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ABSTRACT

Research was undertaken to develop a system for predicting completion time in a self-paced training course. The hypotheses were developed that: 1) course content-related instruments would be better predictors of completion time than general aptitude measures; and that 2) a linear predictive function would provide the best description of the relationship between predictor variables and completion time criteria. A predictive test battery which consisted primarily of content-related tests and mini-lessons that were directly associated with a training course, proved to be better than general aptitude measures for predicting course completion time; a strong linear relationship was found between predictors and completion time criteria. Step-wise linear regression analyses were used to develop predictive functions and to determine potentially useful predictors. Computer programs and nomographs were constructed to display the predictive equations and were recommended for use. Since there were significant inter-group differences in learning rates depending on the media used, the development of media-specific predictive equations was recommended. (Author/PB)

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Alexandria, Virginia

HUMAN RESOURCES RESEARCH ORGANIZATION

Work Unit: STOCK-PRISM

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under Contract DAHC 19-73-C-0004 with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

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FOREWORD

The purpose of the research performed as part of HumRRO Work Unit STOCK was to develop practical techniques for the management of entry-MOS training programs, in order that these programs might more effectively use individualized instruction for students of all aptitude levels. The training management techniques developed under Work Unit STOCK were evaluated and refined as part of Work Unit PRISM.

This document reports on the design, development, and initial evaluation of an approach to predict "time-to-learn" in a student self-paced training program. A previous report, *Self-Paced Advanced Individual Training (AIT) and Duty Assignment Procedures* (Technical Report 73-14) identified the need for a procedure that accurately predicts course completion time in order for individualized instruction to be successfully implemented.

Research performed under Work Units STOCK and PRISM was conducted by HumRRO Division No. 1, Alexandria, Virginia, Dr. J. Daniel Lyons, Division Director. The Work Unit Leader for the research was Dr. C. Dennis Fink; Dr. Harold Wagner was Work Sub-Unit Leader and was directly responsible for conduct of the research. Dr. Richard D. Behringer designed and developed the Predictive Test Battery used in this study. Dr. Currell L. Pattie administered the testing program and collected the data required for analysis. The location of the research was the U.S. Army Quartermaster School, Fort Lee, Virginia.

Enlisted men assigned to the project during the period covered in this report were SP4 Edward T. Weston who developed the PREDICT computer program, and SP4 Darrell L. Anderson who constructed the nomographs included in this report. Both men contributed to the data processing and programming activities required during the research.

HumRRO research for the Department of the Army under Work Unit STOCK-PRISM is conducted under contract DAHC 19-73-C-0004. Army Training Research is performed under Army Project 2Q062107A745.

Meredith P. Crawford
President
Human Resources Research Organization

OBJECTIVES

The purpose of the research performed as part of Work Unit STOCK was to develop practical techniques for managing training programs, so that individualized instruction could be used more effectively. The training management techniques developed under Work Unit STOCK were evaluated and refined as part of Work Unit PRISM.

PROBLEM

A fundamental problem to be solved in the implementation of self-paced training is how to accurately predict each student's course completion date prior to graduation. These predictions are needed so that graduates can be assigned to their duty positions or to additional training in a timely manner. This problem of accurately predicting self-paced course completion time was the focus of the effort described in this report.

APPROACH

The course that served as the research vehicle for this study was the Stock Control and Accounting Specialist (MOS 76P20) course. This course was being individualized at the U.S. Army Quartermaster School (QMS).

A literature survey in the area of "time-to-learn" predictions led to the following assumptions:

(1) Course content-related instruments are better predictors of completion time than general aptitude measures.

(2) A linear predictive function is the "best" description of the relationship between predictor variables and completion time criteria.

These assumptions formed the basis of the approach taken, which involved the use of standardized aptitude tests and course-related instruments as predictors of completion time. The predictive test batteries that were developed contained three different types of tests. First, they included "aptitude-like" tests of those skills and knowledges (e.g., arithmetic, vocabulary) considered necessary to enable the student to acquire the MOS-related behaviors. The second type of test can be described as a "mini-lesson/test" situation. In essence, these were samples of the tasks to be encountered later in the course. A small amount of instruction in each task was given to the students, who were then tested on what they had just learned to do. The third type of test instrument consisted of scales designed to tap the "affective" (or motivational) factors considered important in the subject matter area covered by this course. Scores on these tests, which were administered prior to entry in the course, were used with the standardized test scores in the development of completion time predictions. Predictive equations were generated by the use of the step-wise multiple regression analyses described in the report.

As the entire course had not been completely individualized at the time of this study, the criteria reflected only *that* portion of the course which had been self-paced. The criterion time scores were obtained by instructors of the 76P20 course at the Quartermaster School. The HumRRO staff member stationed at Fort Lee organized and forwarded the data to Alexandria, where it was processed and analyzed. The completion time data were used to determine the accuracy of the predictions.

FINDINGS AND IMPLICATIONS

The research findings showed that scores obtained from HumRRO-developed tests correlated more strongly with completion time criteria than did the standardized ACB scores. However, the AFQT score was a significant component of several useful predictive equations. The assumption that course content-related predictors would be better than general aptitude measures for estimating completion time was supported by these findings.

Stepwise multiple linear regression analyses were employed in the development of predictive functions and the determination of potentially useful predictors. Some multiple correlations obtained between the predictive variables and completion time criteria ranged from .65 to .75, while others ranged from .85 to .87. The latter correlations occurred with the use of within-course time scores as predictors in the equation, whereas the first set of correlations resulted from the use of only the pre-course test scores. Therefore, the second assumption, that a strong linear relationship exists between predictors and completion time criteria, was considered tenable on the basis of these findings.

A computer program was developed for displaying the predictive information. This program was considered to be a useful aid to managers of self-paced training programs, but was limited in that it required access to a computer facility. Nomographs were constructed to display the predictive equations in a more generally useful manner. The nomographs were simple to use and did not require access to a computer. They were recommended for use in the prediction system at the QMS.

In order to estimate completion time accurately, the data had to be grouped according to the instructional mode employed. There were significant differences in the rate of learning between groups trained using different media. Therefore, *media-specific* predictive equations needed to be developed. This led to the hypothesis that if the predictive instruments *and the situation in which they are administered* are more closely related to the *instructional situation*, predictions will be improved. This hypothesis has yet to be tested.

CONTENTS

Individualized Course Completion Time Predictions: Development of Instruments and Techniques

Chapter 1

INTRODUCTION

THE PROBLEM

The recent trend toward individualized training in the Army has been accompanied by a need to solve the administrative problems that are generated by such training. It is the characteristic of *student self-pacing* that produces many of these management problems. In the Army, self-pacing has produced at least two types of problems:

(1) How to efficiently utilize "early" graduates at the local training base, as they may be constrained from overseas assignments by Public Law 51.[1]

(2) How to insure the timely arrival of assignment instructions, so that the students may depart their training base immediately upon graduation.

These problems were identified in Work Unit STOCK (1), a project which had as its objective the successful implementation of an individualized self-paced course at the U.S. Army Quartermaster School (QMS). This work began with a survey of self-paced training programs in all the Services. The survey was followed by a thorough analysis of the Army's personnel assignment system and its effects on self-paced training programs. Both the military-wide survey and the Army assignment system analysis resulted in identical conclusions—there is a military-wide need to accurately predict each student's course completion date prior to graduation, in order for self-paced training to be successfully implemented.

The problem of accurately predicting self-paced course completion time is the focus of the effort described in this report. A course undergoing individualization at the QMS (Stock Control and Accounting Specialist—MOS 76P20) served as the research vehicle for this study. In addition to being self-paced, the 76P20 course uses a "multi-media" approach to present the instruction. In Work Unit STOCK, a technique was devised to predict MOS 76P20 course completion time. The procedures and instruments that make up this technique were evaluated and refined in Work Unit PRISM. This report describes the development and current status of that effort.

RELATED STUDIES OF "TIME TO LEARN"

The use of "time to learn" as a critical variable in recent education and training research stems, in part, from a model developed by John B. Carroll and described by Block (2). Carroll's "Model of School Learning" was essentially a conceptual paradigm that outlined various factors influencing a student's success in school learning. Carroll found that a student's aptitude predicted not only the *level* to which he learned in a *given time*, but also the *amount of time* he required to learn to a *given level.* Rather than viewing aptitudes as determiners of what level of learning a student could reach, Carroll defined aptitudes as determiners of the amount of time required to learn a task to a given criterion level under "ideal" instructional conditions.

[1] PL 51 constrains AIT graduates from departing for overseas assignments until the completion of eight weeks formal training or on-the-job training (OJT), beyond the eight weeks used in Basic Combat Training.

It was Bloom (3) who transformed this conceptual model into an effective working model for "mastery" learning. In describing the model, Bloom stated that if students are normally distributed with respect to aptitude, and the kind and quality of instruction and the amount of time available for learning are made appropriate to the characteristics and needs of *each* student, then the majority of students may be expected to achieve mastery of the subject. Thus, the Carroll model and Bloom's extension of it support the notion that, given an unlimited time to learn (and if other factors have been controlled for or optimized), mastery will be obtained by each student at a different rate. Bloom (3) stated,

> "We believe that the student should be allowed the time he needs to learn a particular subject. Learning time needed will be affected by his aptitudes, his ability to understand the instruction, and the quality of instruction he receives in the class and outside of class. An effective mastery learning strategy must find ways of altering the time individuals need for learning as well as providing the time necessary for each student. Such a strategy, therefore, must solve the instructional as well as the school organizational (including time) problem."

Recently Atkinson (4), describing criteria for a theory of instruction, devoted a substantial portion of his model to the factor of "time to learn." Although it is only one of the ingredients in his instructional model, *time* is considered by Atkinson to be one of the important factors to vary when determining the optimal instructional strategy for each student.

Individual student rate-to-criterion has been suggested as a basis for evaluating individualized instruction (5). The basic assumption for this suggestion is that there are stable performance rates for students within the context of an ideal instructional system. Thus, by keeping achievement constant, measuring the time required to attain the objectives can be employed in a framework for evaluating individualized instruction. Such a measurement index was utilized to evaluate the efficiency of a self-paced economics course (6).

Research concerning the "time to learn" factor has been performed in situations where individualized instruction is contemplated, or in operation. For example, at the University of Pittsburgh there has been a concentrated effort to develop individualized instruction (i.e., Individually Prescribed Instruction - IPI). In this context there have been several investigations of learning rate (7, 8, 9). Several methods of measuring rate of learning were studied. The authors found that the rate of learning was not constant over various learning tasks, and that aptitude and other *general* predictor variables did not estimate these learning rates adequately.

HumRRO researchers have attempted to predict completion times for self-paced, programmed instruction courses, but only general aptitude scores were available for use as predictor variables and unsatisfactory predictions resulted.[2] Stankard (10) attended to the time factor when implementing computer-assisted instruction. Faced with the scheduling and managerial problems that accompany self-paced training, attempts were made to find predictors of student learning rate within the CAI situation. These attempts were unsuccessful. A more *instructional situation-related* approach toward prediction was suggested.

According to Carroll (11), the findings described above could be due to a learning rate that is *quite specific to a particular task*. He stated that the best way of estimating time is to use tests of "*relevant* aptitudes and learnings." This opinion is supported by

[2] An exploratory analysis of completion times at various Army training centers of programmed instruction materials for several MOSs was performed at Division No. 4 in June 1972.

some of the results obtained in HumRRO Work Unit IMPACT (12). First, it was shown that different kinds of learning tasks require specific and unique student abilities--that "general" tests are inadequate predictors of student performance. It was also determined that *some* measures of personal characteristics were useful in predicting student performance *early* in the course, but were not the same as those that predicted performance in later, more complex stages. These findings support the view that early instructional experiences within the training program may overcome some of the personal background factors brought into the situation, and these in-course factors would then be the most "important" determiners of performance within the course.

The studies cited contain much evidence, both direct and indirect, to support the supposition that specific task-related predictors of learning rate are better than most general aptitude measures.

The studies in this area have used a linear model to predict learning time or performance. In doing so, many studies have relied on multiple linear regression analyses for the purpose of predicting performance (13, 14). In the study by Owen and Feldhusen (14), the most useful prediction model was a stepwise multiple regression approach that was based on the assumption that ". . . variables which are similar both in history and composition should predict one another better than variables further removed in time and different in structure." It was hypothesized that the best predictors of achievement were obtained from performance in a *similar environment*. This hypothesis was supported in a study by Wardrop (15) in which miniature learning situations were used to predict classroom performance and proved to be better predictors than "general" measures.

In HumRRO Work Unit PREDICT, multiple regression analyses were used for the purpose of predicting performance. The objective of that study was to develop systems for predicting aviator success in training and in operational assignments (16, 17). In a study by Dees (18) a psychomotor skill, a measure of perseverance, and a measure of leadership ability were selected as criteria to be predicted by a battery of 37 tests employed in a stepwise multiple regression analysis approach. A much greater predictive capability was found than would be obtained from "general intelligence tests" alone.

The studies cited are only a small sample of the studies that have used multiple regression analyses to predict performance/achievement. They, too, support the use of *specific, content-related* predictor variables. Based upon this line of evidence, Work Unit STOCK researchers assumed the following:

(1) Course content-related tests are better predictors of completion time than general aptitude measures.

(2) A linear predictive function is the "best" description of the relationship between predictor variables and completion time criteria.

OBJECTIVES OF THE STUDY

The primary objective of this research effort was to develop a technique that would provide accurate course completion time predictions. This technique was based upon the two assumptions described above. Thus, this study indirectly assessed the validity of those assumptions.

A secondary objective was to provide, for a self-paced course (MOS 76P20), a system that would (a) predict individual training times for its participants, and (b) display these predictions in a manner that would be useful to training managers who administer the individualized program.

The iterative approach used to develop completion time predictions is outlined below. For explanatory purposes, the events will be described in four separate phases, although some of the activities occurred as overlapping steps. These four phases can be described as follows:

I. Exploratory Stage
II. Development of Predictive Test Battery 1
III. Development of Predictive Test Battery 2
IV. Proposed Study Using Predictive Test Battery 3

Chapter 2

PHASE I - EXPLORATORY STAGE

COLLECTION OF AVAILABLE "PREDICTIVE" INFORMATION

The major goal of this Phase was to determine the "*least* useful" predictor variables, in order to eliminate them from further consideration. To accomplish this, all information that might be of use for predicting course completion time was collected from 76P20 course trainees. This included all the scores on standardized aptitude tests that were recorded in the trainees' personnel files. Although other attempts at predicting completion time using these "general" aptitude measures had been unsuccessful (10), this was the only information about each trainee that could be obtained at the beginning of Phase I. Also, it was not known if these "general" measures would be useful for predicting learning rate in the *Supply* content area.

The Armed Forces Qualification Test (AFQT) and the tests comprising the Army Classification Battery (ACB) were the major variables investigated in this Phase. These tests are given under a variety of conditions. The ACB is a set of 11 instruments administered at the reception station during the first week that the trainee is in the Army. The AFQT score (in percentiles) represents a combination of four tests given at the time of the pre-induction physical examination. Table 1 lists the entry characteristic measures obtained for each of the trainees.

The Army Aptitude Area scores are combinations of ACB scores that have been previously validated for their "relationship" with success in certain occupational areas within the Army. Aptitude Area scores are used as prerequisites for a variety of training programs. For example, the Clerical Aptitude Area (CL) score is the average of the scores obtained in the Verbal (VE) and the Army Clerical Speed (ACS) tests. A CL score of 90 is the prerequisite for entry into the 76P20 course at QMS. Thus, the distribution of scores in that Aptitude Area, and on the components of that index (VE and ACS) is truncated due to the lower limit of 90 required for course entry.

SELECTION OF CRITERIA

When this project began in FY 1971, no segment of the 76P20 course had yet been individualized. A plan was devised to use the available predictor variables (AFQT and ACB test scores) to predict time-to-completion on those sections of the conventional course that were "self-paced." In the 76P20 course, the graded practical exercise (PEE) at the end of each instructional block was worked on by the trainees at their own pace. In the traditional classroom, if an individual completed the PEE rapidly, he would assist one of the slower members of the class. In order to assess the predictive ability of each factor, this practice was halted and each student worked by himself. The instructors were provided with forms to record the start and completion time for each PEE. As a reward for completing the PEE as rapidly as possible, students were allowed to leave the classroom and have the rest of the period as free time.

In addition to PEE completion time data, the *performance* scores obtained on the PEEs were collected. Only those time scores for PEEs that were "passed" (i.e., 70%

Table 1

Trainee Entry Characteristic Measures

ACB (Army Classification Battery)

Symbol	Test
VE	Verbal
AR	Arithmetic Reasoning
PA	Pattern Analysis
CI	Classification Inventory
MA	Mechanical Aptitude
ACS	Army Clerical Speed
ARC	Army Radio Code
GIT	General Information
SM	Shop Mechanics
AI	Automotive Information
ELI	Electronic Information

Army Aptitude Areas

Symbol	Title	Formula
IN	Infantry-Combat	$\frac{AR + 2CI}{3}$
AE	Armor, Artillery, Engineers-Combat	$\frac{GIT + AI}{2}$
EL	Electronics	$\frac{MA + 2EI}{3}$
GM	General Maintenance	$\frac{PA + 2SM}{3}$
MM	Motor Maintenance	$\frac{MA + 2AI}{3}$
CL	Clerical	$\frac{VE + ACS}{2}$
GT	General Technical	$\frac{VE + AR}{2}$
RC	Radio Code	$\frac{VE + ARC}{2}$

AFQT (Armed Forces Qualification Test)

Percentile Score - Combination of Verbal, Arithmetic, Spatial Relations, and Knowledge of Tools (Mechanical).

correct) were used as criteria in this investigation. This practice was adopted because the completion of a self-paced course implies reaching a minimum criterion level of performance. In the present study this requirement could best be simulated by using PEE completion time figures for only those students who had obtained a passing grade on the PEE.

In Phase I a question arose as to which would be a more valid criterion—completion time for a single PEE or completion time for all PEEs contained in the course. During Phase I, the 76P20 course was composed of three large instructional blocks (referred to as Annexes A, B, and C). Only the PEEs *at the end* of Annexes A and B were used as criteria in Phase I of this study. At the outset of the study, single PEE times in Annexes A and B were used as criteria. As more data were collected, total PEE time *within* an Annex (A *or* B) was used as the criterion variable.

COLLECTION OF WITHIN-COURSE DATA

The time and performance scores for each of the PEEs were recorded on forms by the instructor in the classroom. (Data collection was not tightly controlled because many different instructors recorded these scores.) The forms were then forwarded to the HumRRO staff member stationed at QMS. He organized and forwarded the data to Alexandria, where it was put on IBM input sheets for keypunching. A card file was set up for each student. In addition to the PEE performance and time scores, the ACB and AFQT scores were transmitted and entered into the file.

ANALYSIS OF DATA

Correlation matrices were then computed. The goal was to identify some of the factors that were likely to be unrelated to the criteria. Four 76P20 classes were used in the initial group of students (Group I). At first, correlations of ACB, AFQT, and Aptitude Area scores with single PEEs in each Annex (A and B) were computed. However, as trainees became more plentiful, the total time and performance scores *across* PEEs for Annex A and for Annex B were used as criteria. Seventy-seven trainees had taken all the Annex A PEEs, and 76 trainees had all the Annex B PEEs. The correlations of the predictor variables with these criteria are shown in Table 2.

Many of the correlations were statistically significant ($p<.05$). Of the Aptitude Areas, GT and GM correlated approximately .5 with time and +.5 with performance. This level of association was also found with the AFQT score. Certain individual ACB tests (AR and PA) were as highly related to these criteria as the combined scores.

The reliability of these findings was assessed with another group (Group II), consisting of three classes. Correlations were calculated and the results can also be found in Table 2. As can be seen, the size of the correlations between predictor variables and Annex A and Annex B PEE performance scores was sustained. However, the relationships with time scores decreased. This reduction, which occurred for most of the predictor variables, could have been a result of the uncontrolled factors previously mentioned (i.e., different instructors in different classes recording the time scores).

In Table 2, correlations that are circled represent correlations (*not* significant at the .05 level) of predictors with criteria *across* Groups. Thus, the correlation of Classification Inventory (CI) scores with criteria (both time and performance) never reached statistical significance. It was assumed, then, that this variable could be eliminated from further

Table 2

Correlations of AFQT, ACB, and Aptitude Area Scores With Annex A and Annex B Time and Performance Scores

	Group I				Group II			
	Annex A (N = 77)		Annex B (N = 76)		Annex A (N = 61)		Annex B (N = 73)	
Predictor	Performance	Time	Performance	Time	Performance	Time	Performance	Time
AFQT	.53	-.46	.51	-.49	.63	-.22	.49	-.41
ACB								
VE	.45	-.38	.34	-.28	.52	-.29	.37	-.25
AR	.58	-.54	.42	-.45	.64	-.18	.45	-.36
PA	.62	-.50	.48	-.37	.50	-.35	.45	-.40
MA	.39	-.35	.42	-.41	.38	-.33	.31	-.20
ARC	.26	-.34	.15	-.33	.20	-.22	.12	-.11
SM	.40	-.44	.40	-.36	.17	-.20	.28	-.11
AI	.30	-.23	.34	-.30	.19	-.34	.32	-.14
ELI	.41	-.22	.42	-.28	.39	-.32	.42	-.23
GIT	.32	-.38	.34	-.33	.45	-.38	.44	-.15
CI	.15	-.21	.20	-.10	.14	.13	.00	-.02
ACS	-.30	.17	.11	-.44	.36	-.34	.17	-.17
Aptitude Area								
CL	.43	-.49	.30	-.45	.55	-.34	.35	-.23
GT	.56	-.50	.43	-.42	.66	-.26	.48	-.36
IN	.35	-.38	.34	-.27	.36	.06	.14	-.15
AE	.33	-.36	.36	-.35	.35	-.40	.43	-.16
EL	.46	-.29	.47	-.36	.44	-.37	.43	-.25
GM	.57	-.53	.48	-.43	.29	-.32	.37	-.25
MM	.36	-.30	.40	-.36	.33	-.37	.41	-.22
RC	.39	-.41	.28	-.38	.37	-.32	.25	-.20

consideration. Similarly, ELI showed low correlations with time scores in both groups. However, it did correlate significantly with performance scores, and was retained along with the other ACBs and AFQT scores.

SUMMARY OF FINDINGS AND CONCLUSIONS

The following conclusions were drawn from the correlation analyses in Phase I:

(1) The individual ACB test scores correlated as well with criteria as did the combined Aptitude Area scores.

(2) The Classification Inventory (CI) score was consistently unrelated to any of the criterion variables (Annexes A and B PEE time and performance scores).

(3) The AFQT usually provided as high a correlation with criteria as any of the single ACB tests.

The decisions made on the basis of these findings were as follows:

(1) In future analyses only the individual ACB scores would be employed. Aptitude Area scores would no longer be used.

(2) The Classification Inventory score would not be included in any further analyses.

(3) The AFQT and 10 other ACB test scores would continue to be obtained in the next Phase of this effort.

Chapter 3

PHASE II - PREDICTIVE TEST BATTERY 1

DEVELOPMENT

While the Phase I analyses were being performed (in FY 1972), the 76P20 course content was carefully reviewed, in order to develop the Supply-related test battery. Although there was no attempt to incorporate content directly into all of the test items, the tests did reflect the skills and knowledges required in the general area of Supply.

Two major types of tests were developed. First, there were "aptitude-like" tests—tests of skills and knowledges (e.g., arithmetic, vocabulary) considered necessary to "enable" the student to acquire the MOS-related behaviors. These tests included items that were course content-related to some extent, but not exclusively.

The second type of test is best described as a "*mini-lesson and test*" situation. Five of the test instruments in this group were developed by Sticht (19) as "reading tests" for another Supply MOS (76Y). The other "mini-lesson/test" instruments reflected Supply tasks that were taught in the 76P20 course.

The composition of Predictive Test Battery 1 is shown in Table 3. A discussion of each test in this battery follows.

Table 3

Predictive Test Battery 1—Supply Area Related

Test Group	Test	Number of Items/ Entries	Time Limit (Minutes)
Arithmetic Skills and Knowledges	Number Recognition (NR)	24	2
	Symbol Recognition and Operation (SR&O)	44	7
	Fractions and Decimals (FR)	23	5 1/2
	Word Problems (WP)	21	10
Clerical Skills and Knowledges	Number Comparison (NC)	33	6 1/2
	Filing and Alphabetizing (FA)	20	3
	Proofreading (PROOF)	25	7
	Following Directions (FD)	25	7
Verbal Skills and Knowledges	Vocabulary (VOC)	39	5
	Sticht Reading Tests[a]		
	Reading Test A (RT-A)	20	5
	Reading Test B (RT-B)	5	2
	Reading Test C (RT-C)	8	4
	Reading Test D (RT-D)	17	8
	Reading Test E (RT-E)	14	3 1/2

[a]See (19) which describes these tests.

ENABLING SKILLS AND KNOWLEDGES TESTS

One test group consisted of four tests that measured certain basic arithmetic skills and knowledges:

(1) Number Recognition (NR). This test assessed basic arithmetic and reading skills. It consisted of presenting a number written out in letter form (e.g., EIGHT), and then providing, in a multiple choice format, five alternative numerical numbers. The student had to decide which of the alternatives was correct. At first glance, the required behavior may appear rather trivial. However, the test included items that had as many as six digits, and recognition was not always easy.

(2) Symbol Recognition and Operations (SR&O). This test required the student to perform all the simple arithmetic operations (addition, subtraction, multiplication, and division). In order to do this, he had to understand the symbols for these operations. For example, $4\overline{)28}$ had to be recognized by the student as a division operation. Then, he had to select the correct answer from the alternatives listed. Thus, there were two skills necessary for successful performance (recognition of the arithmetic operation symbol, and accurate performance of the operation).

(3) Fractions and Decimals (FR). This test measured the student's ability to distinguish between the values of fractions and/or decimals. In this test the student was presented with a set of five alternatives composed of all fractions, all decimals, or some of each. The student had to select the "smallest" value of the alternatives presented.

(4) Word Problems (WP). This test assessed the student's ability to perform simple arithmetic operations in order to solve problems that were presented in narrative form. Thus, reading comprehension skills were also involved. Most of these problems were related to the Supply area, and all were Army-oriented. After he read each problem, the student had to select the correct answer from the alternatives presented.

Two "aptitude-like" tests were developed, to assess certain basic clerical skills and knowledges:

(1) Number Comparison (NC). This test assessed the ability of students to accurately compare a given number, several digits long, with other similar numbers of the same length, in order to find a "match." This skill is relevant to many of the "editing" tasks learned in the 76P20 course, such as checking 11-digit Federal Stock Numbers (FSNs) which are frequently used.

(2) Filing/Alphabetizing (FA). This test assessed knowledges regarding the correct letter sequence to employ when listing items in alphabetical order. The student was provided with five similarly spelled items of equipment, or topics of military interest. Then he was asked to select the item that would come *first* if he were to order these words alphabetically. This knowledge is of particular importance in the Supply area, where many indices, catalogs, and files are organized alphabetically.

One enabling skills and knowledges test was concerned with verbal ability:

Vocabulary (VOC). This test was formatted as a typical multiple-choice vocabulary test. The only difference was that the items were Supply area-related words (e.g., requisition). For each word presented to the student, he had to select the word or phrase that came closest in meaning. Thus, the test assessed the level of knowledge in the MOS vocabulary that the student had when he entered the course. It was assumed that this should have had a direct relationship to the learning rate in the course.

CONTENT-RELATED TESTS (MINI-LESSON/TESTS)

This type of instrument is, in reality, a miniature learning situation (15). In general, a situation to be encountered later in the course was simulated in a miniaturized form and presented to the student. A small amount of instruction in each task was given to the student, who then had to take a "test" on what he had just learned to do.

Two 76P20 content-related tests, which emphasized certain "clerical" behaviors, were developed:

(1) Proofreading (PROOF). This mini-lesson/test instructed students and then measured their ability to edit parts of Army Supply documents (forms). This task is an important one in the 76P20 course. A form with certain entries was presented to the student. Below this first form, another containing similar information was shown. The student's task was to determine whether the information was recorded properly on the second form, by comparing the entries with those on the first form. In some cases the student needed only to state whether each entry was correct or incorrect, in other cases he was expected to be more explicit. A multiple-choice format was used.

(2) Following Directions (FD). This instrument assessed a student's ability to follow step-by-step instructions in recording information. A Supply form was presented to the student. His job was to select the correct information and enter it in the correct space on the form, according to the written instructions provided. Thus, reading comprehension skills were also critical to this task.

STICHT READING TESTS (A-E) (RT-A THROUGH RT-E)

Although grouped together in Table 3 as verbal-related instruments, the Sticht Reading Tests required the use of skills other than reading (e.g., "searching" behavior, simple arithmetic, and alphabetizing). These tests are grouped in the "mini-lesson/test" category because a "learning" experience was included in each situation. The same general procedure was followed for each test, but there were variations in the content, the number of items, and the time limits required for completion. In each situation, a portion or extract of an Army document (e.g., Army Regulations, catalogs) was displayed on the left side of a folder. The specific task to be performed was then described, and an example was provided. Answers were to be written on the answer sheets attached to the right side of the folder. Five such instruments were used. The content of all were in the Supply area, but none was directly related to the 76P20 course.

TEST BATTERY TRY-OUT

Once the instruments described above were constructed and organized into the three groups shown in Table 3, pilot testing was conducted at HumRRO Division No. 1 (Alexandria) and at QMS. The main purpose of these administrations was to set time limits for each of the tests in the battery. The shortest time it took anyone in the pilot group to complete the test was used as the time limit for that instrument. Since all those in the pilot group were of above average ability, it was assumed that at least 90% of the students in the population would not complete the test in that time.

These pilot try-outs also permitted a "shake-down" of the administrative requirements of the battery. Necessary changes were made to the ambiguous items on the tests and to any unclear instructions. The test battery was then printed and preparations were made for its administration.

ADMINISTRATION OF TESTING PROGRAM

The first predictive test battery was administered in 1971. The students who participated in the 76P20 course at that time were approximately 60% draftees and 40% Regular Army and National Guard members.[1]

Arrangements were made with QMS personnel to set aside a classroom for the approximately two hours required for testing. Students reported in at Fort Lee on a Friday and were tested on the following Wednesday morning.

As they arrived in the classroom, students were given all the necessary materials. The HumRRO staff member then read a general set of instructions. Some of the points made in these directions were the following:

(1) Students' performance on the tests would not affect their progress in the course or in the Army.
(2) They should work as rapidly and as accurately as possible.
(3) Each test had a time limit and no one was expected to complete all of the items on each test.
(4) They should "guess" in a multiple-choice situation only if one or more of the choices could be eliminated, as there would be a penalty for incorrect responses (this statement was inserted to minimize guessing, even though the *total number correct* was used as the index for predictive purposes).

The first section of the test battery (Arithmetic Skills) was then presented. Instructions were read and the example item worked on by everyone. This procedure was followed for each test in the battery. After the Arithmetic Skills section was completed, the students were given a ten-minute break. Then the Clerical Skills section was presented, followed by another ten-minute break. Finally, the third section (Verbal Skills) was administered. The Sticht Reading Tests were presented with a prefatory statement that prepared the students for their probable unfamiliarity with this type of test. The time limit of each test was rigidly enforced.

After completing the testing program, students entered the 76P20 course.

SELECTION OF CRITERIA

At the time this study was being performed, no instructional segment of the course had been completely self-paced. Therefore, the same criteria used in Phase I (i.e., time to complete Annex A and B PEEs) were employed. However, Annex A or Annex B PEE total time could not be used as a criterion because only 15% of the students in Phase II participated in all PEEs. Therefore, individual PEE scores were employed in the analyses in this Phase.

COLLECTION OF WITHIN-COURSE DATA

The same procedures used in Phase I were again followed. Arrangements were made with the instructors to collect the criterion data (Annex A and B PEE times and scores). The need to be accurate in making these recordings was emphasized repeatedly. Also, as before, background data were obtained on all students.

[1]These proportions stayed essentially the same through Phase III.

ANALYSIS OF DATA

As in Phase I, correlation matrices were computed. However, *total* PEE time and performance were included among the variables. Although five 76P20 classes were used in this Phase (N = 151), only 20 students had scores for all Annex A PEE components. Thus, the analyses concentrated on PEE components, *one* at a time.

DEVELOPMENT OF PREDICTIVE EQUATIONS

Stepwise multiple linear regression analyses (20, 21, 22) were performed on the data to derive the predictive equations. This is a technique that selects variables for a linear regression equation, one at a time. It begins with a simple correlation matrix, and enters into regression the predictor variables most highly correlated with the criterion variable. A *linear equation* is produced, which includes a *regression coefficient* that is to be multiplied to the *value of the predictor variable*, plus a *constant*.

This analysis also provided a test *(Partial F*—Analysis of Variance) of the "significance" of the variables in the equation. This was, in fact, a test of the significance of the regression coefficients. (Was the "true" regression coefficient significantly different from zero?) If, at a given confidence level, the null hypothesis could not be rejected, then the regression coefficient was assumed to be *zero*. A zero coefficient, multiplied to a given predictor value, would result in *zero* or *no* contribution of that variable to the equation. The variable would thus be prevented from entering the equation.

Another way of looking at this procedure is in terms of the correlation coefficient. In the case of the first variable to enter the equation, it is a *simple correlation coefficient*. With more than one predictor, a multiple R is calculated. The coefficient of determination (R^2) indicates the portion of the variance in the criterion variable distribution accounted for by a given predictor variable (shared variance common to both variables). After the stepwise multiple regression analysis selects the predictor variable that is most highly correlated with the criterion variable, it then selects that variable which, when combined with the first, is the most useful—that is, the one that adds the most to the multiple correlation coefficient, and that yields the best two-predictor equation from among the possible equations containing the first variable selected. A partial correlation coefficient is calculated for each of the predictor variables. The second variable to enter the equation is the one with the highest *partial* correlation with the criterion variable. However, it will enter the equation only if the *partial F* test for that variable is significant at the probability level selected.

The technique then selects (by the same criteria) the variable that, combined with the first two variables, produces the best three-predictor equation. Subsequent variables are selected in a similar manner. Variables can also be removed if they are found to be no longer useful. This is done by evaluating each variable's contribution as if it had entered last. Any variable that provides a non-significant contribution is removed from the equation. This process is continued until no more variables will be admitted to the equation and no more will be rejected. The process then terminates and presents the last "best" regression equation, given the imposed constraints (i.e., when adding the most useful remaining variable produces no statistically significant increase in the multiple correlation according to a pre-selected confidence level). An example of the output of such a computer analysis is shown in Appendix A.

After several attempts using the least restrictive level, it became clear that an optimum approach to employ in selecting the appropriate confidence level was as follows: A confidence level of p = .80 was used by the computer program to allow variables to enter or leave an equation. In some cases the computer program generated an equation with 10-12 predictors in it. Following the selection of the "best" equation by the computer program, a visual inspection and screening was made at the .95 level of confidence, for the purpose of obtaining an equation with a smaller, more efficient set of variables.

In this Phase, equations were generated to predict each PEE time and performance score. As stated above, no total time criterion was obtained. Therefore, different sets of trainees were involved in each separate regression equation. An examination was made of the *order of entry* of each of the variables into the predictive function, to see whether any commonalities existed from one PEE criterion to another. In this way, an indirect attempt was made at determining the more probable "important" predictors.

On the basis of these observations, plus careful scrutiny of the correlation matrices, several variables stood out as highly probable "important" predictors. These were as follows:

For Predicting Time Scores	For Predicting Performance Scores
Symbol Recognition and Operations	Symbol Recognition and Operations
Reading Test A[2]	AFQT
Reading Test D[2]	Arithmetic Reasoning (ACB)
Following Directions	Verbal (ACB)
Vocabulary	Proofreading
Arithmetic Reasoning (ACB)	

As this list shows, there are some tests that were appropriate for performance *and* time (SR&O, AR), whereas others were more related to one criterion than another. In predicting time scores, the tests in Predictive Test Battery 1 did much better than the ACBs. However, the ACBs did as well on performance. This should not be surprising as the HumRRO-developed tests were designed to predict learning *time.*

SUMMARY OF FINDINGS AND CONCLUSIONS

The following conclusions were drawn from the analyses in Phase II:

(1) The HumRRO-developed test scores correlated more strongly with time in Annex A and B PEEs, than did the ACB scores.

(2) The Fractions and Decimals test did not show any predictive utility and was dropped from further consideration.

(3) Stepwise multiple linear regression analyses were employed in the development of predictive functions and the determination of potentially useful predictors.

[2] The sum of scores on all five reading tests was the most powerful correlate with criterion (time).

Chapter 4

PHASE III - PREDICTIVE TEST BATTERY 2

DEVELOPMENT

Although Predictive Test Battery 1 was Supply-related (in terms of the broad content area), an attempt was made in this Phase to develop instruments that were more *directly* related to the course undergoing individualization (MOS 76P20). This activity involved a very detailed examination of the instructional materials so as to identify specific objectives that could be sampled in Test Battery 2. To assess capabilities relative to these objectives, additional content-related tests were developed. The various test components of Predictive Test Battery 2 are described below.

CONTENT-RELATED TESTS (MINI-LESSON/TESTS)

At the time of Phase III (late FY 1972) the Stock Control and Accounting Specialist Course (76P20) was divided into three instructional annexes (see Table 4, which shows current structure of the 76P20 course). Annex A had six subsections; Annex B had six subsections; Annex C (since changed to D)[1] had four subsections. The results of Phase II indicated that the Sticht reading tests were potentially useful predictors. It would be logical, then, to replace the original tests *only* with other similar instruments that contained tasks that were clearly representative of the tasks that students would learn to perform in the 76P20 course. As a number of modifications were being made at that time to Annex C (ASDA Accounting Procedures), no predictive instruments were developed that related to that portion of the content.

The basis for developing the ten mini-lesson/tests (labeled "Reading Tests 1-10") was the instructional material in Annexes A and B. The course objectives were determined from the tests, on which the students were graded during, and at the end, of the course. In other words, the approach was to find out what the students had to know in order to pass the course, and from that point develop the mini-lesson/test situations.

As the first segment of the course to be individualized was in Annex B, a large mini-lesson/test was constructed (PEB) to sample the behaviors associated with that Annex. This test specifically covered tasks in the individualized portion (B-3) of the Annex. For this reason, the PEB was expected to be a good predictor of student performance in B-3. In format, it was similar to the other 10 mini-lesson/tests in this section of the battery.

ADDITIONAL ENABLING SKILLS AND KNOWLEDGES TESTS

One additional clerical skills and knowledges test was constructed for Predictive Test Battery 2:

Abbreviations (ABBREV). This instrument measured the student's ability to recognize common abbreviations used in documents or forms for the 76P20 course.

[1] With the inclusion of the Mechanized Stock Control section as Annex C, ASDA Accounting Procedures was relabeled as Annex D.

Table 4

76P20 Course Instructional Content by Subject[a]

Annex	Major Topic	Sub-Topic
A	Establishing a Stock Record Account	• Establishment of a Technical Library • Verification of Equipment Density Lists • Review of Prescribed Load Lists • Compilation of an Authorized Stockage List • Preparing Stock Accounting Records • Editing Request Documents
B	Management of Stock Records	• Processing Non-Stocked Item Request Documents • Processing Low Priority ASL Requests • Processing High Priority ASL Requests • Processing Inventory Documents • Processing Excess Property • Accounting for Class Using 1005 IX Repair Parts System
C[b]	Mechanized Stock Control at DSC	• Purification of Manual Records • Conversion (Data Preparation) • Document Processing • Systems Programs • Equipment Familiarization
D	ASDA Accounting Procedures	• Processing Requisitions and Requisition Modifiers • Processing of Follow-up and Cancellation Documents • Processing Replenishment Documents • Processing Material Adjustment Documents

[a]Extracted from U.S. Army Quartermaster School, *Program of Instruction for 551-76P20 - Stock Control and Accounting Specialist, MOS: 76P20*, February 1972.

[b]This annex was formerly a separate course and only recently was incorporated into the 76P20 Program of Instruction. For this reason, no course-related predictive measures had been developed for this annex as of the date of this report.

"AFFECTIVE" INSTRUMENTS

In addition to the skills and knowledges tests, a set of "affective" factors considered important in the prediction of classroom behavior were assessed by Test Battery 2. These "motivational" characteristics have been described in the literature as contributing to classroom performance. However, they are not easily measured. An attempt was made in this study to devise several instruments that would get at this "affective" dimension, and thus improve the predictive equations that incorporated these factors. These instruments are described:

(1) Spare Time Interest. This consisted of a list of 15 spare time activities. The activities ranged from passive ones such as watching TV or listening to the radio, to more active ones such as playing sports or fixing things. The student was asked to *rate*, on a seven-point scale, his *interest* in participating in the various activities. (The range of this scale was from "complete disinterest" to "complete interest" in performing a particular activity.) In addition, the trainee was asked to *rank* the 15 activities from "Most Preferred" to "Least Preferred". This instrument served as an *indirect* assessment of instructional media preference (as the course was to have a multi-media format).

(2) Method of Instruction. This instrument, consisting of a list of 10 instructional methods, was similar to the one just described in that it required the student to make both *ratings* and *rankings*. With this instrument, however, the student was asked to *directly* rate the various means by which instruction might be presented to him. (e.g., programmed text, lecture). Again, a seven-point scale was used, ranging from "dislike completely" to "like completely." He was then asked to *rank* the ten instructional methods in order of preference.

(3) Definition Preference. This instrument might best be described as an *indirect* measure of the preference of students for the subject matter areas covered in the Stock Control and Accounting Specialist course. The student was shown a word that has four valid definitions, one of which was Supply-related. He was then asked to order the four alternatives in terms of his preference (Number 1 was used for the most preferred and Number 4, the least preferred). The critical score was the number given to the Supply-related definition. Scores could then be related to actual course performance. This instrument contained a total of 20 words, each with their alternative definitions.

(4) Supply Activity. This test consisted of 15 paragraph descriptions of the important tasks that would be covered in the course. The student was instructed to read each paragraph, and *rate* it according to his interest in performing that activity. He used a seven-point scale ranging from "complete disinterest" to "complete interest." When he finished this part of the test, he was asked to rate *how well* he thought he would perform during the course on each of the 15 tasks. A five-point scale ranging from "fail" to "excellent" was used for this level of aspiration measure.

The 76P20 course was to be developed as a "multi-media" program. That is, both programmed text and AV (slide/tape) versions of the instruction were to be prepared. In order to better predict learning rate in the slide/tape mode, an attempt was made to develop "AV"-related tests. This was accomplished by converting two of the reading tests, Reading Test-4 and Reading Test-8, to Listening Test-A and Listening Test-B, respectively. The student was provided with the reference information on the left hand side of the folder as in the reading tests. Now, however, the questions were presented by means of a tape recorder. Each question was repeated twice, and then the tape was stopped. The student answered the question on his answer sheet and raised his hand as soon as he had finished the item. When two-thirds of the class had raised their hands, the tape was started for the next item of the test. No time limit was imposed on either test. However, Listening Test-A required approximately *seven* minutes and Listening Test-B about *six* minutes to administer.

The tests in Predictive Test Battery 2 are listed in Table 5, along with their time limits and the number of items in each instrument. Several minor changes were made to the tests that remained from Test Battery 1. Mainly, these consisted of deleting, adding, or substituting items to make the tests more course-related. Also, the directions to the student were revised to make them clearer. A comparison of Table 3 with Table 5 shows the changes in the number of items or in the time limits of these tests. Pilot groups were run again to determine the new time limits, using the same procedure followed for Predictive Test Battery 1.

ADMINISTRATION OF TESTING PROGRAM

The second test battery was administered late in FY 1972. By this time the QMS had instituted its version of "zero week," which meant that details and other duties were to be performed during the first week that the trainee was on post. Following this first week, he would be in an academic status, not to be removed for extraneous jobs. However, execution of this principle did not always meet original expectations. Arranging

Table 5

Predictive Test Battery 2—Supply Course (76P20) Related

Test Type	Test	Number of Items/Entries	Time Limit (Minutes)
Arithmetic Skills and Knowledge	Number Recognition	24	2
	Symbol Recognition and Operation	50	8
	Word Problems	24	11
Clerical Skills and Knowledge	Number Comparison	33	6
	Filing and Alphabetizing	20	3
	Proofreading	25	7
	Following Directions	25	7
	Abbreviations	48	3 1/2
Verbal Skills and Knowledge	Vocabulary	39	4
	Reading Test-1	20	7 1/2
	Reading Test-2	23	4 1/2
	Reading Test-3	6	2
	Reading Test-4 (LT-A)[a]	21	–
	Reading Test-5	10	3 1/2
	Reading Test-6	17	8
	Reading Test-7	9	2 1/2
	Reading Test-8 (LT-B)[a]	12	–
	Reading Test-9	9	3 1/2
	Reading Test-10	12	1
	Practical Exercises-B	29	12 1/2
Affective	Spare Time-Interests (Rating and Ranking)	14	None-(10)[b]
	Method of Instruction (Rating and Ranking)	10	None-(5)[b]
	Definition Preference	20	None-(15)[b]
	Supply Activity (Rating, Ranking, and Level of Aspiration)	15	None-(10)[b]

[a]Originally constructed as reading tests, RT-4 and RT-8 were put on tape and used as Listening Tests A and B, respectively.

[b]No time limits imposed on these tests. Average time required to complete each test is in parenthesis.

for test administration was difficult during "zero week" as the trainees were under the auspices of the Brigade Commander, not under QMS academic department personnel. Also, as can be seen in Table 5, Test Battery 2 was considerably longer than Test Battery 1. Approximately four hours were needed for testing, and this time was difficult to obtain.

The trainees were tested in the afternoon. Ten-minute breaks were given at the end of each of the first three sections of the test battery. The general instructions that were read to the students were similar to those described under Test Battery 1. The "Affective" tests were all self-paced and given at the end of the session. That is, after completing the verbal skills tests, individuals were told to complete the "Affective" instruments at their own pace, after which they could leave.

SELECTION OF CRITERIA

The first segment of the 76P20 course was individualized during this Phase of the study. This course segment is referred to as B-3 (the third section of Annex B). The question arose as to what would be the appropriate time scores to use as criteria for predictions. Although *totaal time* in the entire course is the ultimate criterion, there was no evidence that *total time* in the B-3 segment was reflective of the course as a whole. Therefore, a decision was made to initially use multiple criteria, and then empirically determine which functions had the greatest utility.

The B-3 course segment was composed of five instructional modules, an ungraded comprehensive practical exercise (CPE), and a graded practical exercise (PEE). The instructional modules were presented by means of a programmed text or slide/tape (Kodak Carousel 650 projector coupled with a Norelco cassette tape recorder).[2] Each module also had a practical exercise segment in which the student could check his own state of proficiency. He could then go on to the next module or, if necessary, repeat a module. QMS instructional monitors would assist the students if any mechanical problems occurred with a given tape or slide unit.

The STOCK staff and QMS personnel responsible for developing and administering the self-paced course prepared recording forms to be used in the administration of this course segment. The start and stop times for each module, CPE, and PEE were recorded, along with the time taken for breaks by the student. Various combinations of these times served as the criteria in attempts at prediction. However, the most useful criteria were:

- The sum of the times in all five instructional modules = *Instructional Time*;
- Instructional Time plus CPE and PEE time = *Total Time*.

COLLECTION OF WITHIN-COURSE DATA

The within-course PEE times and scores collected during Phase II continued to be collected in this phase. The ultimate "course-related" predictor is, by definition, an earlier section of the course. It was expected that the PEE segments in Annex A and the first one (B-2) in Annex B (prior to the individualized course segment) would increase the predictive accuracy of the equations that were generated using these factors. Thus, equations were derived both with and without these previous course segment scores.

ANALYSIS OF DATA

As in the previous Phases of the study, correlational and stepwise multiple linear regression analyses were performed upon the data. However, valid criterion variables (time scores from an actual self-paced course segment) were employed in this Phase for the first time. Predictive functions were developed, using the regression analysis technique described previously, and then evaluated.

[2] Identification of products is for research documentation purposes only; this listing does not constitute an official endorsement by either HumRRO or the Department of the Army.

EVALUATION OF PREDICTOR VARIABLES AND EQUATIONS

Initially, equations that used *all* of the data for *all* of the students were generated. One surprising finding was a very low multiple correlation coefficient, $MR = .31$ (N = 133). In Phase II, most of the multiple correlation coefficients obtained with Predictive Test Battery 1 upon PEE scores were in the .6 to .7 range. How could a *more* course-related group of predictors produce a *smaller* association with criteria?

In the resulting investigation, the data were grouped along several dimensions. By grouping the data into the *mode of instruction received* (AV or PI-text), a startling increase in association resulted. This occurred *across* classes, thereby increasing confidence in the finding. Instead of a multiple correlation of .31, multiple correlations of .67 and .75 resulted when using the data for AV (N = 47), and PI-text (N = 80) groups, separately.

Thus, in order for accurate predictions to be made in an individualized classroom, the instructional situation (mode/media) is critical for determining learning rate, when there are significant differences in training time depending upon mode of instruction. This finding is supported in the literature cited earlier (15, 16). The results indicated that the AV-instructed students completed the course segment more rapidly ($\overline{X}_{AV}$ = 10 hours) than those receiving PI-text ($\overline{X}_{PI}$ = 12 hours). As these two populations differed significantly, a different predictive function was needed for each group. It should be noted that, although the PI-text group required 12 hours for this course segment, this was still considerably less time than that allocated in the conventional course (16 hours).

Table 6 lists the "best" predictive equations developed during this Phase of the study. Two sets of equations were developed—one set for AV-instructed students, and a second set for those who received their instruction in the PI-text. Most general aptitude measures (ACBs) did not enter significantly into these functions. However, the AFQT score was a significant component of each of the equations. As can be seen in Table 6, the predictors that contributed most to the equations were some of the previous PEE times in the course. For example, the A-3, A-5, and B-2 times were the most important predictors in Equations 3 and 4. The fact that previous within-course component times were highly significant supports the hypothesis of course-relatedness providing the "best" prediction of completion time.

The "best" functions that *did not include* previous course component times are presented as Equations 1 and 2. In short courses (under eight weeks), it is necessary to make completion time predictions prior to the start of the course. The only equations that can be used in that situation are those that contain *extra-course* variables. Thus, only the factors in Predictive Test Battery 2 and the student's background data were used to develop Equations 1 and 2. However, Table 6 indicates that, if a prediction can legitimately be made during course participation, earlier course component times should be employed in the derivation of the predictive function.

Another finding of interest was that Total Time was not as accurately predicted as the Instructional Time of the segment. For example, although the multiple correlation for the PI-text group was .85 using Instructional Time as the criterion, it only reached .78 with Total Time as the criterion. This depressive effect (see findings in Table 7) may be due to the test-taking portion of the Total Time criterion. To check on this, the "best" predictors uncovered by the regression analyses on Instructional Time and Total Time were used to predict "test-taking time." The resulting *MR*s varied between .3 and .5. When a different set of predictors were employed in the regression analysis on test-taking time (PEE time), the *MR*s were up to .65.

Table 6

"Best" Predictive Equations Selected in Phase III

Predictions To Be Made Prior To Entry In Course

(1) For PI-Text Group

$Y = -.0646A - .2909B - 1.1235C - .1606D + 37.678$

Key: Y-Training Time (days) — Standard Error = 3.778 (days)
A-AFQT
B-RT1 — *MR* = .74
C-RT3 — N = 81
D-PEB

(2) For AV Group

$Y = -.0774A - .2055B - .0978C + 32.595$

Key: Y-Training Time (days) — Standard Error = 3.533 (days)
A-AFQT
B-NC — *MR* = .65
C-VOC — N = 52

Predictions To Be Made During Training

(3) For PI-Text Group

$Y = -.0553A - 1.0781B + .1807C + .0786D + 14.93$

Key: Y-Training Time (days) — Standard Error = 3.006 (days)
A-AFQT
B-RT3 — *MR* = .85
C-A-5 (PEE) Time — N = 67
D-B-2 (PEE) Time

(4) For AV Group

$Y = -.0722A + .1111B + .1274C + 11.704$

Key: Y-Training Time (days) — Standard Error = 2.08 (days)
A-AFQT
B-A-3 (PEE) Time — *MR* = .87
C-B-2 (PEE) Time — N = 47

A further investigation needs to be made to uncover the reasons behind this reduced capability to predict test-taking time. However, even with PEE time included, the resultant *MR* of .78 with Total Time compares quite favorably with the results of other studies involving training time predictions. These findings have shown that the content-related variables of Test Battery 2 are better predictors of "time-to-learn" than the general aptitude measures, thus confirming the results obtained in Phase II.

Table 7

Multiple Correlations Obtained With Instructional Time and Total Time in Course as the Criteria for Predictions

Prediction	Criterion			
	Instructional Time		Total Time	
	PI-Text Group	AV Group	PI-Text Group	AV Group
Prior to Entry Predictions (without course component time scores)	.744 (N = 81)	.650 (N = 52)	.671 (N = 76)	.634 (N = 52)
Within-Training Predictions (with course component time scores)	.852 (N = 67)	.871 (N = 47)	.780 (N = 76)	.824 (N = 52)

The tests within Predictive Test Battery 2 that contributed significantly to the functions developed and used in this Phase, are listed below:

Number of recognition (NR)
Symbol Recognition and Operations (SR & O)

Number Comparison (NC)
Proofreading (PROOF)

Vocabulary (VOC)
Reading Test 1 (RT1)
Reading Test 2 (RT2)
Reading Test 3 (RT3)
Reading Test 6 (RT6)
Reading Test 7 (RT7)
Reading Test 10 (RT10)
Practical Exercise B (PEB)

Supply Activity - Rating and Level of Aspiration

DEVELOPMENT OF PREDICTION DISPLAY TECHNIQUES

PREDICT Computer Printouts

One of the reasons for developing the predictive system described in this report was to provide training managers with information they could use for administering a self-paced training program. A computer program was written to display this predictive information in a useful format. The program (labeled PREDICT) displays each student's estimated completion date (see Figure 1).

This was accomplished by applying each predictive equation to the data base from which it was derived. As the criterion data consisted of the time (in minutes) within the *B-3* course segment, a conversion factor was used to extrapolate these estimates into *days*. For example, there are 31.25 training days scheduled in the standard course for instruction in academic subjects. Instructional Time in B-3 is 720 minutes. Total Time

PREDICT Computer Display Printout

(THIS IS AN ESTIMATE OF HOW WELL WE COULD PREDICT COMPLETION TIME EXTRAPOLATED
FROM B-3 DATA (AV-MEAN=22 DAYS) FOR CLASSES 101-127)

PROBABILITY OF COMPLETION TIME BEING WITHIN GIVEN CONFIDENCE INTERVAL

	NAME		99%	95%	90%	80%	70%	50%		
1	TRAINEE A	101	16-29	17-27	18-26	19-25	20-25	21-24	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	22 21
2	TRAINEE B	101	13-26	15-25	16-24	16-23	17-22	18-21	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	20 20
3	TRAINEE C	101	16-29	18-27	18-27	19-26	20-25	21-24	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	23 20
4	TRAINEE D	101	13-26	14-24	15-23	16-22	16-22	17-21	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	19 21
5	TRAINEE E	101	20-33	22-32	23-31	24-30	24-30	25-29	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	27 28
6	TRAINEE F	101	12-25	14-24	15-23	16-22	16-22	17-21	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	19 18
7	TRAINEE G	101	18-31	20-29	20-29	21-28	22-27	23-26	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	24 27
8	TRAINEE H	101	16-29	17-27	18-26	19-25	20-25	21-24	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	22 23
9	TRAINEE I	101	16-29	17-27	18-26	19-25	19-25	20-24	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	22 21
10	TRAINEE J	105	18-31	20-30	21-29	22-28	22-28	23-27	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	25 23
11	TRAINEE K	105	14-27	16-25	16-25	17-24	18-23	19-22	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	21 18
12	TRAINEE L	105	18-31	20-30	21-29	22-28	22-28	23-27	ESTIMATED COMPLETION TIME= ACTUAL COMPLETION TIME=	25 24

Figure 1

(including CPE and PEE) in B-3 is 900 minutes. The conversion factors then were as follows:

For Instructional Time -

$$\frac{\text{Mean Predicted Instructional Time (in minutes)}}{720} = \frac{X}{31.25}$$

For Total Time -

$$\frac{\text{Mean Predicted Total Time (in minutes)}}{900} = \frac{X}{31.25}$$

In this way, the student's predicted time (in minutes) in B-3, was converted to *simulated* predictions of *days* within the entire course.

As can be seen in Figure 1, the PREDICT printout displayed the probability of obtaining a certain estimated completion time. This was based on the standard error of estimate (SE) statistic calculated in the multiple regression analysis. In Figure 1, the estimated completion time for Trainee B was 20 days. The probability that the estimated completion time was within the interval of 18-21 days was 50%; the probability that it was within 15-26 days was 99%. Information displayed in this manner could be used by training managers at QMS to estimate, with varying degrees of confidence, how much time each individual would spend in training. They could also estimate the completion time distribution for entire classes on the basis of this information.

For each person listed in Figure 1, both estimated and actual completion times are shown. The *predictive accuracy* of the functions used to generate the "estimated completion time" was assessed by applying each equation to the data base from which it was derived. Each student's estimated score was compared to his actual score and the *residual* error was determined. For example, if the estimated completion time was 18 days for a given student, and his actual completion time was 20 days, then the residual error was two days. By calculating the number of "hits" and the size of this residual error, the accuracy of each predictive equation could be ascertained.

Ideally, to validate an equation, it should be applied to a new sample. Although this approach would have been preferred, time restrictions and course development constraints did not permit the employment of such a controlled approach. Instead, a "split-half" simulation of such a validation design was used. That is, the data from half the students were used to generate an equation. Then the equation was applied to these students using the PREDICT program. The *MR* and residual errors were computed. The equation was then applied to the other half of the population. The resulting associations (*MR*s) and residual errors were compared with those from the first group, and these comparisons indicated the reliability of the particular equation and its component variables. Each of the equations were "validated" in this manner and the "best" equations were selected. These functions (shown in Table 6), had *MR*s that remained as high on the "new" individuals as they were on the data from which they were derived. Also, their predictive accuracy (as determined by the residual error comparison) did not diminish.

Nomographs

Although the PREDICT display program is an acceptable technique for training managers to apply to self-paced courses, access to a computer is required to produce the PREDICT printouts. There is a need for training managers at the QMS to be able to efficiently use the predictive equations, without the necessity of a computer.

Nomographs provide this capability. Nomographs are charts that express, in graphic form, the relationships that exist in a regression equation. The concept of presenting such relationships in nomographic form is not new and has been used widely in engineering (23, 24). However, its use in the behavioral sciences and education has been infrequent (25). The value of a nomographic representation of a predictive equation lies in its simplicity and the speed with which the information can be obtained by the user.

Two of the "best" regression equations selected in this phase were translated into nomographs (Figures 2 and 3). These nomographs—one for AV, the other for PI-text—permit the training manager at the school to determine the completion time for each student who has the scores required by the predictive equation. As each score is obtained, it can be entered in the appropriate scale and lines drawn in the appropriate sequence to the criterion line (completion time). All that is needed is a straight edge to draw the lines between the scales given on the chart. (The instructions for using each scale are presented in Figures 2 and 3).

As each nomograph is unique, the sequence of connecting the scales by the various lines, as well as all other instructions, needs to be presented within the chart itself. The nomographs presented in this report are *simulations* of the charts that will be developed with the total "individualized" 76P20 course. As only a course segment (B-3) was used to develop the techniques described in this report, the nomographs depict only extrapolations from the data that were obtained.

SUMMARY OF FINDINGS AND CONCLUSIONS

The critical findings in Phase III of the study were as follows:

(1) Course content-related predictors were better than general aptitude measures for predicting completion time in a self-paced course segment. This confirms the findings of Phases I and II.

(2) In order to estimate completion time accurately in an individualized multimedia instructional situation, the data needed to be grouped according to the instructional mode that was employed. This was shown to be the case when there were significant differences in the rate of learning by the media groups. Thus, *media-specific* predictive equations needed to be developed in those situations. This leads to the hypothesis that if the predictive instruments and the situation in which they are administered are more closely related to the *instructional* situation, predictions will be better. Further investigation of this hypothesis is needed. Evidence supporting it has been cited earlier (10, 15).

(3) Although general aptitude measures (the ACBs) did not enter significantly into the "best" predictive functions, the AFQT score was a significant component of several useful equations.

(4) The PREDICT computer program was developed for displaying the predictive information. It was considered to be a useful aid to training managers of self-paced training programs. However, it is limited in that it requires access to a computer facility.

(5) The use of nomographs to display predictive equations in a manner that can be used by training managers was successfully demonstrated. Nomographs are simple to use and do not require access to a computer. They are recommended for use in the prediction system at QMS.

(6) Although Instructional Time was adequately predicted by certain equations, test-taking time (as represented by the PEEs) was not. In fact, PEE time appeared to reduce the accuracy of predictions of Total Time, when *that* score was the criterion. Further investigation of this matter is needed.

Nomograph for Computing Predicted 76P20 Course Completion Times— Programmed Text Mode (Simulated)

Directions for Using the Nomograph

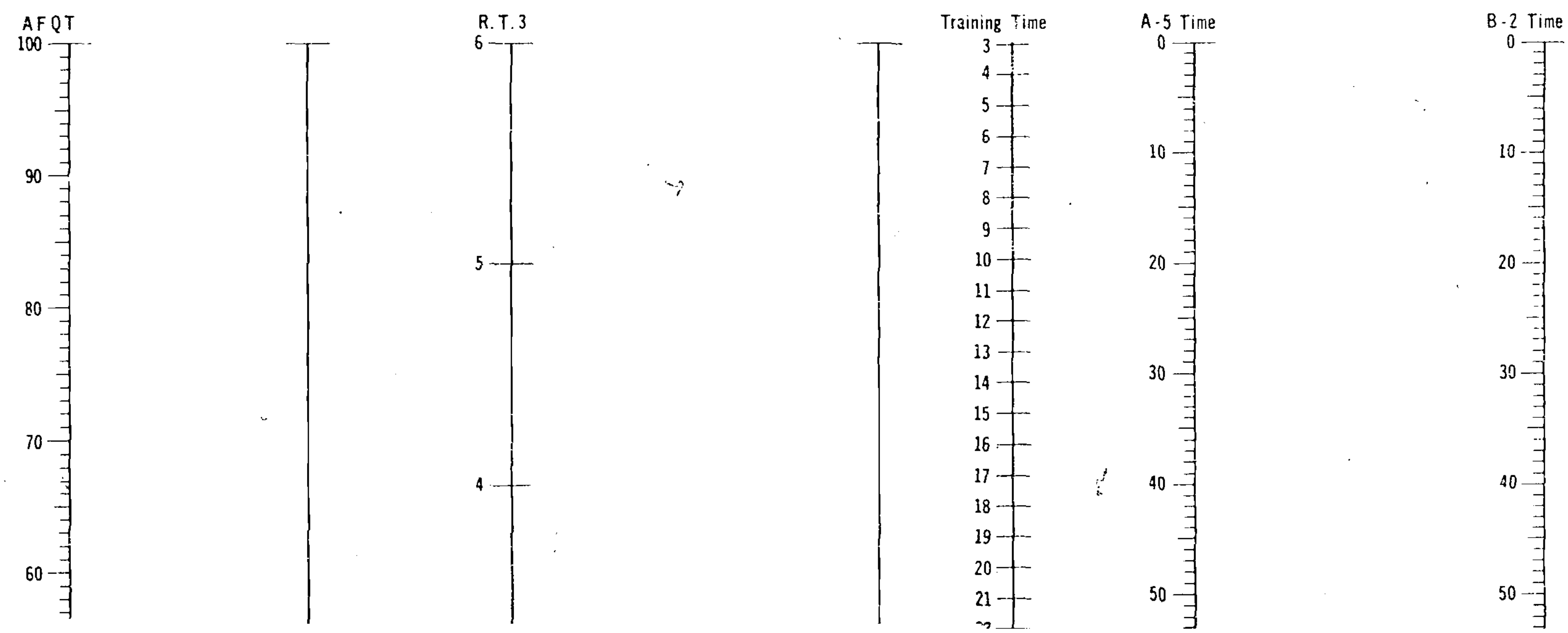
A key to the lettering of each scale will be found below the nomograph.
Each of the scales is labeled with the name of its corresponding measure.

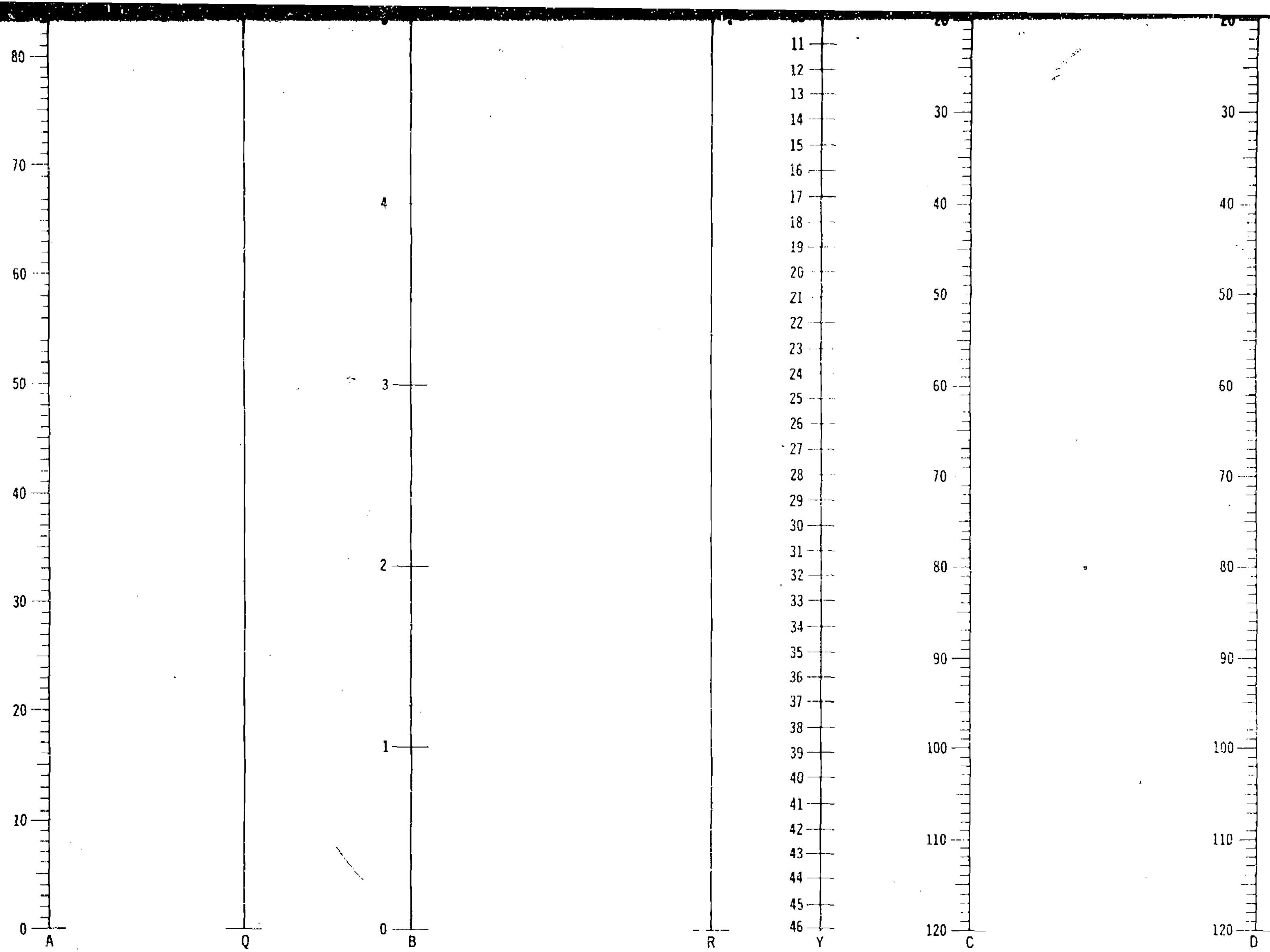
STEPS TO FOLLOW:

1. Locate student's AFQT score on the A scale. Mark this point with an "X".
2. Locate that student's R.T.3 score on the B scale. Mark this point.
3. Place a ruler on the nomograph so that the edge nearer you passes through these two points.
4. Draw a line between these points so that it crosses the unscaled Q line. Mark the point where it crosses the Q line.
5. Locate the student's A-5 PEE time on the C scale. Mark this point.
6. Place the ruler so that the point previously marked on the Q line is connected to the point on the C scale.
7. Draw a line between these points so that it crosses the unscaled R line. Mark the point where it crosses the R line.
8. Locate the student's B-2 PEE time on the D scale. Mark this point.
9. Place the ruler so that the point previously marked on the R line is connected to the point on the D scale.
10. Draw a line between these points so that it crosses the Y scale. Mark this point.
11. Read the value of the Y scale marking immediately below this point. That is the predicted number of training days for that student. (If the point falls exactly on a Y scale marking – use that value.)
12. You may wish to try out this procedure with the following example:

Student I: AFQT = 55
RT 3 score = 3
A-5 time = 80 minutes
B-2 time = 90 minutes

Predicted training time = 31 days.





Key to Scales

A – AFQT
B – R.T.3 (number correct)
C – A-5 PEE time (in minutes)
D – B-2 PEE time (in minutes)
Y – Predicted training time (in days)

This nomograph was constructed from the following regression equation:

$\underline{Y} = -.0553A - 1.0781B + .1807C + .0786D + 14.93$

Standard Error = 3.006 (days)
Multiple Correlation = .852
Based on 1971 data, N = 67

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Figure 2

Nomograph for Computing Predicted 76P20 Course Completion Times—Audio-Visual Mode (Simulated)

Directions for Using the Nomograph

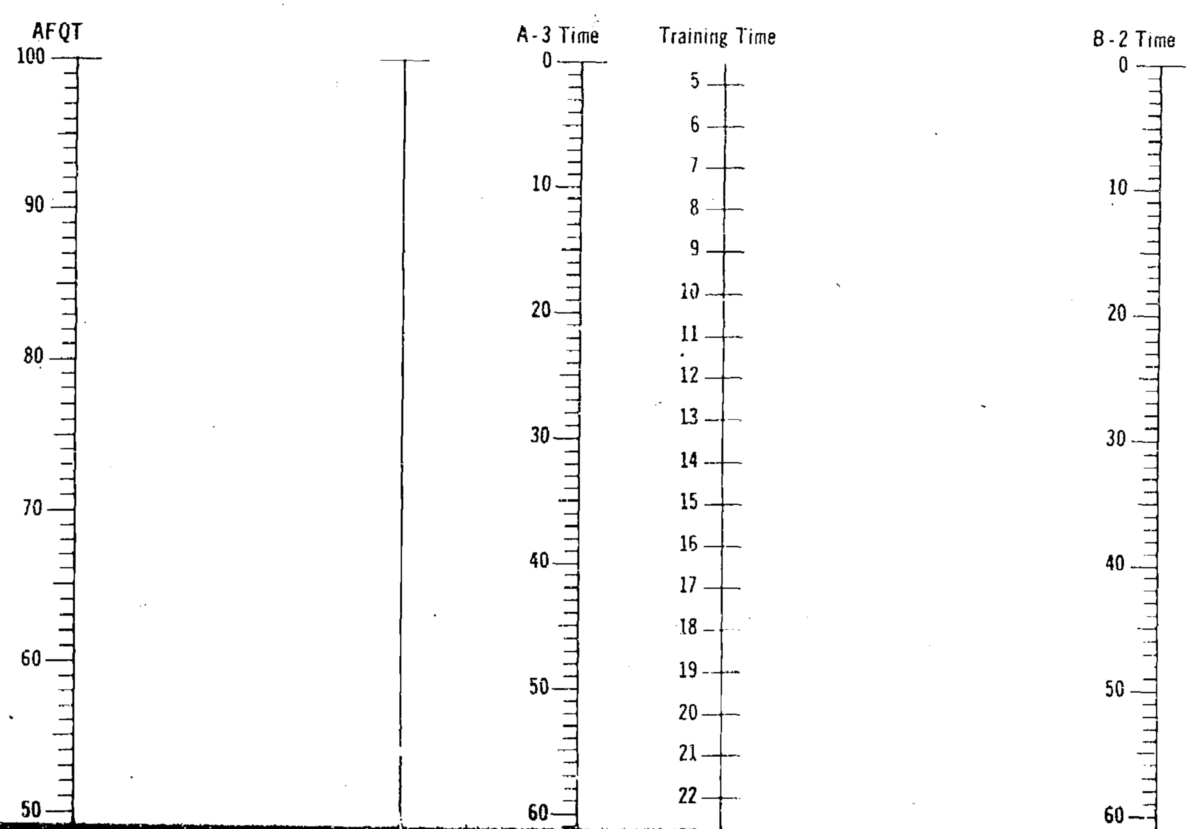
A key to the lettering of each scale will be found below the nomograph.
Each of the scales is labeled with the name of its corresponding measure.

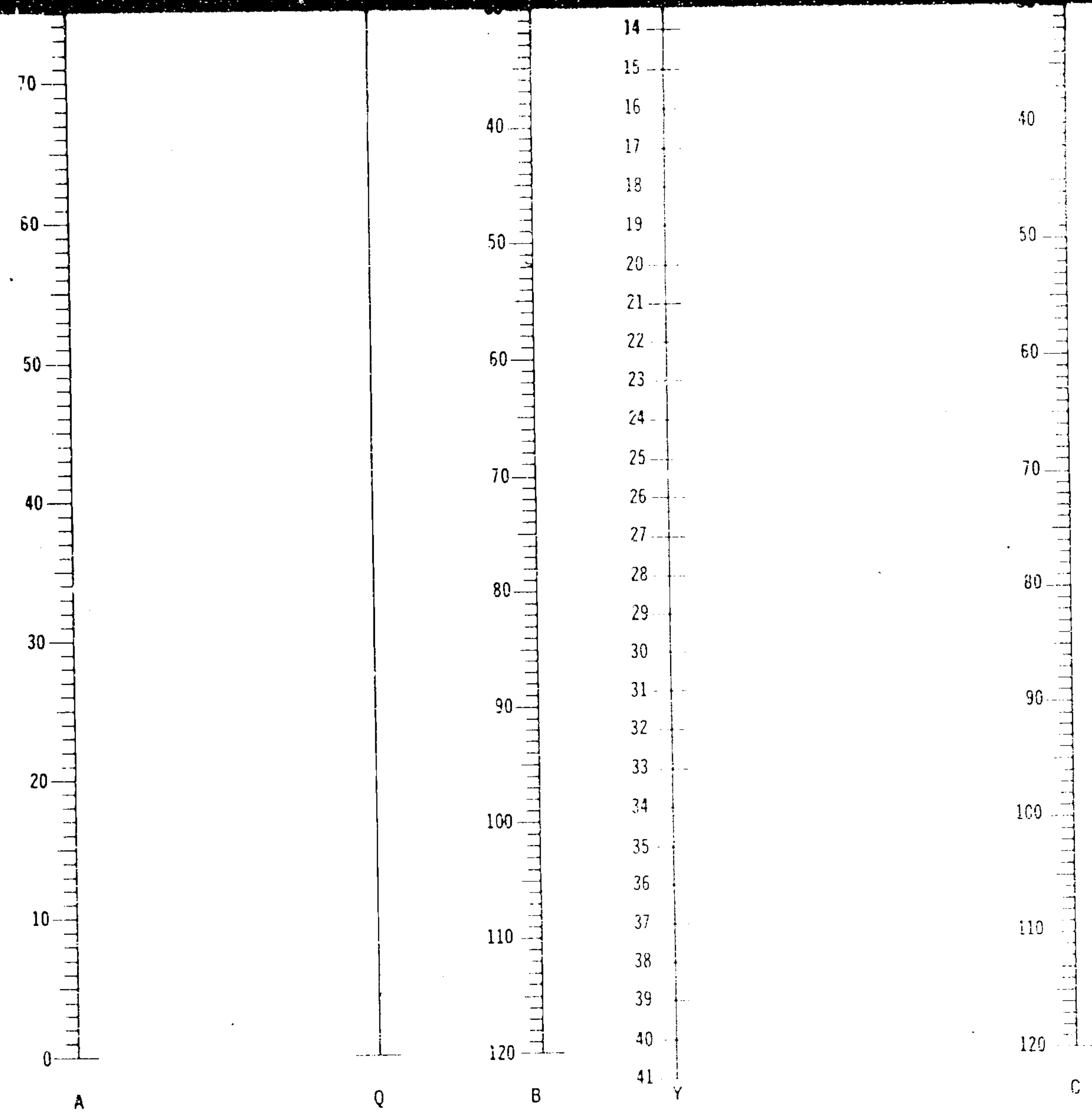
STEPS TO FOLLOW:

1. Locate a student's AFQT score on the A scale. Mark this point with an "X".
2. Locate that student's A-3 PEE time on the B scale. Mark this point.
3. Place a *ruler on the nomograph so that the edge nearer you passes* through these two points.
4. Draw a line between these points so that it crosses the unscaled Q line. Mark the point where the line crosses the Q line.
5. Locate the student's B-2 PEE time on the C scale. Mark this point.
6. Place the ruler so that the point previously marked on the Q line is connected to the point on the C scale.
7. *Draw a line between these points so that it crosses the* Y *scale.* Mark this point.
8. Read the value of the Y scale marking immediately below this point. That is the predicted number of training days for that student. (If the point falls exactly on a Y scale-marking – use that value).
9. You may wish to try out this procedure with the following example:

   Student X: AFQT = 65
   A-3 time = 20 minutes
   B-2 time = 50 minutes

   (Y) *Predicted training time = 16 days.*





Key to Scales

A – AFQT
B – A-3 PEE time (in minutes)
C – B-2 PEE time (in minutes)
Y – Predicted training time (in days)

This nomograph was constructed from the following regression equation:

$$\underline{Y} = -.0722A + .1111B + .1274C + 11.704$$

Standard Error = 2.08 (days)
Multiple Correlation = .871
Based on 1971 data. N = 47

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Figure 3

Chapter 5

PHASE IV - PROPOSED STUDY USING PREDICTIVE TEST BATTERY 3

Currently, the Annex D section of the 76P20 course is completely individualized. Instruction is presented in two modes (PI-text and slide/tape). Annex D is a significant portion of the program (2/7 of the academic training time in the conventional course). The criterion time scores to be employed in the next stage of the research effort will be, therefore, more indicative of the "ultimate" criterion—time in the total course.

The first problem that should be studied is the *feasibility* of obtaining *time* scores as predictors in a pre-test situation. As the results of Phase III have shown, the most course-related predictors (earlier course segment *times*) were the "best" predictors of completion time of the individualized segment. Therefore, for the next test battery, time scores *during* the testing session should be obtained in addition to the accuracy scores (number correct) that were previously collected. It is expected that there may be administrative problems in reliably obtaining these scores. The students would be instructed to record their own starting and finishing times for each test in the battery. A *digital* wall clock would be provided, to enable the students to record the required times.

Students would be told that the remaining time in the day would be free once they have completed the test battery. This should provide sufficient motivation for the student to work as efficiently and rapidly as possible. However, a situation that would not be reflected in the testing environment exists in the self-paced classroom. That is, in the course, if a student *fails* a given module, he can be recycled or repeat the instruction for that module, and then take that test over again. In a pre-test situation, this would be impossible. Therefore, no determination of a "failing" score for each test could be made in advance. All scores would be used in the development of the predictive functions.

The second major problem that should be studied is whether or not *instructional situation-related* scores are more accurate predictors than those obtained in Phase III under fixed-time conditions. Forms would be prepared for use by QMS instructional personnel for recording performance and time scores in the individualized Annex D segment of the course. Each of the instructional modules within Annex D contains both an instructional and PEE component as did the B-3 segment studied in the previous Phase. Thus, there could be D-2, D-3, D-4, and D-5 Instructional Time criteria as well as test-taking time criteria for each of these components. In addition, there is an Instructional Time component for D-1, a CPE component (D-6), and a PEE component (D-7). In addition such scores as Total Time in Annex D, could be used as criterion variables for equation development and the determination of predictive accuracy.

The predictors would consist of a refined and amended test battery, entry characteristic scores (AFQT, ACBs), and PEE scores and times in the first three course sections (Annexes A, B, and C).

As a result of the analyses in Phase III, Predictive Test Battery 3 was developed. Only those tests in Battery 2 that contributed significantly to the "best" predictive functions generated in Phase III were retained. In addition, four mini-lesson/test situations (PED-1, 2, 3, 4) were constructed to relate specifically to the Annex D portion of the course. These instruments were developed from the course objectives in each of the four major instructional modules in the Annex. A complete list of the tests to be used in Predictive Test Battery 3 is shown in Table 8.

Table 8

Predictive Test Battery 3 (Self-Paced)—Supply Course (76P20) Related, Refined and Amended

Test Type	Test	Number of Items/Entries
Arithmetic Skills and Knowledge		
	Number Recognition	24
	Symbol Recognition and Operation	50
Clerical Skills and Knowledge		
	Number Comparison	33
	Proofreading	25
Verbal Skills and Knowledge		
	Vocabulary	39
	Reading Test-1	20
	Reading Test-2	23
	Reading Test-3	6
	Reading Test-6	17
	Reading Test-7	9
	Reading Test-10	12
	Practical Exercises-B	29
Annex D Skills and Knowledges (Individualized portion of 76P20 in Course)		
	Practical Exercise - D(1)	83
	Practical Exercise - D(2)	82
	Practical Exercise - D(3)	77
	Practical Exercise - D(4)	82
Affective		
	Supply Activity (Rating and Level of Aspiration)	15

The major change in Battery 3 is the removal of time limits on each of the tests. This change requires an increased amount of written instruction. It also demands close monitoring of the students to ensure that they record all starting and finishing times for every test.

The same procedures used in Phase III for predictive equation development and evaluation would be employed in Phase IV. The "best" equations to be developed in this Phase would be compared for their accuracy with those developed in Phase III, to determine whether the additional administrative burden required to obtain time scores is "worth" the effort.

Other problems requiring study have been identified. Research is needed to determine the relationship between test-taking time and performance. Such data would indicate whether a linear prediction model is appropriate for use in predicting test-taking time. Recent studies (26) have questioned this assumption. Also, predictor instruments that validly reflect the AV instructional environment need to be developed. The student learns in a semi-enclosed carrel. He uses earphones attached to a tape recorder, and views a screen upon which slides are projected. To produce an "instructional situation-related" predictor, it is proposed that the students be permitted access to this environment during the testing session. Finally, a study needs to be performed to determine what kind of incentive system can be developed to enhance the predictive capability of the STOCK/PRISM test battery.

It is expected that approximately 200 students would be required for the proposed Phase IV research. By the end of FY 1973 the entire individualized 76P20 course is supposed to be completed. At that time, the utility and accuracy of the predictive functions and techniques generated by this research could be assessed.

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AND

APPENDIX

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Appendix A

EXAMPLE OF STEPWISE MULTILE LINEAR REGRESSION ANALYSIS

On the following pages are printouts of a stepwise multiple linear regression analysis that generated one of the predictive equations in Phase III.

On printout A-1 the result of the first step in the analysis is shown. At this point the variable that had the highest correlation with the criterion was entered into regression. This was the A-5 PEE time, which had a *.688* correlation with the B-3 Instructional Time criterion. The regression coefficient is listed along with the *t* value, which represents a test of significance of the regression coefficient.

On printout A-2, the second variable (RT-3) enters the equation. RT-3 had the largest partial correlation coefficient with the criterion of the variables remaining to be selected. That is, the second variable to enter was the one that added the most to the multiple correlation coefficient (in this case it raised it to *.806*). This yielded the best two-predictor equation from among the possible functions containing A-5 PEE time (the first variable that had been selected). Also presented in the printout are the beta coefficients, which provide an indication of the relative importance of each predictive variable within the equation. In the case of the two predictors presented on printout A-2, their contributions are about equal.

On printout A-3, the third step in the regression analysis is shown. The B-2 PEE time was selected as the variable which, when combined with the first two, produced the best three-predictor equation. Also, the *t* values for each of the predictors were above *1.96* (p = .95). This indicated that the multiple correlation coefficient was increased significantly at that level of confidence. In the same manner, the fourth variable (AFQT) is shown on printout A-4 as significantly entering the equation.

On the last printout (A-5), the fifth step in this process is displayed. RT 1 now enters the equation. However, the *t* value for RT 1 is below that selected as the cutoff (t = 1.96) when visually inspecting the results of the analysis. A cutoff of t = 1.28 (p = .80) was used *within* the program to permit variables, such as RT 1, to enter the equation. Such factors would not have done so with more stringent criteria. This approach was used to identify the variables that almost "made it," and were still worth considering. A comparison between the equation in printout A-4 and the one in printout A-5 shows that there was not much of an increase in the multiple correlation coefficient with the addition of the fifth predictor. Also, the standard error of estimate did not decrease greatly. A decision was then made to use the equation in printout A-4.

A-1

STEPWISE MULTIPLE LINEAR REGRESSION
PREDICTING B-3 INSTR TIME FOR CLASSES 101-127 (PI)

STEP NUMBER 1 ENTER A-5
STANDARD ERROR OF ESTIMATE= 92.228
MULTIPLE CORRELATION COEFFICIENT = 0.688
GOODNESS OF FIT,F(1, 65)= 58.3261
CONSTANT TERM= 100.2605

VARIABLE NAME	COEFF	STD DEV COEFF	T VALUE	BETA COEFF
A-5	7.0924	0.9287	7.6372	0.6877

A-2

STEPWISE MULTIPLE LINEAR REGRESSION
PREDICTING B-3 INSTR TIME FOR CLASSES 101-127 (PI)

STEP NUMBER 2 ENTER RT 3
STANDARD ERROR OF ESTIMATE= 75.847
MULTIPLE CORRELATION COEFFICIENT = 0.806
GOODNESS OF FIT,F(2, 64) = 59.1735
CONSTANT TERM= 314.7476

VARIABLE NAME	COEFF	STD DEV COEFF	T VALUE	BETA COEFF
RT 3	-40.5820	7.1619	-5.6663	-0.4528
A-5	5.3389	0.8240	6.4790	0.5177

A-3

STEPWISE MULTIPLE LINEAR REGRESSION
PREDICTING B-3 INSTR TIME FOR CLASSES 101-127 (PI)

STEP NUMBER 3 ENTER B-2
STANDARD ERROR OF ESTIMATE= 70.956
MULTIPLE CORRELATION COEFFICIENT = 0.835
GOODNESS OF FIT,F(3, 63)= 48.4518
CONSTANT TERM= 236.0327

VARIABLE NAME	COEFF	STD DEV COEFF	T VALUE	BETA COEFF
RT 3	-31.3937	7.2954	-4.3035	-0.3503
A-5	4.3227	0.8344	5.1806	0.4192
B-2	2.1444	0.6738	3.1825	0.2764

A-4

STEPWISE MULTIPLE LINEAR REGRESSION PREDICTING B-3 INSTR TIME FOR CLASSES 101-127 (PI)

STEP NUMBER 4 ENTER AFQT
STANDARD ERROR OF ESTIMATE= 68.058
MULTIPLE CORRELATION COEFFICIENT = 0.852
GOODNESS OF FIT,F(4, 62)= 41.1192
CONSTANT TERM= 338.0073

VARIABLE NAME	COEFF	STD DEV COEFF	T VALUE	BETA COEFF
AFQT	-1.2510	0.4915	-2.5455	-0.2085
RT 3	-24.4079	7.5167	-3.2472	-0.2723
A-5	4.0903	0.8055	5.0778	0.3966
B-2	1.7803	0.6619	2.6896	0.2295

A-5

STEPWISE MULTIPLE LINEAR REGRESSION PREDICTING B-3 INSTR TIME FOR CLASSES 101-127 (PI)

STEP NUMBER 5 ENTER RT 1
STANDARD ERROR OF ESTIMATE= 67.276
MULTIPLE CORRELATION COEFFICIENT = 0.858
GOODNESS OF FIT,F(5, 61)= 34.1539
CONSTANT TERM= 382.1501

VARIABLE NAME	COEFF	STD DEV COEFF	T VALUE	BETA COEFF
AFQT	-1.3206	0.4878	-2.7071	-0.2201
RT 1	-3.6348	2.3228	-1.5649	-0.1285
RT 3	-18.2462	8.4092	-2.1698	-0.2036
A-5	3.7209	0.8305	4.4801	0.3608
B-2	1.8661	0.6566	2.8420	0.2405

Unclassified

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19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

Content-related tests	Predictive equations	Training management
Course completion time predictions	Predictive tests	
Individualized instruction	Self-paced training	
Multi-media instruction	Test development	
Nomographs	Time-to-learn	

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

A system for predicting individual self-paced course completion time was developed and tested. Such a system permits the timely reporting of assignment information and the efficient utilization of course graduates. A predictive test battery was developed, consisting primarily of content-related tests and "mini-lessons" that were directly associated with the Stock Control and Accounting Specialist (MOS 76P20) course. Such predictors

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20. (Continued)

proved to be better than general aptitude measures for predicting course completion time in this training program. Stepwise multiple linear regression analyses were used to develop predictive functions and determine potentially useful predictors. Nomographs were constructed to display the predictive equations and are recommended for use.

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1 DIR WRAIR WALTER REED ARMY MED CTR ATTN NEUROPSYCHIAT DIV
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1 DIR OF INSTR US MIL ACAD WEST POINT NY
1 USA INST FOR MIL ASSIST ATTN LIB BLDG 1572P19 FT BRAGG
4 USA INST FOR MIL ASSIST ATTN COUNTERINSURGENCY DEPT FT BRAGG
1 COMDT DEF MGT SCH FT BELVOIR
2 COMDT USA MSL & MUN CTR & SCH ATTN CHF OFC OF OPS REDSTONE ARSNL
2 HQ ABERDEEN PG ATTN TECH LIB
1 CO USA INTELL CTR & SCH ATTN DIR OF ACADEMIC OPS FT HUACHUCA
1 CO USA INTELL CTR & SCH ATTN DIR OF DOC & LIT FT HUACHUCA
1 COMDT USA CGSC OFC OF CHF OF RESIDENT INSTR FT LEAVENWORTH
1 COMDT USA CA SCH ATTN OFC OF DOCTRINE DEVEL LIT & PLNS FT BRAGG
1 COMDT USA CA SCH ATTN DOI FT BRAGG
1 COMDT USA CA SCH ATTN EDUC ADV FT BRAGG
1 COMDT USA CA SCH ATTN LIB FT BRAGG
1 COMDT USA SCH & TNG CTR ATTN ACOFS G3 HQ DIV FT MCCLELLAN
1 COMDT USA SCH & TNG CTR ATTN ACOFS G3 PLNS & OPS DIV FT MCCLELLAN
10 COMDT USA INST FOR MIL ASSIST ATTN DOI FT BRAGG
1 LIBN USAIS FT BENNING
8 COMDT USA FLD ARTY SCH ATTN DOI FT SILL
1 COMDT USA ARTY SCH ATTN EDUC SERVICES DIV FT SILL
1 COMDT USA ARTY SCH ATTN EDUC ADV FT SILL
1 COMDT USA TRANS SCH ATTN LIB FT EUSTIS
1 USA INST FOR MIL ASST ATTN EDUC ADV FT BRAGG
1 COMDT USA ARTY SCH ATTN LIB FT SILL
1 CG USA SCH & TNG CTR ATTN ACOFS G3 FT GORDON
1 DIR OF GRAD STUD & RSCH ATTN BEHAV SCI REP USACGSC
1 COMDT USA AD SCH ATTN AKBAAS-DL-EA FT BLISS
2 DIR BRGD + BN OPNS DEPT USAIS FT BENNING
1 DIR COMM ELEC USAIS FT BENNING
1 DIR ABN-AIR MOBILITY DEPT USAIS FT BENNING
1 CG USA SIG CTR & SCH ATTN ATSSC-DP-COB FT MONMOUTH
1 SECY OF ARMY, PENTAGON
1 DCS-PERS DA ATTN CHF C+S DIV
1 DIR OF PERS STUDIES & RSCH ODCSPER DA WASH DC
2 ACSFOR DA ATTN CHF TNG DIV WASH DC
1 US ARMY BEHAVIOR & SYS RSCH LAB ATTNCRD-AR ARL VA
1 PROVOST MARSHAL GEN DA
1 OFC RESERVE COMPON DA
12 ADMIN DDC ATTN: TCA (HEALY) CAMERON STA ALEX., VA. 22314
1 CO US ARMY MED RES LAB FT KNOX
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
1 CO USA CDC MED SERV AGCY FT SAM HOUSTON
1 USA BEHAVIOR & SYS RSCH LAB ATTN CRD-AIC ARL VA
1 CAREER MGT BR ATTN R DETIENNE CAMERON STA ALEX VA
1 USA LIB DIV-TAGO ATTN ASDIRS
1 PRES ARMY MAINT BD FT KNOX
1 CG CONARC ATTN COL E M HUPAK ATIT-SA FT MONROE
15 CG CONARC ATTN ATIT-STM FT MONROE
2 CG CONARC ATTN LIB FT MONROE
1 USA ARCTIC TEST CTR CHF INSTR & TEST METH DIV SEATTLE
1 CHF USA AD HRU FT BLISS
1 CHF USA ARMOR HRU FT KNOX
1 CHF USA AVN HRU FT RUCKER
1 CHF USA INF HRU FT BENNING
1 CHF USA TNG CTR HRU PRES OF MONTEREY
3 CG ARMY ARMOR CTR FT KNOX ATTN G3 AIPKGT
1 CG 3RD INF DIV ATTN ACOFS G3 APO NY 09036
1 CG 7TH INF DIV ATT ACOFS G2 APO SAN FRAN 96207
3 CG 4TH INF DIV (MECH) & FT CARSON ATTN ACOFS G3
1 DA HQS FT CARSON & HQS 4TH INF DIV (MECH) ATT MAJ HARRIS
3 CG 82ND ABN INF DIV ATTN ACOFS G3 FT BRAGG
1 CG XVIII ABN CORPS ATTN ACOFS G3 FT BRAGG
1 CO 197TH INF BRGD FT BENNING ATTN S3
1 CO 2ND BN 15TH INF 3RD INF DIV ATTN S3 APO NY 09026
1 CO 4TH BN (MECH) 54TH INF ATTN S3 FT KNOX
2 DA OFC OF ASST CHF OF STAFF FOR COMM-ELCT ATTN CEES-6 WASH
1 USA RECRUITING COMD HAMPTON VA
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1 CG USAFAC & FT SILL ATTN AKPSIGT-TNTN
20 CO III CORPS ARTY ATTN G3 SEC FT SILL
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1 TECH LIB BUR OF SHIPS CODE 210L NAVY DEPT
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1	U OF CALIF GEN LIB DOCU DEPT
1	PSYCHOL LIB HARVARD UNIV CAMBRIDGE
1	U OF ILL LIB SER DEPT
2	U OF KANSAS LIB PERIODICAL DEPT
1	U OF NEBRASKA LIBS ACQ DEPT
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	SERIALS REC UNIV OF MINN MINNEAPOLIS
1	STATE U OF IOWA LIBS SER ACQ
1	NO CAROLINA STATE COLL DH HILL LIB
2	BOSTON U LIBS ACQ DIV
1	U OF MICH LIBS SER DIV
1	BROWN U LIB
1	COLUMBIA U LIBS DOCU ACQ
1	DIR JOINT U LIBS NASHVILLE
2	LIB GEO WASH UNIV ATTN SPEC COLL DEPT WASH DC
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
1	SO ILL U ATTN LIBN SER DEPT
1	BRIGHAM YOUNG U LIB SER SECT
1	U OF LOUISVILLE LIB BELKNAP CAMPUS
1	GEORGETOWN U LIB SER DEPT WASH DC
1	LIBS COLO STATE U ATTN DOC LIBN FT COLLINS
1	COMDT USA QM SCH ATTN DIR ENLSTD SUPLY DEPT
1	COMDT USA QM SCH ATTN DPTY DIR ENLSTED SUPLY DEPT