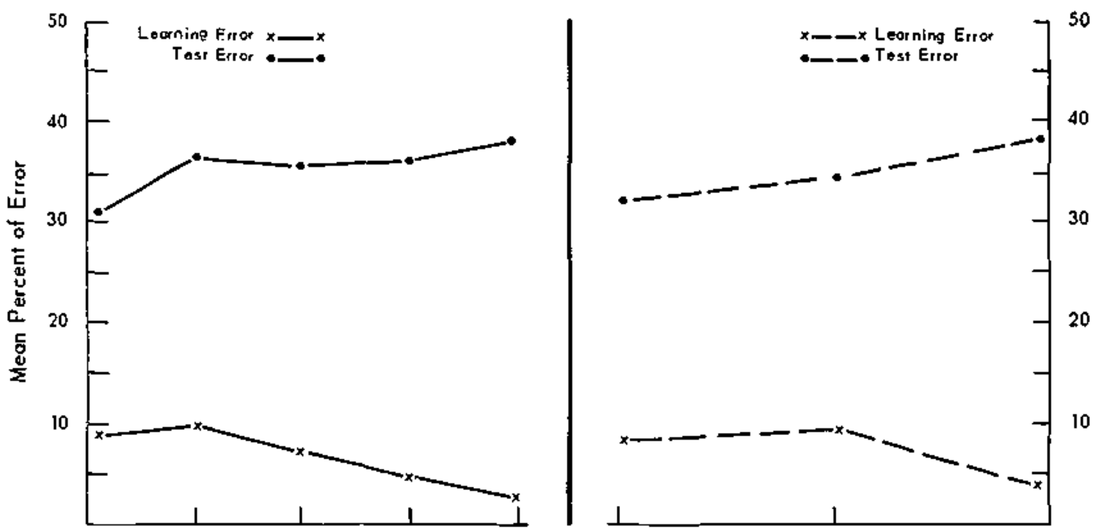

Figure 4

Effects of Prompting and Confirmation on Criterion Test Performance: Part III

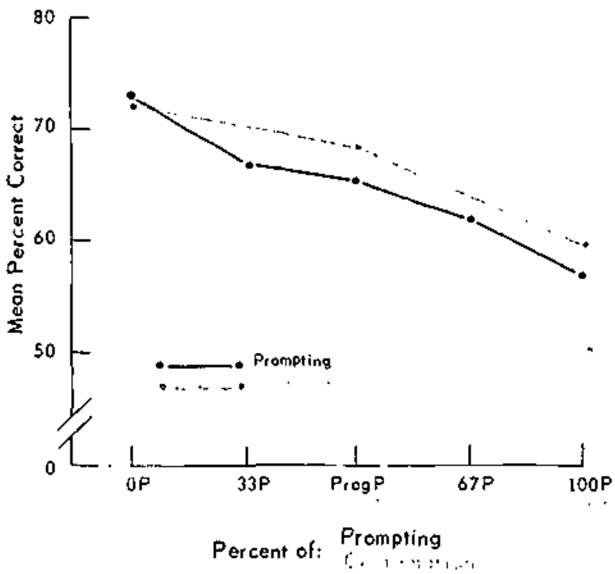

Figure 5

stimulus support to 2% for complete support (total prompting). Performance during training was directly related to degree of stimulus support; the greater the support the fewer the errors. However, test performance was inversely related to stimulus support ($p < .01$) when scores were adjusted for learning errors. Test scores for the adjusted data are shown in Figure 5.

The data showed marked variability in Part IV. The overall median dropped to 64% correct; the mean fell to 55%. In Part V the test scores were even lower, 38% correct as the mean and 35% as the median. Therefore, modified nonparametric runs tests were employed using deciles instead of individual scores. Results supported the findings in Part III. Where confirmation and prompting reflected comparable stimulus support—all of the Zero Prompting Groups vs. all of the Zero Confirmation Groups, and all of the 100% Prompting Groups vs. all of the 100% Confirmation Groups—the confirmation treatment proved more effective for criterion performance. A decile analysis of the criterion data relevant to these comparisons from Parts III and IV yielded significant differences ($p < .01$). In Part V the Zero Confirmation-Prompting comparison gave the same result, but the 100% groups did not differ.

On the final retention test, given four weeks after completion of all instruction, the direction of the effects was the same. The lower the stimulus support during training the better the scores. However, significant differences were obtained only among the confirmation levels ($p < .001$). A decile comparison among the prompting conditions revealed that both the Zero and 33% Prompting Groups scored significantly higher than the 100% Prompting Group (both with $p < .01$). The other intermediate prompting groups did not differ from the Zero Prompting Group, but did score significantly higher than the 100% group. In short, the long-term retention test further indicated that the greater the error during learning the better the performance on criterion problem solving. The retention test means and medians are presented in Table 8. These data are not adjusted for learning errors.

Table 8

Group Means and Medians on Final Retention Test: Experiment 2

Group	Mean Percent Correct	Median Percent Correct
Variety	56	56
No-Variety	57	62
Zero Confirmation	67	73
50% Confirmation	56	56
100% Confirmation	52	44
Zero Prompting	61	49
33% Prompting	54	54
Progressive Prompting	59	69
67% Prompting	56	55
100% Prompting	47	36

Variety-of-Practice Effects. There was little difference in learning

between the Variety and No-Variety Groups during training. However, students who had practiced under the Variety condition scored significantly higher on the criterion test for Part III ($p < .01$; Figure 6). Analyses of criterion test data from Parts IV and V did not reveal any significant differences. However, the Variety students scored higher on the Part IV test on a deciles comparison ($p < .01$). On the Part V criterion test and on the final retention test the effect disappeared completely, although even in retention the direction of the difference still held (Variety mean, 44%; No-Variety, 38%).

Relation Between Learning Error and Criterion Test Error Under Variety-of-Practice Conditions: Part III

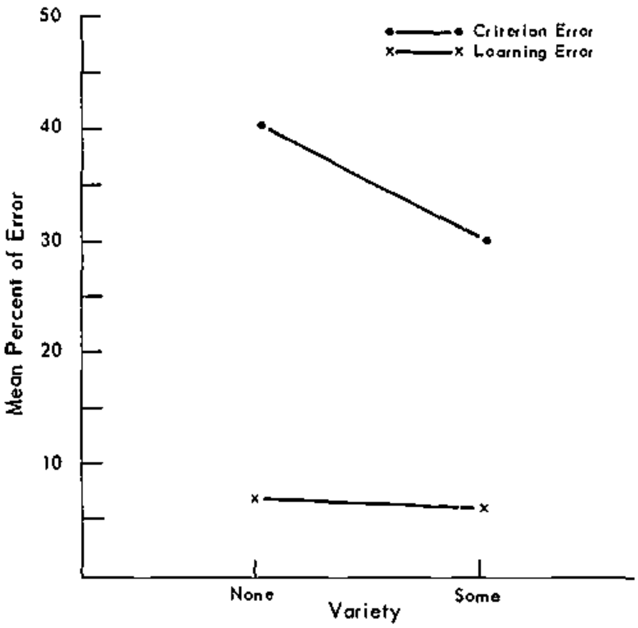

Figure 6

Since the Variety students practiced with three different verbal contexts during training (vacuum tubes, salaries, and inventories of uniforms) and there were four different contexts used in the five criterion problems, it could be argued that their superiority derived from a greater similarity between training and testing than was the case with the No-Variety Group, which practiced on vacuum tube problems only.

This possibility was tested by dichotomizing the criterion problems into those that were stated in a novel context for both groups (4 problems) and those using a setting new only to the No-Variety Group (2 problems). The Variety Group was superior on both types of problems. Thus, it can be inferred that variety of context resulted in better learning of the general mediating skills necessary to write computer programs, and not simply better learning of the overt associations practiced during training.

Verbalization Effects. Due to clerical error in assembling grouping of course materials, and to attenuation of some groups because of high dropout, no meaningful data were generated from the treatments added to get supplementary information on the effects of verbalization.

RELATIONSHIPS BETWEEN EXPERIMENTS 1B AND 2

Since Experiments 1B and 2 were conducted in succession, using the same students and teaching a continuity of subject matter, it became important to determine the relationships between the two studies. Results presented below deal with the question of how various learning conditions in Experiment 1B combined with learning conditions in Experiment 2 to affect the criterion test performance in Parts III, IV, and V. The two variables of Experiment 1B and the three of Experiment 2 yielded six combinations of interest:

Experiment 1B		Experiment 2
Prompting/confirmation	with	Level of confirmation
Naming/no-naming	with	Level of confirmation

Prompting/confirmation	with	Level of prompting
Naming/no-naming	with	Level of prompting
Prompting/confirmation	with	Variety/no-variety
Naming/no-naming	with	Variety/no-variety

Since there were no significant interactions among the variables of Experiment 2, they were treated as independent for purposes of analysis. Data from Experiments 1B and 2 were cast into three-way analysis of variance tables to note possible interactions. Parts III, IV, and V were treated as replications. Graphs of the main effects of confirmation levels and prompting levels are shown in Figures 7 and 8 respectively (see also Tables 9 and 11, Analyses of Variance).

Effects of Degrees of Confirmation on Criterion Test Performance: Experiment 2

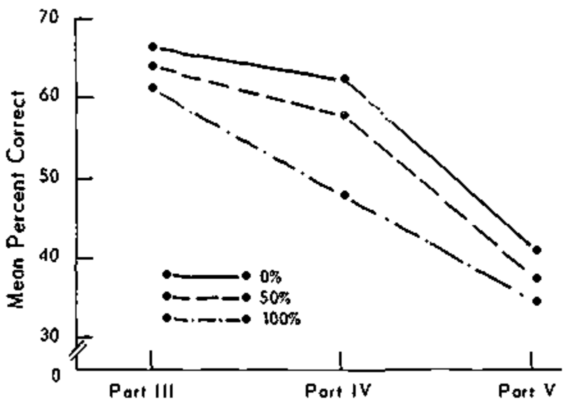

Figure 7

Effects of Degrees of Prompting on Criterion Test Performance: Experiment 2

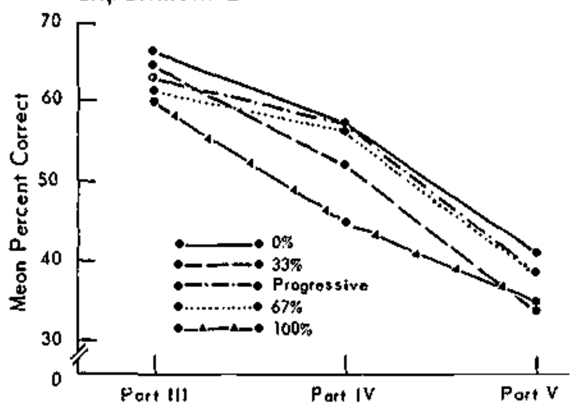

Figure 8

<u>Naming/No-Naming (Exp. 1B) With Confirmation Levels (Exp. 2).</u> The analysis of the naming and no-naming conditions of Experiment 1B combined with the three confirmation levels of Experiment 2 is summarized in Table 9. Significant interactions were indicated. The means for the various treatment combinations are shown in Table 10 grouped according to a Duncan Range analysis, which enables a comparison of individual treatment means to be made.

Table 9

Analysis of Variance of the Effects of Confirmation (Experiment 2) by Naming/No-Naming (Experiment 1B) on Criterion Tests for Parts III, IV, and V

Source of Variance	*df*	MS	*F*	*p*
Naming/No-Naming, Exp. 1B (A)	1	541800	24.6	<.05
Confirmation, Exp. 2 (B)	2	780503	9.8	<.005
Replications (C)	2	4571461	37.6	<.001
AB	2	548986	23.5	<.025
AC	2	22060	<1	NS
BC	4	79496	3.4	NS
ABC	4	23383	<1	NS
Within Cells	870	121642		

Table 10

Duncan Range Groupings of the Effects of Confirmation (Experiment 2) - Naming/No-Naming (Experiment 1B) Combinations on Criterion Tests for Parts III, IV, and V[a]

(N 296)

Part III			Part IV			Part V		
Percent Correct	Confirmation	Naming	Percent Correct	Confirmation	Naming	Percent Correct	Confirmation	Naming
68.8	0%	No	63.7	0%	Yes	47.2	0%	Yes
67.7	100%	Yes	63.2	0%	No	— — —	— — —	— — —
— — —	— — —	— — —	— — —	— — —	— — —	44.0	0%	No
65.1	0%	Yes	58.9	50%	Yes	— — —	— — —	— — —
64.4	50%	Yes	58.1	50%	No	42.3	100%	Yes
— — —	— — —	— — —	57.6	100%	Yes	— — —	— — —	— — —
64.4	50%	Yes	— — —	— — —	— — —	39.0	50%	No
63.5	50%	No	39.0	100%	No	— — —	— — —	— — —
— — —	— — —	— — —				36.6	50%	Yes
55.9	100%	No				— — —	— — —	— — —
						27.2	100%	No

[a]Means that are clustered together are not significantly different from one another. The groups differ significantly ($p < .05$).

Table 10 reaffirms the stimulus support effect noted previously, that the lower the stimulus support during training (here, the lower the confirmation), the better the criterion scores. This effect appeared to be heightened when combined with prior use of mnemonics (naming the rules); practice in naming rules in Experiment 1B plus low confirmation in Experiment 2 seemed to promote the best criterion performance. The effect is clearest in Part III where learning began to deteriorate with increased difficulty in the instructional materials. Here the No-Naming/Zero Confirmation Group came in first, the Naming/Zero Confirmation Group second, and so on, with the No-Naming/100% Confirmation combination representing the worst learning conditions.

Prompting/Confirmation (Exp. 1B) With Confirmation Levels (Exp. 2). The analysis of the prompting/confirmation conditions of Experiment 1B in combination with the various confirmation levels of Experiment 2 revealed no significant interactions. Examination of the individual groups did, however, suggest a type of interaction effect related to similarity of stimulus support. It appeared that the more similar the stimulus support conditions the better the performance (see Figure 8). Specifically, zero confirmation (the Prompting Group of Experiment 1B) followed by zero confirmation (in Experiment 2) resulted in better scores on criterion tests for Parts III, IV, and V than total confirmation followed by zero confirmation. This relationship also held for the zero-to-total vs. total-to-total confirmation sequences except for Part IV, where there was a reversal.

Naming/No-Naming (Exp. 1B) With Prompting Levels (Exp. 2). Analyses of the data (Table 11) reaffirmed the importance of low stimulus support (here, low prompting levels) and early practice with mnemonics (naming the rules) to criterion performance on Parts III, IV, and V. Mean scores resulting from the various sequences of treatments, Experiment 1B to Experiment 2, are shown in Table 12, grouped according to the results of a Duncan Range analysis. In general, naming followed by low prompting promoted the best performance; no-naming followed by high prompting was the worst combination.

Table 11

Analysis of Variance of the Effects of Prompting (Experiment 2) by Naming/No-Naming (Experiment 1B) on Criterion Tests for Parts III, IV, and V

Source of Variance	df	MS	F	p
Naming/No-Naming, Exp. 1B (A)	1	1011347	29.2	$<.05$
Prompting, Exp. 2 (B)	4	264323	7.9	$<.01$
Replications (C)	2	1128516	33.0	$<.001$
AB	4	155902	9.6	$<.01$
AC	2	34593	2.1	NS
BC	8	33594	2.1	NS
ABC	8	16237	<1	NS
Within Cells	858	125213		

Table 12

Duncan Range Groupings of the Effects of Prompting (Experiment 2) - Naming/No-Naming (Experiment 1B) Combinations on Criterion Tests[a] for Parts III, IV, and V

(N 296)

Part III			Part IV			Part V		
Percent Correct	Prompting	Naming	Percent Correct	Prompting	Naming	Percent Correct	Prompting	Naming
68.9	0%	No	66.0	Progressive	Yes	46.4	Progressive	Yes
- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
66.8	0%	Yes	61.9	67%	Yes	43.4	0%	Yes
66.1	67%	Yes	- - -	- - -	- - -	41.9	100%	Yes
66.1	Progressive	Yes	59.4	0%	No	- - -	- - -	- - -
66.0	100%	Yes	58.2	0%	Yes	41.9	100%	Yes
- - -	- - -	- - -	- - -	- - -	- - -	40.4	0%	No
66.0	100%	Yes	54.2	100%	Yes	40.3	67%	Yes
64.1	33%	Yes	53.8	33%	Yes	- - -	- - -	- - -
- - -	- - -	- - -	52.8	Progressive	No	37.7	67%	No
62.0	Progressive	No	- - -	- - -	- - -	- - -	- - -	- - -
60.6	33%	No	52.8	Progressive	No	34.6	33%	Yes
- - -	- - -	- - -	51.1	67%	No	34.3	Progressive	No
58.1	67%	No	- - -	- - -	- - -	33.6	33%	No
- - -	- - -	- - -	48.9	33%	No	- - -	- - -	- - -
55.4	100%	No	- - -	- - -	- - -	24.1	100%	No
			32.9	100%	No			

[a]Groups are separated at or beyond the .05 level.

Prompting/Confirmation (Exp. 1B) With Prompting Levels (Exp. 2). The interaction of early prompting/confirmation treatments (Experiment 1B) with later prompting levels (Experiment 2) was highly pronounced (Table 13). The dominant factor appeared to be similarity of stimulus support, as it was in the previous discussion of prompting/confirmation followed by confirmation. Thus, as seen in Figure 9, students given total prompting in both studies performed better on Parts III, IV, and V than students given zero prompting followed by total prompting. Similarly, zero prompting in both experiments promoted better performance on all three criterion tests than total prompting followed by zero prompting.

Table 13

Analysis of Variance of the Effects of Prompting (Experiment 2) by Prompting/Confirmation (Experiment 1B) on Criterion Tests for Parts III, IV, and V

Source of Variance	*df*	MS	*F*	*p*
Prompting/Confirmation, Exp. 1B (A)	1	228591	6.2	NS
Prompting, Exp. 2 (B)	4	164381	7.0	.05
Replications (C)	2	1297561	31.5	.01
AB	4	103593	3.2	.025
AC	2	37147	< 1	NS
BC	8	32834	< 1	NS
ABC	8	56722	< 1	NS
Within Cells	858	124422		

Effects of Similarity of Stimulus Support From Experiment 1B (0 or 100) to Experiment 2 (0 or 100) on Criterion Test Performance: Experiment 2

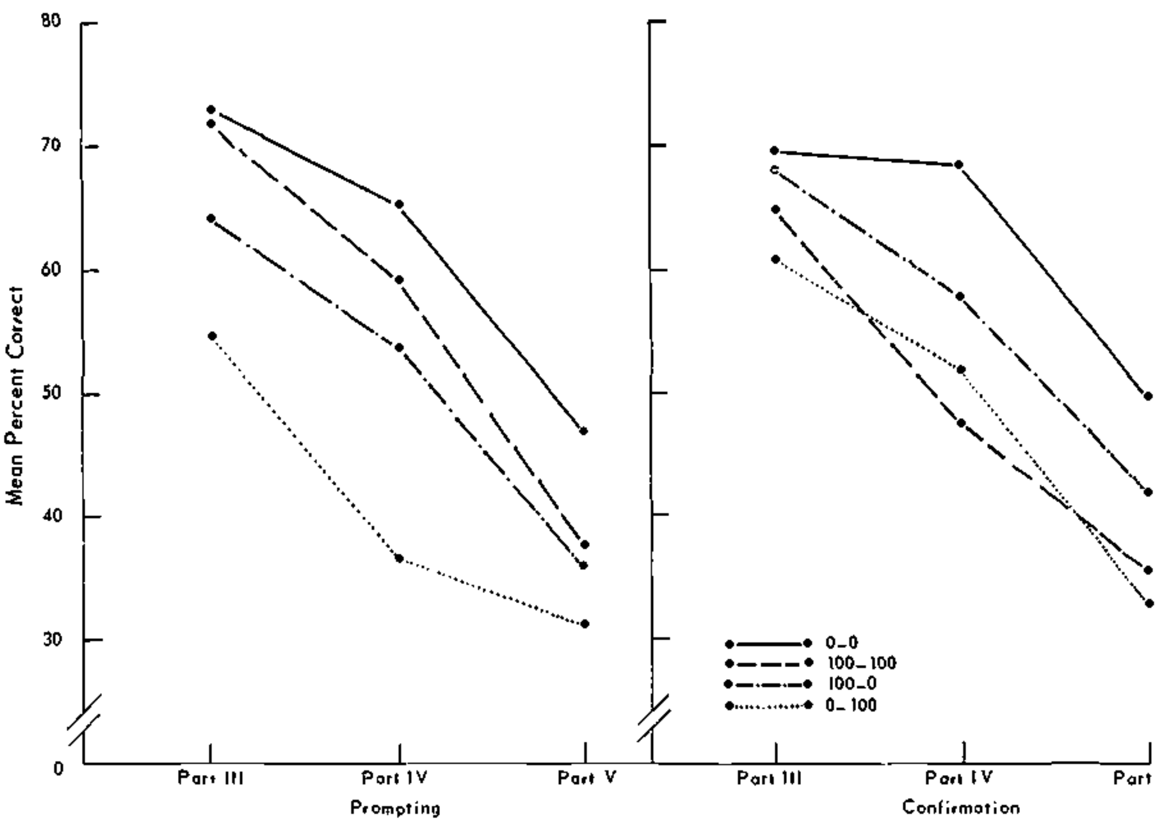

Figure 9

Naming/No-Naming (Exp. 1B) With Variety Level (Exp. 2). Analyses showed that criterion performance in Parts III, IV, and V was clearly affected by the various combinations of early naming/no-naming with later variety/no-variety (Table 14). Although the data were not entirely consistent, it appeared that performance improved as the combination approached the mix of early naming with later variety. Further, the importance of naming seemed to increase as materials became more complex (and, concomitantly, as performance dropped

Table 14

Analysis of Variance of the Effects of Variety/No-Variety (Experiment 2) by Naming/No-Naming (Experiment 1B) on Criterion Tests for Parts III, IV, and V

Source of Variance	*df*	MS	*F*	*p*
Naming/No-Naming, Exp. 1B (A)	1	907246	28.2	<.01
Variety/No-Variety, Exp. 2 (B)	1	778827	4.4	<.025
Replications (C)	2	4783363	39.4	<.001
AB	1	1602861	42.0	<.01
AC	2	32132	<1	NS
BC	2	178816	1.7	NS
ABC	2	38175	<1	NS
Within Cells	876	121305		

off), while the importance of variety seemed to decrease. Means of the various combinations are shown in Table 15, arranged according to the results of a Duncan Range analysis.

Prompting/Confirmation (Exp. 1B) With Variety Level (Exp. 2). No significant interactions were found.

Table 15

Duncan Range Groupings of the Effects of Variety/No-Variety (Experiment 2) - Naming/No-Naming (Experiment 1B) Combinations on Criterion Tests[a] for Parts III, IV, and V

(N = 296)

Part III			Part IV			Part V		
Percent Correct	Variety	Naming	Percent Correct	Variety	Naming	Percent Correct	Variety	Naming
70.7	Yes	No	63.7	No	Yes	44.1	No	Yes
---	---	---	58.8	Yes	No	40.3	Yes	No
68.0	Yes	Yes	---	---	---	---	---	---
---	---	---	58.8	Yes	No	40.3	Yes	No
63.5	No	Yes	56.1	Yes	Yes	39.4	Yes	Yes
52.5	No	No	---	---	---	---	---	---
			44.1	No	No	30.4	No	No

[a]Groups are separated at or beyond the .05 level.

FACTORS RELATED TO DROPOUT

As noted earlier, about 57% of the students did not complete instruction. A series of analyses were conducted to determine the relationships between dropout and stimulus support, level of aspiration (LOA), intelligence, and performance.

Stimulus Support. The more stimulus support in training—that is, the greater the degree of prompting or confirmation—the greater was the likelihood a student would finish the course (χ^2 trend test of proportions, $p < .05$). Figure 10, based on Part III data, shows that the prompting and confirmation factors operated alike in this regard.

Level of Aspiration. At the end of Parts I and II, students were asked to estimate how well they had performed on the previous part and how well they expected

to perform on the instruction to follow. The correlations between performance estimates on completed instruction and actual performance were quite high (.65). However, students who later dropped out expected to perform much higher on subsequent criterion tests than they did, relative to students who finished ($p < .01$). That is, the discrepancy between level of aspiration and performance was much higher for dropouts than for finishers. In addition, the expectations of the dropouts were significantly lower than the expectations of the finishers after Part I, and the performance of the dropouts was significantly lower.

In short, relative to the finishers, the dropouts (a) expected to perform at a lower level, (b) greatly overestimated their capability, and (c) did perform significantly worse.

Relation Between Stimulus Support and Proportion of Dropouts: Part III

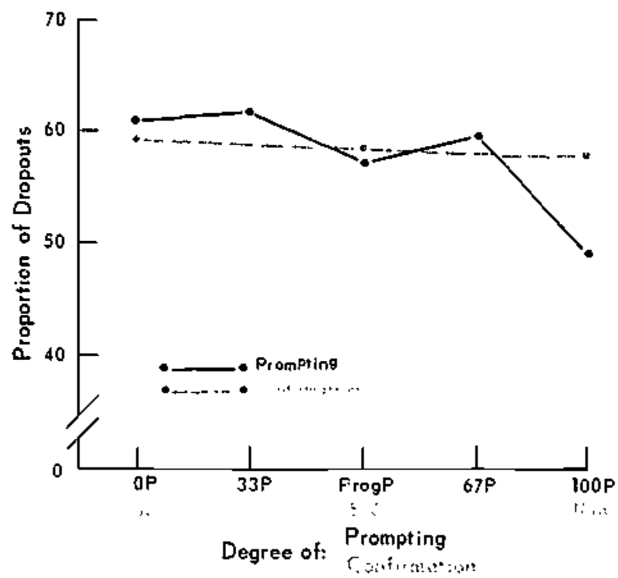

Figure 10

Intelligence. Dropouts were characterized by significantly lower intelligence (verbal ACB scores) than finishers.

CORRELATIONS BETWEEN EXPERIMENTS 1B AND 2

Experiment 1B. The overall correlation between intelligence and criterion performance was high (Part I, $r = .69$; Part II, $r = .70$). The relationships were even higher for finishers (Part I, $r = .73$; Part II, $r = .73$).

The overall correlations between learning errors and scores on the related criterion tests were not so marked, but increased from Part I to Part II (.46 to .68). For those subjects on whom intelligence measures were not obtained, the relationship between learning and testing was even higher (.48, $N = 141$; .82, $N = 140$). Since learning errors fell within a narrow range (2%–8%), these correlations may be spuriously low.

On dividing students by intelligence into low, medium, and high, it was found that the learning-testing relationship was significant for the average and bright students who dropped out, but not for the average and bright students who finished. For low aptitude students the correlations between learning errors and criterion scores were about the same, positive but low (Table 16).

The correlation between the criterion tests for Parts I and II was high, about .7. Thus, performance on the first criterion test was a good predictor of success on the second.

Experiment 2. The partial correlations, for finishers only, between LOA (expectations), intelligence, and criterion performance are given in Table 17. The relationship between LOA and subsequent criterion performance, with intelligence scores partialled out, increased (except between Parts IV and V) as students progressed through the course. On the other hand, overall relationships between intelligence and criterion scores decreased through the instruction. The relationship between LOA (expectations) and intelligence decreased even more markedly, shrinking to almost zero (+ .05) on the last criterion test.

Table 16

Correlations by Intelligence Level Between Learning and Criterion Scores of Finishers and Nonfinishers: Experiment 1B

Intelligence	Part	Finishers		Nonfinishers	
		r	*p*	*r*	*p*
Low	I	.34	< .01	.40	< .01
	II	.42	< .01	.31	< .01
Medium	I	.00	NS	.27	< .05
	II	.14	NS	.33	< .01
High	I	.14	NS	.49	< .01
	II	.4	NS	.45	< .01

Table 17

Correlations Between Expected Success, Intelligence, and Criterion Performance of Finishers, as a Function of Course Complexity: Experiment 2

Factors Correlated	Part II	Part III	Part IV	Part V
Expected Success and Criterion Performance[a]	.37 ($N = 280$)	.50 ($N = 204$)	.59 ($N = 200$)	.55 ($N = 150$)
Intelligence and Criterion Performance	.74 ($N = 295$)	.53 ($N = 295$)	.50 ($N = 294$)	.48 ($N = 290$)
Intelligence and Expected Success	.46 ($N = 280$)	.19 ($N = 204$)	.09 ($N = 200$)	.05 ($N = 154$)
Successive Pairs of Criterion Tests	.61 ($N = 337$)	.63 ($N = 302$)	.69 ($N = 301$)	.84 ($N = 296$)

[a]For these four correlations intelligence was partialled out.

In short, as the finishers progressed through the course, the relation between instructional-based factors—LOA and performance—increased; however, the relationships between these factors and intelligence, a measure taken before instruction began, decreased.

Chapter 4

DISCUSSION

The organization of the ensuing discussion will be from specific to general, and from experimental hypotheses tested in Experiments 1A and 1B to those tested in Experiment 2. Following material pertinent to the immediate findings, the implications of this type of study for future research and development in PI will be discussed. Finally, the potential utility of the secondary product of the METHOD II research, the programed course in fundamentals of computer programming, will be indicated.

COMPARISON OF EXPERIMENTS 1A AND 1B

Evidence for Learning

The means for percent correct on the criterion tests on both Parts I and II were almost identical across studies: 87% on Part I and approximately 83% on Part II. The retention test scores for Experiment 1A are somewhat higher than for 1B; however, the test for Experiment 1A was given on the day following criterion testing, whereas in Experiment 1B a week separated criterion and retention testing.

The intelligence indicator was significantly and positively correlated with criterion scores in both studies and no interactions appeared between intelligence and treatment conditions on the principal measure, writing computer programs.

Treatment Effects

Learning Time

Unfortunately, administrative problems prevented obtaining adequate time measures in Experiment 1B. In Experiment 1A, length of learning time was negatively related to score on the criterion. Doubtless, this was due to the time spent by the Rules Group in writing out complex programming rules, a requirement which appeared to dull their terminal performance. The learning time/criterion score relationship may not generalize to other PI environments.

Criterion Scores

(1) Prompting/Confirmation Results. The tendency in Experiment 1A for the prompting/confirmation effect during learning to be reversed on testing was found even more strongly in the covariance analysis under Experiment 1B. Learning errors in the two studies were highly comparable: 3% and 3.5% for prompting, 10% and 11.5% for confirmation.

(2) Verbalization Results. With respect to the requirement of writing the names of the rules during training (mnemonics) as opposed to just writing computer programs, the suggestion in Experiment 1A of superiority of the Naming Group with the more complex materials in Part II was heightened in

Experiment 1B, which involved five times as many students. Moreover, the superiority of the Naming Group (mnemonics) in the larger study was in the percent correct *per se* on the criterion in Part II and did not involve time-weighting the scores. That is, use of mnemonics resulted in an absolute and not just relative superiority, which carried over a two-week period, adding to the practical value of this particular finding.

Summary

Summing up the effects of the treatment conditions across both experiments, the use of mnemonics in learning the concepts in the computer programming course aided students in tests of computer programming. On the other hand, practice in writing the entire rule in the context given by the booklet hindered ability to use the rules effectively.

The confirmation and prompting comparisons are not so clear. Taken together, the two studies reveal that while confirmation led to more errors during learning, it did not lead to differences on criterion testing. If, however, one takes into account the covariate of errors during learning, then confirmation was superior to prompting (indicating that the Confirmation Group benefited from the errors made during training). Nevertheless, one cannot say that in the context of these two experiments error rate during learning was an important factor in criterion test performance.

EXPERIMENT 2

Stimulus Support

It seems clear within the context of the present research that a low degree of stimulus support (in the form of problem information), with attendant relative high degree of error during training, is desirable for achieving a high degree of proficiency on a criterion test requiring the synthesis of the materials presented during training.[1] Variations in degree of prompting or confirmation were inversely related to criterion performance.

At the outset it was thought likely that a certain amount of error during training would result in the best criterion performance. A legitimate question is: Why did not this optimization relationship turn up?

Although the reasoning is *post hoc*, a good starting point is to note that the key to good instruction is transmission of information. Since error rate in the worst experimental variation of the course was still low, approximately 13%, it is proposed that all groups were either at or beyond the hypothesized optimal point relating information transmission, difficulty level, and test performance. To explore this assumption in future research, it would be worthwhile to degrade the information transmitted by decreasing the chunks of conceptual content presented at each step of training and relate these variations to end of course performance (see Seidel, 21, on the problem of units of meaning).

These findings support the proposition that complex human learning such as problem solving is of a different nature than the rote learning of isolated

[1]Although the temptation may be great to treat these findings as instances of effects of knowledge of results (KR), it would be inappropriate to do so. The study does not concern KR vs. no-KR as traditionally understood, since concepts were nested in each succeeding one. True, some KR was achieved indirectly, and the subject had some self-confirmation as well. However, prompting and confirmation acted alike, and clearly a prompt, which appeared before the student attempted to answer, could not be looked upon as KR. Thus, the term "knowledge of results" seems inappropriate when generalized to include foreknowledge. More applicable here is the term "stimulus support," which treats degree of prompting or confirmation alike.

paired associates or serialized items. The latter involves training to an internal achievement criterion, as opposed to the problem-solving criterion which is external and of such a nature as to require synthesis of the concepts and the development of a strategy in a transfer test. Perhaps a good point of departure for the research reported here is Kendler's recent statement (12, p. 231):

> If researchers in the field of programed learning believe that the major response being learned is the one that the student writes in the frame, they are badly mistaken. What is being learned are concepts and what are modified are large segments of the students' verbal repertoire.

It should be noted that, when prompting or confirmation were given in the present set of experiments, they were applied not to simple stimulus-response associations (as in rote learning) but to strategies or portions thereof.

In order to be appropriately applied in the current context, Kendler's statement should be amended to include that not only are concepts being learned but strategies enabling the student to use these concepts are being learned as well. Thus, he reaches a higher level of learning called problem solving. This is in agreement with Gagné's recent distinction (13) between concept learning and problem solving.[1]

Variety

The overall approach of the present research can be meaningfully compared to a similar study by Gagnè and Bassler (23), who used a programed instructional environment to study teaching and retention of elementary non-metric geometry with sixth graders. Despite certain procedural differences, conceptually the approaches are sufficiently similar so that a detailed comparison of results should indicate some possible generalizations as well as being quite instructive for future research.

To begin with Gagné and Bassler found a moderate correlation—of the order of +.62—between achievement scores immediately following learning and those of retention. In the present study, a comparable relationship (of the order of +.64) was found. In the study by Gagné and Bassler, they were able to compare the subordinate learning sets immediately following learning and in retention and found a correlation of +.46. Correlations in the present study for the early or subordinate criterion tasks were on the order of 1.00. Whereas Gagné and Bassler found that the correlations between the retention and the original achievement scores for the subordinate learning sets were lower than for the higher order learning sets, the data in the present study indicated no such difference.

These findings are reflected in another way by looking at retention ratios (retention score divided by original score) for the various problems. They are all just about 1.0 or fairly close to it. Differences which did appear were confined to the effects of different degrees of prompting in Parts III, IV, and V; the mean ratios for the latter are given in Table 18. The differences occurring on

[1]In a larger framework, the current study suggests that Kendler's admonition be extended to a theoretical level: If learning or training theorists believe that the basic unit for complex learning is the classical S-R association, they may also be badly mistaken. Scandura (22) arrived at the same skepticism after completing a number of studies involving the teaching of various mathematical algorithms. He proposed as an alternative to S-R associationistic theory a "set function language" (SFL) which seems to describe more precisely the conceptual and problem-solving levels of behavior. Previously, Shaw and Seidel, in a paper on informational context as a determinant of what can be learned (in preparation), showed that even with as simple an organism as the rat, associationistic principles are insufficient to account for higher order conceptual learning when such is permitted to occur. Certainly, a new alternative to associationistic theory such as Scandura's SFL is an interesting one and worthy of further development.

Table 18

Retention Ratios[a] for Prompting Treatments: Experiment 2

Problem	Degree of Prompting				
	0%	33%	Progressive	67%	100%
1	1.00	.99	.96	.98	1.00
2	1.06	1.02	.96	.98	1.09
3	1.04	.98	1.02	1.04	1.09
4	1.08	.80	.99	1.02	.61
5	.93	.78	.80	.98	.69
Total	1.04	.92	.97	1.02	.93

[a] $\frac{\text{Retention Score}}{\text{Original Score}}$

Problem 4 in that table and on the overall retention problems among the various prompting conditions are significant. These effects generally reflect the original effects of the stimulus support variables, showing the least stimulus support (zero prompting) yielding the maximum percent correct and the 100% stimulus support showing the least percent correct ($\underline{F} = 2.96$, $\underline{df} = 4/174$, $\underline{p} < .05$ for Problem 4; $\underline{F} = 2.73$, $\underline{df} = 4/174$, $\underline{p} < .05$ for overall retention comparison).

Gagné and Bassler found that ". . . the present evidence suggests that their [the subordinate learning sets] importance diminishes once the final task has been achieved" (23, p. 127). However, in the present study the retention results indicated this was not the case, that the subordinate concepts were retained and had the same effect as they did on the initial achievement.

Contrary to the findings of Gagné and Bassler, while the results of the present study showed the effect of Variety on immediate achievement, the effects diminished to nonsignificance on the retention test four weeks later. Their data yielded just the reverse effect, but it should be noted that in their study achievement was measured after 11 successive days of training, whereas in the current study final achievement was measured after approximately 10 weeks of study, one session per week. Retention in their investigation was measured nine weeks after the immediate achievement test, whereas in the present instance retention measures were taken four weeks following the last achievement test. Thus, it is possible that differences in the results may be due in part to the differences in the time frames for instruction and retention testing.

Mnemonics Training

Another aspect to the results of the current research relates to the value of written verbalization of rules which an individual is required to use in developing his strategies for problem solution. The data of both experiments taken together clearly indicate that "what is in a name" is important. If an individual is given mnemonics practice early in training and is required to learn these mnemonics as well as to use them in forming his strategy (writing computer programs), he is able to formulate the rules for later use with greater facility than if he is required to write the rules in the verbal context given by the instructor.

This makes good sense if one thinks about how we go about encoding our environment from day to day. If an individual is asked to recall an event, it is much easier for him to provide a sentence or two in his own words than to report

in great detail or verbatim (if the event is a poem or story). In like manner, when requiring a student to learn the conceptual rules for the use of computer commands, if he is provided with a mnemonic key with which to tag the rule as he formulates it himself, he will be able to use his own verbal repertoire to good advantage. On the other hand, if the student is required to use the instructor's words—which may not match his own—in formulating the rule, he may indeed end up just memorizing the words without developing any understanding in the use of these rules. At least, that seems to be the inference to be made from our present study.

It is this last feature which seems to take exception to one of Gagné's positions (13, pp. 307-308) in which he emphasized the value of recallability of "subordinate capabilities." The present study clearly supports a distinction between recallability and availability of these subordinate abilities, the latter being the more important of the two. The Rules Group in Experiment 1A recalled the rules much better than the other groups, but they did so at the expense of being able to use these lower-order skills. On the other hand, the Naming Group was not only able to recall the rules well, but was able to have them available for use in working the computer programs.

This distinction between recallability and availability receives further support from Torrey's recent work (24) on the teaching of Russian grammar. She found that students given contextual drill during learning were better in dealing with new material on a generalization test than were the controls. The latter students learned all the training material by a vocabulary method. It is important to note that the control subjects were periodically tested to show their ability to generate correct sentences according to the Russian grammar rules. Thus, during training they were able to generate the rule, but on the test they were not able to apply it.

The value of mnemonics as used in the present study (Naming Group) warrants further discussion. As already noted, naming practice was helpful in solving computer problems related to the course material directly involved (Part II criterion). Of perhaps greater significance were the more lasting advantages which appeared in later and more complex portions of the course. When overall proficiency dropped to a low level (Part V and final retention test), a significant interaction appeared between early naming practice (Parts I and II) and the later treatments (Parts III, IV, and V). This took the form of good early training in Experiment 1B (Naming) compensating for poorer training conditions in Experiment 2 (see Tables 10, 12, and 15).

For example, the No-Variety students who had early training with mnemonics were able to maintain as high a level of criterion proficiency in Parts IV and V as the Variety Group. In other words, the rate of loss of proficiency was not as great for the No-Variety Naming Group as it was for the Variety No-Naming Group. The compensating effect was also superimposed on the stimulus support treatment effects as seen in Tables 10 and 12.

A reasonable question which follows from these results is: What is the relationship between stage of training in which mnemonics are introduced and enhancement of criterion performance? An attempt was made in Experiment 2 to obtain some relevant data by continuing the use of mnemonics through the more complex portions of the course for three additional groups of subjects. Unfortunately, because of clerical error in the preparation of the booklets, and group attenuation because of drop-out, meaningful data were not generated. The question of timing and relative value of mnemonics, of course, remains an open and important one for future research.

Transfer Effects of General vs. Task-Specific Factors

Further discussion of the transfer effects of general vs. task-specific factors is worthwhile because the subject has special relevance to the design of instructional programs. As seen in Table 17, the initial intelligence measure is of decreasing value as a predictor of succeeding criterion performance. Conversely, the successive criterion test data and level-of-aspiration measures increased in predictive value. These findings suggest (as does Bunderson, 25) that a general intelligence (or reasoning) factor may be of greatest importance only for early stages of instruction. Thus, in constructing instructional models for optimizing a student's path through a course, the implication is that weighting for general and task-specific factors should be differentially assigned and continually checked (to decrease the former and increase the latter) at appropriate choice-points during instruction.

PRACTICAL POTENTIAL OF THE PROGRAMED COURSE

Relationship of Content to the Parent Army Course

In order to evaluate most appropriately the practical potential of the programed course, it would be desirable to be able to state the number and percentage of hours covered relative to that required by the total ADPS programming course presented at the Signal School. However, because the material selected was chosen to represent the basic fundamentals of computer programming and because the authors' frame of reference for organizing did not necessarily coincide with that used by the instructors in the ongoing course, it would be extremely difficult to try to represent the finished programed instructional product in this manner. As an alternative, it may be helpful to examine the relationship between the conceptual material presented in the programed course and in the total ADPS course at the Signal School.

Concepts covered in the programed course deal with internal data handling of the central processing unit (CPU). Also included is material on desk-checking and flow-charting. No input or output instructional materials were included. The number of commands included (11) represent roughly 27% of those in the parent course dealing with internal data manipulations. Viewed in terms of the proportion of such conceptual categories represented, the programed course includes approximately 50% of those given in the ADPS course. Finally, if the basic logic of internal data handling is considered (i.e., within the CPU), the programed course includes virtually the entire content. Thus encompassed are the simple movement of data from place to place in storage (although not without moving to an intermediate central location), arithmetic operations, comparing and sorting (general use of the loop concept), and some sophisticated programming techniques (e.g., use of index registers). All except the last category were involved in the experiments conducted with the programed course.

Administration, Motivation, and Population Factors

Certainly the large percentage of dropouts among the volunteer subjects in Experiments 1B and 2 (57%) prevents a firm conclusion about the practical potential of the programed course. That motivational factors as well as course difficulty might have been the cause for the number of dropouts was supported by the level-of-aspiration data (the differences in realistic expectation between those who dropped out and those who remained in the course) and the importance of the stimulus support (prompting or confirmation) factors as determinants of tendency to drop out.

A further complication to determining the course's practical potential was the fact that the administrative conditions under which the course was given were not those which obtain in the real world, whether it be in an Army school or a civilian school setting. Specifically, the students were volunteers and received no incentive in the larger study (Experiment 1B and 2) except a certificate at the end of the 14-week course indicating proficiency in the HumRRO computer programming fundamentals course. In Experiment 1A, on the other hand, the students met for three successive afternoons for a maximum of four hours per afternoon and were paid for their participation. Interestingly enough, these students performed better than did the other high school students in Experiments 1B and 2 in the comparable portion of the course.

Finally, the students in the large-scale study may not have been as intelligent as the target population of Army students (the mean ACB CL score of the high school students was 96, whereas the Army requirement for acceptance in the ADPS Course is 110).

After the large-scale experimentation, it was decided to investigate further the possible contribution of motivation, administrative procedures, and course difficulty to outcome by administering the course to a sample of enlisted personnel at Fort Gordon, Georgia ($N = 25$). Such men presumably would be more representative of the target population for whom the course was originally constructed. The men chosen for the experiment had just finished a teletype operator's course (MOS 723)[1] and were waiting to be shipped to their duty assignments. They were given six hours of instruction per day for five successive days. Their incentives were ball-point pens and cigarettes, allocated according to degree of proficiency. As in the large study, roughly half the students failed to complete the course, although again the general attitude on the part of the students toward the course materials was favorable. They felt that they would like this kind of course presented with the aid of an instructor. As in the larger study, the ACB CL scores of the dropouts were virtually identical to the scores of those who finished the course.

Instructional Effectiveness

When attempting to evaluate the instructional effectiveness of the course, one must keep clearly in view the fact that the primary purpose of the overall study was to investigate a wide range of training techniques. Thus, it would be expected that only a few of the combinations would yield adequate proficiency, particularly as the training materials and criterion requirements became more complex. Thus, although the Duncan Range analysis (Table 10) appears to show very poor performance on the most complex portion of the course (Part V), the combination of lowest degree of stimulus support (especially 0% confirmation) still yielded a criterion mean close to 50% correct. The medians of the zero confirmation conditions ($N = 79$) showed 81% correct on Part III; 73% on Part IV; and 48% on Part V. A further breakdown into variety or no-variety and degree of prompting as well as interactions with the treatments of Experiment 1B is not valuable since the number of subjects within each of these smaller groups would be much too small to yield meaningful data. Nevertheless, one can make a reasonable inference that at least some of these combinations would lower the median score for the entire 0% Confirmation Group averaged across all of these conditions.

[1]Under the current MOS structure, the teletype operator's title is Communications Center Specialist, and his MOS is 72B.

The tentative inference, then, is that the instruction was effective, but because of the overriding experimental goals of the study, coupled with the other factors noted herein, no exact statement is possible. Although no hard data are available on attitudes, it has been the impression of the course administrators and proctors that general reactions toward the programed instructional nature of the materials were favorable.

While it seemed apparent that revision was required to simplify the course material, it was not completely clear that motivational factors could be ruled out as contributory to the resulting performance of the experimental students. One final point with regard to the contribution of administrative procedures to performance should be made. Because experimental control over student reading of the materials was of primary interest, all students were required to read one page at a time and not to turn back to previous sections whenever they were in difficulty. Obviously in a practical setting, the opportunity to review material already covered would be desirable. If in the experimental setting it would have been possible simply to measure the number of times a student returned to a previous page or, for that matter, turned ahead to other pages, it would have been perfectly acceptable to allow it. Because of the need for experimental control, however, and the impossibility of measuring the review the student might do, it could not be permitted.

FINAL REVISION OF THE COURSE

As a result of information obtained from the experimental situations, the materials were simplified and certain format features were added. The final version also incorporated implications from the experimental findings and the course was then completed by including a section on the use of index registers as the most complex portion of the instruction.

Description

In the revised course, the entire context remains oriented toward the writing of computer programs. That is, a concept is introduced and then a problem incorporating this concept is presented for the student to program. These problems were taken from actual computer programming problems encountered on the job. It is this problem-oriented approach in the course that makes it rather different from most of the other programed booklets available.

Before each concept is presented, the student is given a preview of things to expect. Then, as he is introduced to the concept, he is given short completion questions with the answers in light type on pages opposite the questions (see Appendix C for sample pages). The problems to be programmed appear in a box-like format and the student is expected to answer the problem, whenever possible, without looking up the answer first. At the end of each section, the student is given a review and then led on to the next set of concepts.

As was noted previously, because a secondary objective of the research was to produce a programed course available for use by the Army, the repertoire of commands and the symbolic language in which the computer programs are written have been chosen from material previously used by the Army to teach students how to program the MOBIDIC computer. The language—the FIELDATA Symbolic Language—not only represents a set of symbols interpretable by the MOBIDIC, but is sufficiently general that it largely applies to almost any other computer and to the English language (the addresses).

The Introduction to the course provides an overview of the concepts of computer programming and covers concepts of command and sample mnemonics,

address, the accumulator, memory locations, input and output, and computer functioning. There are periodic review materials and questions for the student and, finally, a short sample program.

The course proper is separated into four levels:

(1) Basic Operations (five sections), includes an introduction to storage locations, the concept of a central work area, the movement of numbers from place to place, and simple arithmetic operations.

(2) Basic Looping concepts are covered next (five sections), including general transfer commands, counting the loops, leaving the loops, and program preparation.

(3) Data Processing (four sections) deals with address modification and address arithmetic (effective addressing), sorting and counting data into various categories, and multiple address modification.

(4) Advanced Techniques for transferring data are given (five sections), including indexing.

In addition to writing many computer programs following the completion of each level, the student practices on problems within each section of the course.

Evaluation

The final revision of the course was administered successfully to seven college freshmen and six high school seniors. Of the college freshmen, four had scores of 90% or better on the final criterion test, two were in the high 80s, and one scored 77%. Median completion time was 26 hours, with daily sessions self-paced and lasting from 3 to 5 hours. The high school students scored slightly lower, 78% to 88%, with median course duration being 31 hours. It should be noted that the two highest scores (88%) in the high school sample were obtained by students in the bottom third of their senior class standing. Again, the general attitude of the students toward the course was favorable and they felt they had learned something that would be useful to them.

Apparently the revised version of the course was highly successful. It can be anticipated that the instruction would be successful in a military setting by virtue of the combination of experimentally effective training methods, simplified content, and administration procedures normally employed in military courses. However, no large-scale validation of the revised course to establish proficiency and failure rates in a military setting was undertaken, since this was not the principal purpose of the research.[1]

Suggested Utilization

The ultimate question is how the revised programed course could best be utilized. The nature of the course content is such that it would be quite useful for any officer or enlisted man who needs to have some familiarity with computer programming, whether for administrative or supervisory duties or some allied operation activity.

The adequacy of the self-contained aspects of the programed instructional course has not yet been evaluated on a large scale. However, since the structure of the course is geared to actually writing computer programs—to learning by doing—it should serve both as a useful introduction to a full-scale ADPS programming course and as supplementary instruction for students who may be having difficulties with those portions of the course covered in the programed instructional version.

[1]One potentially useful finding related to predictor validity was the fact that the Verbal score on the ACB correlated much higher with criterion performance ($r =$ [illegible].7) than the Clerical score ($r =$ [illegible].25). The Army now uses a combined CL score for course acceptance.

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AND

APPENDICES

LITERATURE CITED

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Appendix A

SAMPLES OF COURSE CONTENT AND PROBLEMS FROM EXPERIMENT 2

In these pages of sample course materials from Experiment 2, the material below and on the next two pages illustrates presentation of course content; the next three pages present three problems typical of the practice and test problems given the students, and the final three pages show the answer sheets for the three problems. These materials are from the Variety/Confirmation condition.

27 [in course]

Data Processing: MULTIPLE CATEGORIZATION

Either TRZ or TRN can be used to sort addresses into two categories. But what if you want to sort into more than two piles? For example, suppose that each address in a series has a 1, a 2, or a 3 in it, and you want to know how many numbers there are of each type? The process is called multiple categorization. Here is a sample set of instructions for the sorting portion of data processing. Notice that it is the same type of sorting used in the subtract-sort-and-count problems, but that it includes just one additional instruction--the use of both TRZ and TRN.

```
        CLA  NUMBER
        SUB  TWO

  (1)   TRN  TYPE1    If negative, the number was originally a 1

  (2)   TRZ  TYPE2    If zero after subtraction, the number was a 2

  (3)   CLA  TRIO     If the number in the Accumulator is neither a -1
        ADD  ONE      nor a 0, it must have been a 3 before subtraction,
        STR  TRIO     and can be counted immediately following sorting.
```

In other words, clear and add the number (copy it into the Accumulator) and subtract a constant which will make it possible to branch on TRZ or TRN (2 in this example).

1. If the number was originally a 1, subtracting 2 results in a -1 in the Accumulator, which is a negative number. The TRN (TRansfer if Negative) command then transfers the program down to Symbolic Location TYPE1 where the instructions which process the information coded by 1's is processed.

2. If the number was originally a 2, subtracting 2 results in a 0 in the Accumulator, a zero. The TRZ command then transfers the program to TYPE2.

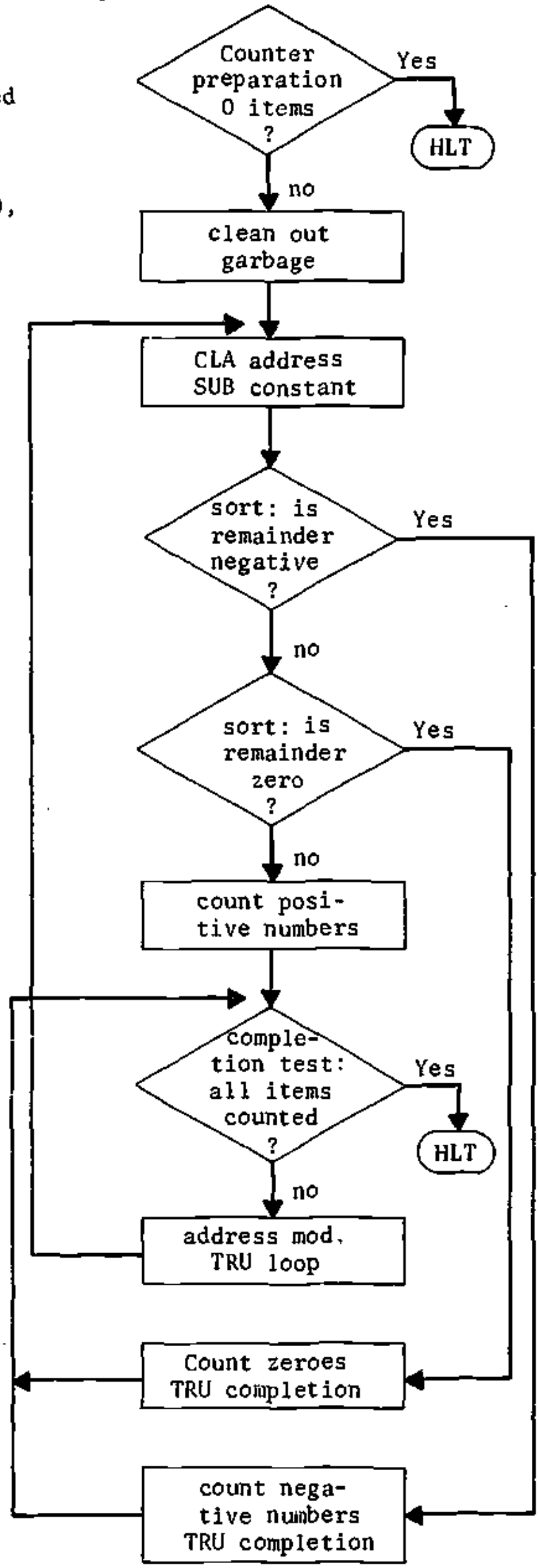
3. If the number was originally a 3, the remainder in the Accumulator will be a +1, and instead of branching, the computer will perform the instructions next in order.

A supply depot maintains a two-word record on each vacuum tube in stock, stored in sequence relative to TUBE. The words are cost and location. The first word is coded with a 2 if the tube cost less than $5, with a 3 if it cost between $5 and $10, or with a 4 if it cost more than $10. Write a program to determine the number of tubes in each category. Store the answers in LOCOST, AVCOST, and HICOST. The total number of tubes in stock is in TOTUBE, which can be saved for the loop counter by storing in temporarily in COUNT.

Notice that data processing requires (1) subtraction of a constant, (2) sorting with both TRZ and TRN, and (3) TRU instructions to the test for completion after both types of addresses counted at the end.

Preliminary Description

```
        Prepare COUNT
        Zero LOCOST, AVCOST, and
          HICOST

        Subtract and sort:
REPEAT  CLA  TUBE
        SUB  THREE
        TRN  LOW
        TRZ  MEDIUM

        Count 1's:
        add 1 to HICOST and store

  LAST  test COUNT for completion

        modify TUBE
          (add 2 to REPEAT)
        TRU  REPEAT

        Count -0's:
MEDIUM  add 1 to AVCOST and store
        TRU  LAST

        Count -1's:
   LOW  add 1 to LOCOST and store
        TRU  LAST

  STOP  HLT
```



1		CLA TOTUBE TRZ STOP STR COUNT	First we prepare the loop counter to be used later in the test for completion by checking TOTUBE to guarantee at least one tube and storing it in COUNT.
		CLA ZRO STR LOCOST STR AVCOST STR HICOST	Since no other number needs to be saved for computation, we next "clean out garbage" from all locations to be used for storing answers by replacing any numbers that might be there with zeroes.
2	REPEAT	CLA TUBE SUB THREE TRN LOW TRZ MEDIUM	Since the word indicating the tube's location contains a 2, 3, or 4, we subtract 3 to make the numbers -1, 0, and +1. After the subtraction, a -1 remainder indicates a LOCOST tube, which the TRN command will detect and transfer the program down to Symbolic Location LOW, where these tubes are counted. Similarly, a 0 indicates an AVCOST tube, which the TRZ command will pick up.
3		CLA HICOST ADD ONE STR HICOST	If the number was neither a -1 nor a 0, the TRN and TRZ commands will not transfer the program. The remainder must have been a +1, indicating a HICOST tube.
4	LAST	CLA COUNT SUB ONE STR COUNT TRZ STOP	TOTUBE contains the total number of tubes to be processed, but since we wanted to save that number, it was copied into COUNT, which we now use in the test for completion.
5		CLA REPEAT ADD TWO STR REPEAT	Since each tube has a two-word record, we must add 2 in address modification to get to the address containing information on cost for the next tube.
6		TRU REPEAT	Having reached the bottom of the loop, we transfer back up to begin processing of the next tube.
7	LOW	CLA LOCOST ADD ONE STR LOCOST	The TRN command detected a -1, which means that the number was originally a 2 (before subtracting 3), and a 2 was the code number for a low cost tube.
8		TRU LAST	Since the program branched out of normal order, we must transfer back up to finish out the loop.
9	MEDIUM	CLA AVCOST ADD ONE STR AVCOST	A 3 in the word indicated an average cost tube. Subtracting 3 made it a 0, which the TRZ command detected. Having picked up an AVCOST tube, we count it here.
10		TRU LAST	All tubes must be accounted for in the test for completion, whether they are counted right after the subtract-and-sort or down here at the end.
	STOP	HLT	

It would be a good idea to go over these two pages a few more times.

Problem 1

The Base Electronics Warehouse wants a program that will count the number of tubes used in January of last year and the number used in February. The results are to be stored in JAN and FEB.

The words for each tube are in memory starting at location VACUUM. The words are: part number, date received, shipment number, manufacturer, date tube was used, and place tube was used. TUBES contains the number of vacuum tubes in the warehouse. The month in which the tube was used is coded by number: 1 for January, 2 for February, 3 for March, and so on.

Locations CON1 and CON2 contain constants of 1 and 2, respectively. No other constants are available. Use HOLD as temporary storage for TUBES.

Use both the TRZ and TRN commands in writing this program. Write your preliminary description at the left first, paying special attention to the data processing portions.

Write the complete program below:

	__________
	__________
	__________
	__________
	__________
	__________
COMPUT	__________
	__________
	__________
	__________
LAST	__________
	__________
	__________
	__________
	__________
	__________
	__________
	__________
	__________
	__________
MONTH1	__________
	__________
	__________
	__________
MONTH2	__________
	__________
	__________
	__________
STOP	__________

Turn to Page 32-1 for the correct answer. (Appendix-76)

Problem 2

Post Personnel wants a program that will count the number of men who have been in Alaska and the number who have been in Asia. The results are to be stored in ALASKA and ASIA.

The words for each man are in memory starting at location TROOPS. The words are: serial number, rank, dependent status, assigned unit, last overseas area, and MOS. POST contains the number of personnel on Post. The overseas area is coded by number: 1 for Alaska, 2 for Asia, 3 for Europe, and so on.

Locations K1 and K2 contain constants of 1 and 2, respectively. No other constants are available. Use SAVE as temporary storage for POST. Use both TRZ and TRN commands in writing this program.

Write your preliminary description at the left first, paying special attention to the data processing portions.

Write the complete program below:

	______
	______
	______
	______
	______
	______
MODIFY	______
	______
	______
	______
DONE	______
	______
	______
	______
	______
	______
	______
	______
	______
	______
NORTH	______
	______
	______
	______
SOUTH	______
	______
	______
	______
STOP	______

Turn to Page 30-2 for the correct answer. (Appendix-77)

Problem 3

A business firm wants a program that will count the number of men who scored between 91 and 100 on a screening test, and the number who scored between 81 and 90. The results are to be stored in EXCEL and GOOD.

The words for each man are in memory starting at location TEST. The words are: title, salary, dependent status, branch, test score, and health. MEN contains the number of men in the firm. Test scores are coded by number: 1 for 91-100, 2 for 81-90, 3 for 71-80, and so on.

Locations ONE and TWO contain constants of 1 and 2, respectively. No other constants are available. Use KEEP as temporary storage for MEN. Write your preliminary description at the left first, paying special attention to the data processing portions.

Write the complete program below:

______
______
______
______
______
______
CHANGE ______
______
______
______
OVER ______
______
______
______
______
______
______
______
______
______
FIRST ______
______
______
______
SECOND ______
______
______
______
STOP ______

Turn to Page 33-1 for the correct answer. (Appendix-78)

Answer to Problem 2, Page 29A

Post Personnel wants a program that will count the number of men who have been in Alaska and the number who have been in Asia. The results are to be stored in ALASKA and ASIA.

The words for each man are in memory starting at location TROOPS. The words are: serial number, rank, dependent status, assigned unit, last overseas area, and MOS. POST contains the number of personnel on Post. The overseas area is coded by number: 1 for Alaska, 2 for Asia, 3 for Europe, and so on.

Locations K1 and K2 contain constants of 1 and 2, respectively. No other constants are available. Use SAVE as temporary storage for POST. Use both the TRZ and TRN commands in writing this program. Write your preliminary description at the left first, paying special attention to the data processing portions.

This is the program:

```
        CLA  POST
        TRZ  STOP
        STR  SAVE
        CLA  ZRO
        STR  ALASKA
        STR  ASIA
MODIFY  CLA  TROOPS+4
        SUB  K2
        TRN  NORTH
        TRZ  SOUTH
  DONE  CLA  SAVE
        SUB  K1
        STR  SAVE
        TRZ  STOP
        CLA  MODIFY
        ADD  K2
        ADD  K2
        ADD  K2
        STR  MODIFY
        TRU  MODIFY
 NORTH  CLA  ALASKA
        ADD  K1
        STR  ALASKA
        TRU  DONE
 SOUTH  CLA  ASIA
        ADD  K1
        STR  ASIA
        TRU  DONE
  STOP  HLT
```

Now continue your study with Page 29B. (Appendix-79)

Answer to Problem 1, Page 29

The Base Electronics Warehouse wants a program that will count the number of tubes used in January of last year, and the number used in February. The results are to be stored in JAN and FEB.

The words for each tube are in memory starting at location VACUUM. The words are: part number, date received, shipment number, manufacturer, date tube was used, and place tube was used. TUBES contains the number of vacuum tubes in the warehouse. The month in which the tube was used is coded by number: 1 for January, 2 for February, 3 for March, and so on.

Locations CON1 and CON2 contain constants of 1 and 2, respectively. No other constants are available. Use HOLD as temporary storage for TUBES. Use both the TRZ and TRN commands in writing this program.

Write your preliminary description at the left first, paying special attention to the data processing portions.

This is the program:

```
        CLA  TUBES
        TRZ  STOP
        STR  HOLD
        CLA  ZRO
        STR  JAN
        STR  FEB
COMPUT  CLA  VACUUM+4
        SUB  CON2
        TRN  MONTH1
        TRZ  MONTH2
  LAST  CLA  HOLD
        SUB  CON1
        STR  HOLD
        TRZ  STOP
        CLA  COMPUT
        ADD  CON2
        ADD  CON2
        ADD  CON2
        STR  COMPUT
        TRU  COMPUT
MONTH1  CLA  JAN
        ADD  CON1
        STR  JAN
        TRU  LAST
MONTH2  CLA  FEB
        ADD  CON1
        STR  FEB
        TRU  LAST
  STOP  HLT
```

Now continue your study with Page 29A.

Answer to Problem 3, Page 29B

A business firm wants a program that will count the number of men who scored between 91 and 100 on a screening test, and the number who scored between 81 and 90. The results are to be stored in EXCEL and GOOD.

The words for each man are in memory starting at location TEST. The words are: title, salary, dependent status, branch, test score, and health. MEN contains the number of men in the firm. Test scores are coded by number: 1 for 91-100, 2 for 81-90, 3 for 71-80, and so on.

Locations ONE and TWO contain constants of 1 and 2, respectively. No other constants are available. Use KEEP as temporary storage for MEN. Write your preliminary description at the left first, paying special attention to the data processing portions.

This is the program:

```
        CLA  MEN
        TRZ  STOP
        STR  KEEP
        CLA  ZRO
        STR  EXCEL
        STR  GOOD
CHANGE  CLA  TEST+4
        SUB  TWO
        TRN  FIRST
        TRZ  SECOND
  OVER  CLA  KEEP
        SUB  ONE
        STR  KEEP
        TRZ  STOP
        CLA  CHANGE
        ADD  TWO
        ADD  TWO
        ADD  TWO
        STR  CHANGE
        TRU  CHANGE
 FIRST  CLA  EXCEL
        ADD  ONE
        STR  EXCEL
        TRU  OVER
SECOND  CLA  GOOD
        ADD  ONE
        STR  GOOD
        TRU  OVER
  STOP  HLT
```

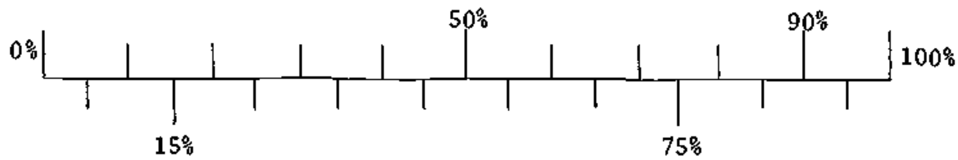
Now continue your study after Page 29B.

Appendix B

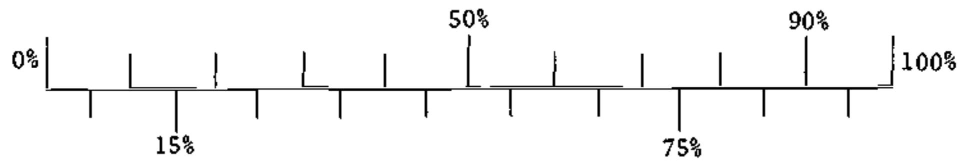
LEVEL-OF-ASPIRATION SCALE

Name ______________________

Before you continue your instruction, tell us what percentage you think you scored on the test you just completed: Make an X on the line for your estimate. The numbers are only guides. For example, if you think you scored 99%, your X would be close to the end of the line.



Now tell us what score you think you will make on the test in the next section: Remember, make an X wherever you think you will score.



DON'T FORGET YOUR NAME AT THE TOP OF THE PAGE (Appendix-82)

Appendix C

SAMPLES OF REVISED COURSE FORMAT

The samples in this appendix illustrate the content and format used in the final revised version of the course. The first three pages are excerpts (non-continuous) from the course, showing presentation of instructional content with six practice problems. The following two pages are excerpts from the separate answer booklet, showing the answers to the six problems.

Problem 1.1. There are two kinds of vacuum tubes in an inventory, 6SN7 tubes and 6AQ6 tubes. Write a program to compute the total value of both kinds, placing the answer in TOTAL. The number of 6SN7 tubes is in STOCK1. The number of 6AQ6 tubes is in STOCK2. Temporary storage will be TEMP and TEMP+1. The cost of a 6SN7 is in VALUE and the cost of a 6AQ6 is in VALUE+1. Store the total worth of 6SN7 tubes in VALSTK and the total worth of 6AQ6 tubes in VALSTK+1. Assume at least one tube of each type. There is a 1 in KON. If you have to, use COMPUT as symbolic location for the first looping program, NEXT for the second, and SUM to get the total of both. Use asterisks wherever possible.

Problem 1.2. This problem is like the preceding one, except that the number of each type of tube is not known. Instead, each tube has information on its type stored relative to TUBE. Each location in the series has either a 1 or a 0--a 1 to indicate a 6SN7 tube, and a 0 to mean a 6AQ6 tube. The total number of all tubes is in STOCK, which can be saved in TEMP. Assume at least one tube. Use NEXT for sorting, LAST for the test for completion, and COMPUT for computation outside the loop. Use asterisks wherever possible. VALSTK and VALSTK+1 will not be needed. You can add VALUE into TOTAL in one subroutine and VALUE+1 into TOTAL in another.

Symbolic Locations with Address Arithmetic

Tracing out a program that uses asterisks becomes a little difficult, especially for someone else, when the skips are much greater than 9 instructions. In these situations, you are better off using a symbolic location with address arithmetic.

TRU DONE+2 means, "Transfer to the instruction two steps after symbolic location DONE."

What instruction would be performed after TRU OK-1 below?

```
        CLA THIS
OK      STR THERE
        TRU OK-1
```

Review: There are three ways to transfer to an instruction or to refer to it for address modification: (1) by using its symbolic location, as in the past; (2) by using an asterisk and the number of its position in relation to the instruction containing the asterisk; and (3) by using a symbolic location and the number of the instruction's position in relation to that symbolic location. For example:

```
LOOP  CLA THIS        CLA THIS               CLA THIS
      STR THAT        STR THAT      LOOP     STR THAT
      TRU LOOP        TRU *-2                TRU LOOP-1
```

Use as few symbolic locations as possible in the following problems by (1) using the * for transfer of 9 steps or less, and (2) address arithmetic relative to a symbolic location for transfers of more steps.

Problem 1.4. There is information about the ages and ranks of enlisted men and officers starting at location *INFO*, in the following three-word format: enlisted man or officer, age, and rank. The first word is coded with a + to indicate an officer, or a - to indicate an enlisted personnel. Count the number of enlisted personnel in location TOTEM. The total number of personnel is in location MEN. A constant of 1 is in K1 and a constant of 3 is in K3. Use EM as symbolic location for counting. Use DATA to modify the record to be processed. (The + and - signs can be considered the same as positive and negative numbers.)

Problem 1.5. Headquarters wants to know the number of Second Lieutenants eligible for promotion to First Lieutenant at the end of this month. Eighteen months active duty in grade are required for promotion from Second Lieutenant to First Lieutenant. The data for officers are stored in 5-word records as follows: rank, serial number, months in grade on active duty, MOS, and assigned unit. Ranks for officers are coded by 1 for Second Lieutenant, 2 for First Lieutenant, and so on. The records are kept relative to RATING. PERSON contains the number of personnel. This number is not to be destroyed. Store it temporarily in HOLD. Assume at least one officer. An 18 is in TIME, a 1 is in KON, and a 5 is in K5. Store the number of eligible officers in UP. Use RANK to modify addresses referring to rank, LAST for the completion test, and SECOND for instructions referring to time in grade if the officer is a Second Lieutenant.

In effect, ADD DATA,IR2 says to copy DATA into a special temporary location (IR2) and there add to it the contents of that location (IR2). As IR2 contains the number 1, DATA+1 results. Thus, the complete instruction says the same thing as: ADD DATA+1.

> Problem 2.1. Write an instruction that says the same thing as SUB COST+1. Index Register 3 contains the number 1.

> Problem 2.2. Write an instruction that says the same thing as STR BOOK+2. Index Register 1 contains the number 2.

The Comma

Why the comma?

It is needed to separate two address fields, the one that we have been using all along and a new one that is used in indexing.

Up to now, you have been working with symbolic location fields, operational codes (the commands), and a single address field. For example:

Symbolic Location	Op. Code	Address Field
REPEAT	ADD	COST

The address field you have been using is called the First Address Field. All addresses that we have used previously appeared in the First Address Field.

Indexing uses another address field, known as the Second Address Field. And, thus, the comma. Anytime more than one address field is used, a comma is required to keep them separated. Hence, the comma:

ADD DATA,IR2

What is the address field for DATA in the instruction above? IR2?

ANSWERS TO PROBLEMS OF PHASE III: DATA PROCESSING

Problem 1.1.

```
        CLA REPEAT
        ADD ONE
        STR REPEAT
```

Problem 1.2.

```
        CLA HUBERT
        ADD DIGIT
        STR HUBERT
```

Problem 1.4.

```
        CLA ZRO
        STR FINAL

REPEAT  CLA VALUE
        ADD FINAL
        STR FINAL

        CLA REPEAT           Change VALUE to VALUE+1 so that on
        ADD K                the next loop VALUE+1 will be added
        STR REPEAT           into FINAL.

        TRU REPEAT
```

Problem 1.5.

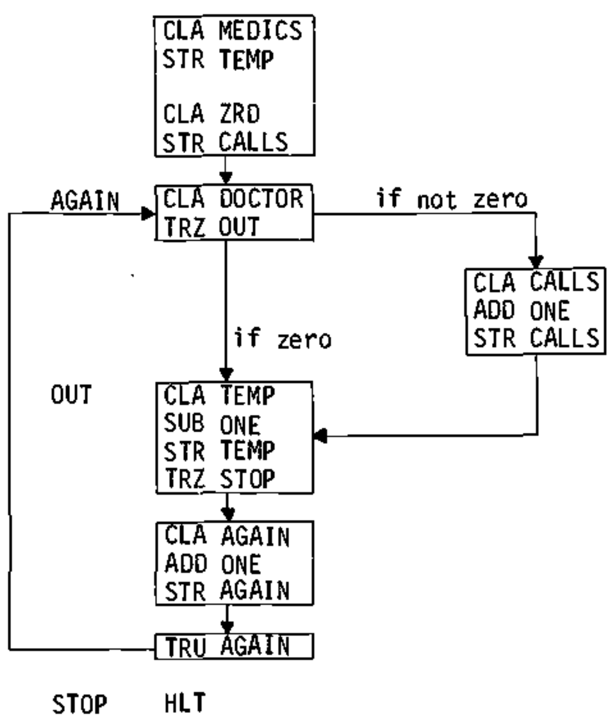
```
        CLA ZRO
        STR EVERY

 AGAIN  CLA COST
        ADD EVERY
        STR EVERY

        CLA AGAIN            COST is modified to COST+2 for the
        ADD TWO              next loop.
        STR AGAIN

        TRU AGAIN
```

Problem 2.1.

```
        CLA ZRO
        STR BONUS

CHECK   CLA PUSH       Copy in a number.
        TRZ TEST       If it's a zero, skip to the test for
                       completion.
        CLA BONUS      If it's not zero, count the salesman
        ADD UNIT       here; he must have made at least one
        STR BONUS      sale.

TEST    CLA MEN
        SUB UNIT       Test for completion.
        STR MEN
        TRZ STOP

        CLA CHECK
        ADD UNIT       Address modification.
        STR CHECK

        TRU CHECK      Looping.

STOP    HLT
```

Problem 2.2.

```
        CLA MEDICS
        STR TEMP

        CLA ZRO
        STR CALLS

AGAIN   CLA DOCTOR
        TRZ OUT

        CLA CALLS
        ADD ONE
        STR CALLS

OUT     CLA TEMP
        SUB ONE
        STR TEMP
        TRZ STOP

        CLA AGAIN
        ADD ONE
        STR AGAIN

        TRU AGAIN

STOP    HLT
```



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13. ABSTRACT

In continuing research into the technology of training, a study was undertaken to devise guidelines for applying programed instruction to training courses that involve the learning of principles and rules for use in problem solving. As the research vehicle, a portion of the material in the Army's ADPS Programing Specialist Course was programed to explore several different factors in using automated instruction to teach computer programming. Experimental versions of the course were administered to over 900 subjects in various experimental groupings. Criterion and retention tests based on actual job problems were used to measure subjects' performance, along with in-training measures. Results in a series of prompting/confirmation variations indicated that giving subjects extensive stimulus support during training helps motivate them and improves scores during training, but hampers them in using what they have learned. Requiring subjects to fully write out rules during training hindered them in developing problem-solving skills applying these rules; however, using mnemonics (writing only the names of the rules) during training aided subjects in retaining what they had learned, particularly for more complex material. Working with a variety of practice problems facilitated the learning of problem-solving skills.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Computer Programming						
Confirmation						
Error Rate						
Learning						
Mnemonics						
Problem Solving						
Programed Instruction						
Prompting						
Stimulus Support						
Training Technology						
Variety of Practice						
Verbalization						

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1	CINC US EUROPEAN COMD ATTN SUPPORT PLANS BR J3
1	CINC US ARMY PACIFIC APO 96558 SAN FRAN ATTN G3 CBT DEVEL DIV
2	CG SOUTHERN EUROPEAN TASK FORCE APO 09168 NY
1	CG US ARMY JAPAN APO 96343 SAN FRAN ATTN G3
3	CG US ARMY FORCES SOUTHERN COMD ATTN SCARCD APO 09834 NY
2	CG US ARMY ALASKA ATTN ARACC APO 98749 NY
2	CG US ARMY EUROPE APO 09403 NY ATTN OPNS DIV
1	CO ARMY TRANS RES COMD FT EUSTIS ATTN TECH LIB
1	CG US ARMY AD COMD ENT AFB ATTN ACGCB
6	CG 1ST ARMY FT GEORGE G MEADE
1	CG 3RD US ARMY FT MCPHERSON GA
1	CG FOURTH ARMY FT SAM HOUSTON ATTN G3
1	CG FIFTH ARMY FT SHERIDAN ATTN ALFGC TNG
1	CG SIXTH ARMY PRES OF SAN FRAN ATTN AMAAV
1	CG EUSA ATTN AG-AC APO 96301 SAN FRAN
2	CG EUSA ATTN G-3 APO 96301 SAN FRAN
1	CLIN PSYCHOL SERV DEPT OF NEUROPSYCHIAT WALTER REED GEN HOSP
1	DIR HEL APG MD
2	ENGNR PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
4	TECH LIB ARMY NATICK LABS NATICK MASS
3	CO ARMY CHEM R+D LABS EDGEWOOD ARSNL MD ATTN LIBN
1	CO ARMY CBT DEVEL COMD CHEM BIOL + RADIOL AGY FT MCCLELLAN
1	REDSTONE SCIENTIFIC INFO CTR US ARMYMSL COMD ATTN CHF DOC SEC ALA
1	CO USAPA MBLTY DET TOBYHANNA ARMY DEPOT
1	CG ARMY ELEC PG FT HUACHUCA ATTN TECH LIB
12	CO 1ST AIR DEF GUIDED MSL BRGD TNG FT BLISS
1	CG US ARMY CDC EXPERIMENTATION COMD FT ORD
1	SIXTH U S ARMY LIB DEPOT BLDG N 13 14 PRES OF SAN
1	CHF DEPT OF CLIN + SOC PSYCH WALTER REED ARMY INST OF RES WASH. D9C9
1	PLANS OFFICER PSYCH HQ CTRES USACDEECFORT ORD
5	CG FT ORD ATTN G3 TNG DIV
1	CO DUGWAY PG UTAH ATTN TECH LIB
1	DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
2	DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR ATTN NEUROPSYCHIAT DIV
1	CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1	DPTY FOR BIOASTRONAUT PG AIR PG CTR EGLIN AFB
1	DIR ARMY ENGNR R+D LABS FT BELVOIR ATTN TECH DOCU CTR
1	CO FRANKFORD ARSNL ATTN SMUFA-N6400/202-4
1	CG 2D RGN ARADCOM RICHARDS-GEBAUR AFB
1	CG 5TH RGN USARADCOM FT SHERIDAN ATTN G3 TNG
3	6TH RGN USARADCOM FT BAKER
1	4TH ARMY MSL COMD AIR TRANSPORTABLE SAN FRAN
1	PERS SUBSYS DIV CREW SUBSYS DRCT AERONAUT SYS DIV WRIGHT-PATTERSON AFB
1	DIR ARMY BD FOR AVN ACCIDENT RES FT RUCKER
2	CO PICATINNY ARSNL DOVER N J ATTN SMUPA VC1
1	DEF SUPPLY AGY CAMERON STATION ATTN LIB
1	CO ARMY CBT DEVEL COMD FT BENJ HARRISON ATTN ADJ GEN AGY
1	REF M MS 15 NASA ALA
1	CBT OPNS RES GP ARMY CBT DEVEL COMD FT BELVOIR ATTN OPNS ANLS HUMAN FACTORS
1	CO ARMY CBT DEVEL COMD FT BENNING ATTN INF AGY
1	CO ARMY CBT DEVEL COMD FT KNOX ATTN ARMOR AGY
8	ARMY CBT DEVEL COMD FT BRAGG ATTN SPEC WARFARE AGY
1	EVAL DIV OAC ARMY SIG CTR + SCH FT MONMOUTH
1	CO US ARMY CDC AVN AGCY FT RUCKER
1	CHF CURRICULUM BR RESIDENT INSTR DEPT ARMY LOGISTICS MANGT CTR FT LEE
3	CO ARMY CBT DEVEL COMD CBT SUPPORT GP
1	CG USCONARC ATTN DCS INTEL FT MONROE
5	CIVLN PERS OFCR US ARMY SPT CTR ST LOUIS ATTN EMPLOYEE DEVEL OFCR
3	ARMY WAR COLL CARLISLE BKS ATTN LIB
1	ASST COMDT ARMY INTEL SCH FT HOLABIRD ATTN PLANS DIV DAD
1	COMDT COMD + GEN STAFF CC FT LEAVENWORTH ATTN ARCHIVES
1	DIR OF MILIT PSYCHOL + LDRSHP US MILIT ACAD WEST POINT
1	US MILIT ACAD WEST POINT ATTN LIB
1	COMDT ARMY AVN SCH FT RUCKER ATTN SCH LIB
2	COMDT ARMY SECUR AGY TNG CTR + SCH FT DEVENS ATTN LIB
1	COMDT ARMED FORCES INDSTR COLL FT LESLEY J MCNAIR
2	COMDT NATL WAR COLL FT LESLEY J MCNAIR ATTN CLASSF RECORDS BR LIB
1	MED FLD SERV SCH BROOKE ARMY MED CTR FT SAM HOUSTON ATTN STIMSON LIB
10	DIR OF INSTR ARMOR SCH FT KNOX
1	COMDT ARMY ARMOR SCH FT KNOX ATTN WEAPONS DEPT
1	COMDT ARMY CHAPLAIN SCH FT HAMILTON
1	COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN EDUC ADV
1	ARMY FINANCE SCH FT BENJ HARRISON
4	COMDT ARMY ADJ GEN SCH FT BENJ HARRISON ATTN EDUC ADV
1	ARMY INF SCH FT BENNING ATTN EDUC ADV
1	USA INF SCH ATTN DIR OF INSTR FT BENNING
1	HQ US ARMY ADJ GEN SCH FT BENJ HARRISON ATT COMDT
1	ARMY QM SCH FT LEE ATTN LIB
1	COMDT ARMY QM SCH FT LEE ATTN EDUC ADV
1	COMDT ARMY TRANS SCH FT EUSTIS ATTN EDUC ADV
1	COMDT ARMY MILIT POLICE SCH FT GORDON ATTN DIR OF INSTR
2	COMDT US ARMY SOUTHEASTERN SIG SCH ATTN: EDUC ADVISOR FT GORDON
1	CG ARMY ORD CTR + SCH ABERDEEN PG ATTN AISO-SL
5	ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
10	CG ARMY ARTY + MSL CTR FT SILL ATTN AVN OFFR
1	COMDT ARMY DEF INTEL SCH ATTN ST+AS DEPT
1	COMDT ARMED FORCES STAFF COLL NORFOLK
1	COMDT ARMY SIG SCH FT MONMOUTH ATTN EDUC COORD
1	COMDT JUDGE ADVOCATE GENERALS SCH U OF VA
1	EDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
6	COMDT ARMY ENGNR SCH FT BELVOIR ATTN AIBBES-SY
2	COMDT US ARMY SCH EUROPE ATTN REF LIB APO 09172 NY
1	CHF POLICY + TNG LIT DIV ARMY ARMOR SCH FT KNOX
1	COMDT ARMY AVN SCH FT RUCKER ATTN EDUC ADV
1	COMDT ARMY PRIMY HEL SCH FT WOLTERS
1	DIR OF MILIT INSTR US MILIT ACAD WEST POINT
1	SPEC WARFARE SCH FT BRAGG ATTN LIB
4	USA SPEC WARFARE SCH ATT: COUNTERINSURGENCY DEPT FT BRAGG
1	ARMY SIG CTR + SCH FT MONMOUTH ATTN TNG LIT DIV DAD
1	COMDT US ARMY MGT SCH FT BELVOIR
2	SECY US ARMY MSL + MUNITIONS CTR + SCH REDSTONE ARSNL
2	COMDT WOMENS ARMY CORPS SCH + CTR FT MCCLELLAN
2	HQ ABERDEEN PG ATTN TECH LIB
1	COMDT US ARMY INTEL SCH FT HOLABIRD
1	COMDT ARMY QM SCH OFC DIR OF NONRESID ACTVY FT LEE ATTN TNG MEDIA DIV
2	DIR ORGO + BN OPNS DEPT USAIS FT BENNING
1	LEADERSHIP COM CC OPS DEPT US ARMY INF SCH FT BENNING
1	DIR COMM ELEC USAIS FT BENNING
2	DIR COMPANY TACTICS DEPT USAIS FT BENNING
1	CG US ARMY SIGNAL CTR + SCH ATTN SIGYL-3ICDBET III
1	SECY OF ARMY
1	DCS-PERS DA ATTN CHF C+S DIV
1	DIR OF PERS STUDIES + RES ODCSPER DA ATTN BG WALLACE L CLEMENT
1	CO FOREIGN SCI + TECH CTR MUN BLDG
2	ACS FOR FORCE DEVEL DA ATTN CHF TNG DIV
1	DIR OF CBR OPS OACS FORCE DEVEL ATTN FOR CM PP
1	CHF OF ENGNRS DA ATTN ENGTE-1
1	CHF OF INFO DA ATTN CHF II DIV
1	HQ ARMY MAT COMD R+D DRCTE ATTN AMCRD-RC
1	CHF OF PERS OPNS DFCR PERS DRCTE DA ATTN SIG BR
1	CLIN PSYCHOL CONSLT OFC OF CHF PSYCHIAT + NEUROL CONSLT OFC OF SURG GEN ATTN AT CGL MSC
2	CG ARMY MED R+D COMD ATTN BEHAV SCI RES BR
1	US ARMY BEHAVIORAL SCI RES LAB WASH. D.C. ATTN: CRD-AR
1	OPO PERS MGT DEV OFC ATTN MOS SEC (NEW EQUIP) OPDMD
1	ARMY PROVOST MARSHAL GEN
2	DIR CIVIL AFFAIRS DRCTE ODCSOPS
1	OFC RESERVE COMPON DA
2	CHF ARMY SECUR AGY ARLINGTON HALL STA ATTN ACS-G1
50	ADMIN DDC ATTN: TCA (HEALY) CAMERON STA ALEX., VA. 22314
1	CO US ARMY MED RES LAB FT KNOX
1	CG ARMY ELECT COMD FT MONMOUTH ATTN AMSEL CB
1	CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
1	PERS + TNG DIV DRDMC OFC OF CHF OF ORD DA
2	CG ARMY MED R+D COMD ATTN MEDDH-SR
1	U S ARMY BEHAVIORAL SCI RES LAB WASH. D.C. ATTN CRD-AIC
1	COMDT ARMY CBT SURVEIL SCH FT HUACHUCA ATTN ATSUR ST
1	CG ARMY AIR DEF COMD ENT AFB
2	TNG + DEVEL DIV DCCS-PERS
1	CO US ARMY MAT COMD WASH D.C. ATTN: AMCPT-CM ROBT DETIENNE
2	PRES ARMY ARMOR BD FT KNOX
1	PRES ARMY INF BD FT BENNING ATTN FE+SP DIV
2	PRES ARMY AIR DEF BD FT BLISS ATTN MST DIV
1	PRES ARMY MAINT BD FT KNOX
2	PRES ARMY AVN TEST BD FT RUCKER
2	PRES ARMY ARTY BD FT SILL
1	ARMY ABN ELEC + SPEC WARFARE BD FORT BRAGG ATTN LIB
1	DPTY PRES ARMY MAT COMD BD ABERDEEN PG
1	CO ARMY CBT DEVEL COMD MILIT POLICE AGY FT GORDON
1	US ARMY ARCTIC TEST CTR R + D OFFICE SEATTLE
1	OFC OF SURG 1ST ARMORED DIV FT HOOD
1	CG 2D ARMORED DIV FT HOOD ATTN DIV AVN OFCR
10	CG 4TH ARMORED DIV APO 09326 NY
2	CO 16TH ARMOR GP FT. KNOX
5	CO 2D ARMORED CAV REGT APO 09696 NY
1	CO 3D ARMORED CAV REGT APO 09034 NY
4	CO 14TH ARMORED CAV REGT APO 09026 NY
2	CG ARMY ARMOR + ARTY FIRING CTR FT STEWART ATTN ACS-G3 TNG OFCR
1	1ST ARMORED DIV HQ+HQ CO FT HOOD ATTN ACS-G2
10	1ST INF DIV 1ST MED TANK BN 63D ARMOR FT RILEY
8	3D INF DIV 1ST BN 64TH ARMOR APO 09036 NY
2	1ST TANK BN 73D ARMOR 7TH INF DIV APO 96207 SAN FRAN
8	8TH INF DIV 2D BN 68TH ARMOR APO 09034 NY
1	CO COMPANY A 3D BN 32D ARMOR 3D ARMORED DIV (SPEARHEAD) APO 09039 NY
1	CO 1ST BN 69TH ARMOR APO 96270 SAN FRAN
1	CO 5TH BN 33D ARMOR FT KNOX
1	CO 3D MED TANK BN 68TH ARMOR ATTN S3APO 09028 NY
1	CO 3D MED TANK BN 37TH ARMOR APO 09066 NY
6	CO 2D BN 34TH ARMOR FT IRWIN
2	CALIF NG 40TH ARMORED DIV LOS ANGELES ATTN AC OF SG3
1	55TH COMD HQ DIV ARMY NG JACKSONVILLE FLA
4	CO 150TH AVN BN NJ AIR NG ELIZABETH
1	CG HQ 27TH ARMORED DIV NY AIR NG SYRACUSE
1	TEXAS NG 49TH ARMORED DIV DALLAS
1	CG ARMY ARMOR CTR FT KNOX ATTN G3 AIBKGT
2	CG 1ST INF DIV FT RILEY ATTN G3
1	CG 3RD INF DIV ATTN G3 NY
3	CG 4TH INF DIV FT LEWIS ATTN G3
1	CG 7TH INF DIV SAN FRAN ATTN G2
3	CG 8TH INF DIV ATTN G2 APO 09111 NY
1	CG 5TH INF DIV (MECH) FT CARSON
5	CG 24TH INF DIV ATTN G3 APO 09112 NY
1	CG HQ US ARMY HAWAII ATTN G2 APO 96557 NY
3	CG 82D ABN INF DIV FT BRAGG ATTN G3
1	CO 197TH INF BRGD FT BENNING ATTN S3
1	CO 1ST BN (REINF) 3D INF (THE OLD GUARD) FT MYER
1	CO HQ 2D BN 6TH INF REGT APO 09742 NY
7	CO 3D BN 6TH INF REGT APO 09742 NY
3	CO 171ST INF BRGD APO 98731 NY
3	CG 25TH INF DIV APO 96225 NY
1	CO 4TH BG 30TH INF FT SILL
1	CO 3D BN 39TH INF APO 09029 NY
1	CO 1ST BN 39TH INF APO 09034 NY
1	CO 2ND BN 15TH INF NY ATTN S 3
5	CO 1ST BN (MECH) 52D INF 1ST ARMORED DIV (OLD IRONSIDES) FT HOOD
7	4TH BN (MECH) 54TH INF FT KNOX
1	CO ARMY PARTIC GP NAV TNG DEVICE CTR PT WASHINGTON ATTN CODE 01A
2	CONSOL RES GP 7TH PSYOP GP APO 96248SAN FRAN

2 CHF AUDIO VISUAL APPLICAT OFC ARMY PICTORIAL DIV OFC OF CHF SIG OFCR
1 CHF MED RES PROJ ARMY HOSP US MILIT ACAD WEST POINT
1 CG MILIT DIST OF WASHINGTON
1 US DOCU OFCR OFC OF US NATL MILIT REP SHAPE APO 09055 NY
1 SYS RES GP ENGNR EXPRM STA COLUMBUS O
1 DIR ARMY LIB PENTAGON
1 STRATEGIC PLANNING GP CORPS OF ENGNR ARMY MAP SERV
1 CHF OF MILIT HIST DA ATTN GEN REF BR
1 82D ABN DIV FT BRAGG
1 CO 24TH ARTY GP LADI COVENTRY
1 CG 31ST ARTY BRGD AIR DEF OAKDALE PENNA
1 49TH ARTY GP AIR DEF FT LAWTON
2 HQ 4/59TH ARTY HAMPTON RDS ARMY TERM NORFOLK
1 28TH ARTY GP AIR DEF SELFRIDGE AFB
1 52D ARTY BRGD AIR DEF HIGHLANDS AFS
1 HQ NIAGARA-BUFFALO DEF 31ST ARTY BRGD AIR DEF LOCKPORT
1 HQ 45TH ARTY BRGD AIR DEF ARLINGTON HTS ILL
1 35TH ARTY BRGD AIR DEF FT GEO G MEADE
1 CG 101ST ABN DIV FT CAMPBELL
1 CG 1ST CAV DIV APO 96490 SAN FRAN
1 US ARMY GEN EQUIP ATTN TECH LIB FT LEE
1 US ARMY TROPIC TEST CTR PO DRAWER 942 ATTN BEHAV SCIENTIST FT CLAYTON
2 CO ARMY RES OFC DURHAM
1 DA HDQTRS 525TH MIL INTELL GP SAN FRAN 96307
2 CINC US PACIFIC FLT FPO SAN FRAN
1 CINC US ATLANTIC FLT CODE 312A NORFOLK ATTN LTC DOTY
1 CINC PACIFIC OPNS ANLS SECT FPO SAN FRAN
1 COR TNG COMMAND US PACIFIC FLT SAN DIEGO
1 CHF BUR OF MED + SURG DN ATTN CODE 513
1 CHF RES DIV BUR OF MED + SURG DN
1 HEAD CLIN PSYCHOL SECT PROFESNL DIV BUR OF MED + SURG DN
5 TECH LIB PERS LIB BUR OF NAV PERS ARL ANNEX
3 DIR PERS RES DIV BUR OF NAV PERS
1 TECH LIB BUR OF SHIPS CODE 210L NAVY DEPT
1 BUR OF YDS + DKS DN ATTN ASST CHF FOR RES DEVEL TEST + EVAL
2 NAV AIR SYS COMD REP ATLANTIC NAV AIR STA NORFOLK
1 PERS + TNG BR PSYCHOL SCI DIV OFC OF NAV RES
1 CO + DIR NAV TNG DEVICE CTR CAL' ATTN TECH LIB
1 CO FLT ANTI-AIR WARFARE TNG SAN
1 CO NUCLEAR WEAPONS TNG CTR PAC NAV AIR STA SAN DIEGO
1 CO NAV AIR DEVEL CTR JOHNSVILLE PENNA ATTN NADC LIB
2 FLT ANTI-AIR WARFARE TNG CTR DAM NECK VA BEACH
2 CO FLT TNG CTR NAV BASE NEWPORT
1 COR FLT TNG GP NAV BASE CHARLESTON
2 CO FLT TNG CTR NORFOLK
2 HUMAN FACTORS DEPT COMM PSYCHOL DIV NAV TNG DEVICE CTR PT WASHINGTON
1 CO FLEET TNG CTR U S NAV STA SAN DIEGO
1 CLIN PSYCHOL MENTAL HYGIENE UNIT US NAV ACAD ANNAPOLIS
1 PRES NAV WAR COLL NEWPORT ATTN MAHAN LIB
3 CO SERV SCH COMD NAV TNG CTR SAN DIEGO
3 CO NAV GUIDED MSL SCH DAM NECK VA BEACH
2 CO + DIR ATLANTIC FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1 CO NUCLEAR WEAPONS TNG CTR ATLANTIC NAV AIR STA NORFOLK
2 CO FLT ANTI-AIR WARFARE TNG CTR DAM NECK VA BEACH
2 CO FLT SONAR SCH KEY WEST
1 CO FLT ANTI-SUB WARFARE SCH SAN DIEGO
1 CHF OF NAV RES ATTN SPEC ASST FOR R + D
1 CHF OF NAV RES ATTN HEAD PERS + TNG BR CODE 458
1 CHF OF NAV RES ATTN DIR PSYCHOL SCI DIV CODE 450
1 CHF OF NAV RES ATTN HEAD GP PSYCHOL BR CODE 452
1 DIR US NAV RES LAB ATTN CODE 5120
5 CO OFF OF NAV RES BR OFFICE BOX 39 FPO 09510 NY
1 CHF OF NAV AIR TNG TAG RES DEPT NAV AIR STA PENSACOLA
1 CO NAV SCH OF AVN MED NAV AVN MED CTR PENSACOLA
1 NAV MED RES LAB NAV SUB BASE GROTON ATTN LIB
1 CO MED FLD RES LAB CAMP LEJEUNE
1 COR NAV MSL CTR POINT MUGU CALIF ATTN TECH LIB CODE 3022
1 DIR AEROSPACE CREW EQUIP LAB NAV AIR ENGNR CTR PA
1 CO + DIR NAV ELEC LAB SAN DIEGO ATTN LIB
1 OIC NAV PERS RES ACTVY SAN DIEGO
1 NAV NEUROPSYCHIAT RES UNIT SAN DIEGO
2 COR NAV MSL CTR POINT MUGU CALIF ATTN HUMAN ENGNR DIV CODE N-335
1 DIR PERS RES LAB NAV PERS PROGRAM SUPPORT ACTIVITY WASH NAV YD
1 NAV TNG PERS CTR NAV STA NAV YD ANNEX WASHINGTON ATTN CODE 83 LIB
1 COMDT MARINE CORPS HQ MARINE CORPS ATTN CODE AO-1B
1 HQ MARINE CORPS ATTN AX
1 DIR MARINE CORPS EDUC CTR MARINE CORPS SCH QUANTICO
ATTN SECRET + CONF FILES GP
1 DIR MARINE CORPS TEST ATTN EVAL UNIT
1 CHF OF NAV OPNS OP-01PL
1 CHF OF NAV OPNS OP-03T
1 CHF OF NAV OPNS OP-0712
1 CHF OF NAV AIR TECH TNG NAV AIR STA MEMPHIS
1 DIR OPS EVAL GRP OFF OF CHF OF NAV OPS OP03EG
2 COMDT HQ COAST GUARD HC
1 CHF OFCR PERS RES + REVIEW BR COAST GUARD HQ
1 OPNS ANLS OFC HQ STRATEGIC AIR COMD OFFUTT AFB
1 CINC STRATEGIC AIR COMD OFFUTT AFB ATTN SUP-3
1 AIR TNG COMD RANDOLPH AFB ATTN ATFTR
1 HQ AIR TNG COMD ATTES RANDOLPH AFB
1 HQ AIR FORCE ATTN AFCIN-3C2
1 CHF SCI DIV DRCTE SCI + TECH DCS R+D HQ AIR FORCE AFRSTA
1 CHF SPEC WARFARE DIV DRCTE OF PLANS + OPNS DCS-PLANS+OPNS
HQ AIR FORCE
1 CHF OF PERS RES BR DRCTE OF CIVILIAN PERS DCS-PERS HQ AIR FORCE
1 CHF EVAL BR(AFPDPCE) CAREER DEVEL DIV DRCTE OF PERS PLAN HQ AIR FORCE
2 DPTY INSPECTOR GEN AIR FORCE (AFIAS-G)1 NORTON AFB
1 AFSC-STLO (RTSAW) CO DEPT OF THE NAVY
1 FAA CHF INFO RETRIEVAL BR WASH D.C.
1 FED AVN AGY MED LIB HC-640
2 HQ AFSC SCBB ANDREWS AFB
1 ROME AIR DEVEL CTR RASH GRIFFISS AFB
2 COR ELEC SYS DIV L G HANSCOM FLD BEDFORD MASS ATTN ESRHD
2 SACRAMENTO AIR MAT AREA SMACO-PERS RES MCCLELLAN AFB
1 ATC ATARQ RANDOLPH AFB
1 HQ BALLISTICS SYS DIV PERS SUBSYS BR BSD(P NORTON AFB
2 MILIT TNG CTR OPE LACKLAND AFB
2 6570TH AERO MED RES LAB MAPT WRIGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR AMAH BROOKS AFB
1 DCS-TECH TNG DIR MILIT + SPT TNG RANDOLPH AFB
4 HQ AIR TRANS COMD ATCTO-M RANDOLPH AFB
1 COR ELEC SYS DIV LG HANSCOM FLD ATTN ESTI
1 DIR AIR U LIB MAXWELL AFB ATTN AUL3T-63-253
1 AIR FORCE SCH OF AEROSPACE MED BROOKS AFB ATTN AEROMED LIB
1 DIR OF LIB US AIR FORCE ACAD
1 DRCTE OF AEROSPACE SAFETY AFIAS-L DPTY IG NORTON AFB
1 COMDR ARCTIC AEROMED LAB APO 98731 SEATTLE
1 6570TH PERS RES LAB PRA-4 AEROSPACE MED DIV LACKLAND AFB
1 TECH TNG CTR TNT LOWRY AFB
1 PSYCHOBIOLOGY PROG NATL SCI FOUND
1 DIR DIV OF DATA SOURCES C STAND NATL CTR FOR EDUC STATISTICS
OFC OF EDUC
1 DIR NATL SCI FOUNDN WASHINGTON ATTN ASST DIR FOR SOC SCI
1 DIR NATL SECUR AGY FT GEO G MEADE ATTN TDL
1 DIR NATL SECUR AGY FT GEO G MEADE ATTN DIR OF TNG
5 CENTRAL INTEL AGY ATTN OCR/DD STANDARD DISTRIBUTION
1 SYS EVAL DIV RES DIRECTORATE DOD-DDR PENTAGON
1 DEPT OF STATE BUR OF INTEL + RES EXTERNAL RES STAFF
3 US INFO AGY INTL PROCUREMENT LIB
1 SCI INFO EXCH WASHINGTON
2 CHF REGL TNG BR TNG DIV FED AVN AGY ATTN RE 18
1 BUR OF RES + ENGR US POST OFC DEPT ATTN CHF HUMAN FACTORS BR
1 EDUC MEDIA BR OE DEPT OF HEW ATTN T D CLEMENS
1 CHF PERS RES STAFF OFC OF PERS DEPT OF AGRICUL
1 OFC OF INTERNATL TNG PLANNING & EVAL BR AID WASH.
2 SYS DEVEL CORP SANTA MONICA ATTN LIB
2 DUNLAP + ASSOC INC DARIEN ATTN LIB
2 RESEARCH ANALYSIS CORP MCLEAN VA 22101
1 RAND CORP WASHINGTON ATTN LIB
1 DIR RAND CORP SANTA MONICA ATTN LIB
1 U OF ILL GP EFFECTIVE RES LAB
2 U OF SO CALIF ELEC PERS RES GP
1 COLUMBIA U ELEC RES LABS ATTN TECH EDITOR
1 MITRE CORP BEDFORD MASS ATTN LIB
2 U OF PGH LEARNING R+D CTR ATTN DIR
1 HUMAN SCI RES INC NORFOLK
1 WESTERN ELECTRIC CO INC NY
1 HUMAN SCI RES INC MCLEAN VA
2 TECH INFO CTR ENGNR DATA SERV N AMER AVN INC COLUMBUS O
1 CHRYSLER CORP MSL DIV DETROIT ATTN TECH INFO CTR
1 AVCO CORP LAWRENCE MASS ATTN MANGR HUMAN FACTORS DEPT
3 CTR FOR RES IN SOCIAL SYS AMER U ATTN LIBN
1 RAYTHEON CO ELEC SERV OPNS BURLINGTON MASS
2 EDUC + TNG CONSULTANTS LOS ANGELES ATTN PRINCIPAL SCI
1 GEN DYNAMICS POMONA CALIF ATTN LIB
1 AVN SAFETY ENGR C RES DIV OF FLIGHT SAFETY FOUND INC PHOENIX
2 MARQUARDT CORP POMONA CALIF ATTN DEPT 580
2 OTIS ELEVATOR CO DIV ATTN LIB STAMFORD CONN
1 CHF PERS SUBSYS AIRPLANE DIV MS 74-70 RENTON WASH
1 THIOKOL CHEM CORP HUMETRICS DIV LOS ANGELES ATTN LIBN
2 CTR FOR RES IN SOCIAL SYS FLD OFC DESEGV SPEC WARFARE SCH FT BRAGG
1 INST FOR DEF ANLS RES + ENGNR SUPPORT DIV WASHINGTON
1 HUGHES AIRCRAFT COMPANY CULVER CITY CALIF
1 DIR CTR FOR RES ON LEARNING + TEACHING U OF MICH
1 OHIO STATE U
1 EDITOR TNG RES ABSTR AMER SOC OF TNG DIRS U OF TENN
1 U OF CHICAGO DEPT OF SOC
1 HUMAN FACTORS SECT R+D GEN DYNAMICS ELECTRIC BOAT GROTON
1 CTR FOR RES IN SOCIAL SYS AMER U
6 BRITISH EMBSY BRITISH DEF RES STAFF WASHINGTON
3 CANADIAN JOINT STAFF OFC OF DEF RES MEMBER WASHINGTON
3 CANADIAN ARMY STAFF WASHINGTON ATTN GSO2 TNG
2 CANADIAN LIAISON OFCR ARMY ARMOR BD FT KNOX
1 GERMAN LIAISON OFCR ARMY AVN TEST BD FT RUCKER
3 ACS FOR INTEL FOREIGN LIAISON OFCR TO NORWEG MILIT ATTACHE
2 ARMY ATTACHE ROYAL SWEDISH EMBSY WASHINGTON
1 NATL INST FOR ALCOHOL RES OSLO
1 DEF RES MED LAB ONTARIO
2 FRENCH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 BRITISH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 OFC OF AIR ATTACHE AUSTRALIAN EMBSY ATTN: T.A. NAYGH
WASH. D.C.
1 YORK U DEPT OF PSYCHOL
2 AUSTRALIAN EMBSY OFC OF MILIT ATTACHE WASHINGTON
2 U OF SHEFFIELD DEPT OF PSYCHOL
1 MENNINGER FOUNDATION TOPEKA
2 AMER INST FOR RES SILVER SPRING
1 AMER INST FOR RES PGH ATTN LIBN
1 DIR PRIMATE LAB UNIV OF WIS MADISON
1 COLUMBIA U SCH OF BUS
1 MATRIX CORP ARLINGTON ATTN TECH LIBN
1 AMER TEL+TEL CO NY
1 U OF GEORGIA DEPT OF PSYCHOL
1 OBERLIN COLL DEPT OF PSYCHOL
1 DR GEORGE T HAUTY CHMN DEPT OF PSYOLU OF FLL
1 GEN ELECTRIC CO SANTA BARBARA ATTN LIB
1 VITRO LABS SILVER SPRING MD ATTN LIBN
1 HEAD DEPT OF PSYCHOL UNIV OF SC COLUMBIA
1 TENN VALLEY AUTHORITY KNOXVILLE ATTN LABOR RELATIONS OFCR DIV OF PERS
1 U OF GEORGIA DEPT OF PSYCHOL
1 U OF UTAH DEPT OF PSYCHOL
1 AMER INST FOR RES PALO ALTO CALIF
1 MICH STATE U COLL OF SOC SCI
1 N MEX STATE U
1 ROMLAND + CO HADDONFIELD NJ ATTN PRES
1 NORTRONICS DIV OF NORTHROP CORP ANAHEIM CALIF
1 OHIO STATE U SCH OF AVN
2 AIRCRAFT ARMAMENTS INC COCKEYSVILLE MD
2 OREGON STATE U DEPT OF MILIT SCI ATTN ADJ
1 TUFTS U HUMAN ENGNR INFO + ANLS PROJ
1 HUMAN FACTORS RES GP WASH U ST LOUIS
1 AMER PSYCHOL ASSOC WASHINGTON ATTN PSYCHOL ABSTR
1 NO ILL U HEAD DEPT OF PSYCHOL
1 GEORGIA INST OF TECH DIR SCH OF PSYCHOL
1 DR A. V. FEND STANFORD RES INST FT O
1 BELL TEL LABS INC TECH INFO LIB WHIPPANY LAB NJ ATTN TECH REPORTS LIBN
1 REPUBLIC AVN CORP FARMINGDALE LONG ISL ATTN SUPERV ENGNR LIB
1 WASHINGTON ENGNR SERV CO INC KENSINGTON MD
1 LIFE SCI INC FT WORTH ATTN PRES
1 AMER BEHAV SCI CALIF
1 SAN DIEGO STATE COLL PUBLIC ADMIN CTR
2 DIR INSTR RESOURCES STATE COLL ST CLOUD MINN
1 COLL OF WM + MARY SCH OF EDUC
1 SO ILLINOIS U DEPT OF PSYCHOL
2 COMMUNICABLE DISEASE CTR DEVEL + CONSULTATION SERV SECT ATLANTA
2 WASH MILITARY SYS DIV BETHESDA MD
1 RCA BURLINGTON MASS ATTN: WM R BUSH
1 NORTHWESTERN U DEPT OF INDSTR ENGNR
1 HONEYWELL ORD STA MAIL STA 806 MINN
1 NY STATE EDUC DEPT ABSTRACT EDITOR AVCR
1 AEROSPACE SAFETY DIV U OF SOUTHERN CALIF LA
1 MR BRANDON B SMITH RES ASSOC U OF MINN
1 CTR FOR THE ADVANCED STUDY OF EDUC ADMIN ATTN JONE PIERRON U OF OREG
1 CHF PROCESSING DIV DUKE U LIB
1 U OF CALIF GEN LIB DOCU DEPT
1 FLORIDA STATE U LIB GIFTS + EXCH
1 HARVARD U PSYCHOL LABS LIB
1 U OF ILL LIB SER DEPT
2 U OF KANSAS LIB PERIODICAL DEPT
1 U OF NEBRASKA LIBS ACQ DEPT

1	SO ILL U ATTN LIBN SER DEPT
1	KANSAS STATE U FARRELL LIB
1	BRIGHAM YOUNG U LIB SER SECT
1	U OF LOUISVILLE LIB BELKNAP CAMPUS
1	OHIO STATE U LIBS GIFT + EXCH DIV
1	PENNA STATE U PATTEE LIB DOCU DESK
1	PURDUE U LIBS PERIODICALS CHECKING FILES
1	STANFORD U LIBS DOCU LIB
1	LIBN U OF TEXAS
1	SYRACUSE U LIB SER DIV
1	U OF MINNESOTA LIB
1	STATE U OF IOWA LIBS SER ACQ
1	NO CAROLINA STATE COLL CH HILL LIB
2	BOSTON U LIBS ACQ DIV
1	U OF MICH LIBS SER DIV
1	BROWN U LIB
2	COLUMBIA U LIBS DOCU ACQ
1	DIR JOINT U LIBS NASHVILLE
1	U OF DENVER MARY REED LIB
2	DIR U LIB GEO WASHINGTON U
2	LIB OF CONGRESS CHF OF EXCH + GIFT DIV
1	U OF PGH DOCU LIBN
1	CATHOLIC U LIB EDUC & PSYCHOL LIB WASH DC
1	U OF KY MARGARET I KING LIB

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