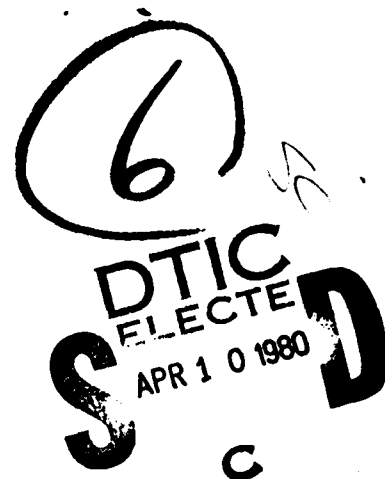


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LEVEL II



ALTERNATIVE MODELS FOR INDIVIDUALIZED ARMOR TRAINING,
PART I, INTERIM REPORT: REVIEW AND ANALYSIS OF THE LITERATURE

Richard K. Matlick, Robert W. Swezey, and Kenneth I. Epstein
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U. S. Army

Research Institute for the Behavioral and Social Sciences

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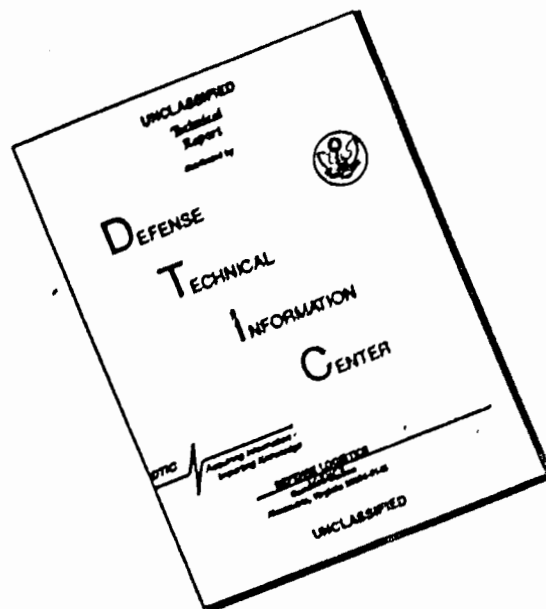
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This report presents a review and analysis of literature pertaining to individual and/or self-paced instruction in educational, industrial, and military settings. It describes the major types of individualized or self-paced instructional systems that have been investigated or implemented, and it examines eight (8) factors which vary among applications of methods of individualized instruction and which are held to strongly influence the feasibility of methods for any given instructional environment (context). The eight (8) controlling factors examined are: (1) time available/required for learning; (2) instructional personnel; (3) facilities;		

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(4) management; (5) student populations/learner characteristics; (6) course content/task types; (7) instructional methods; and (8) media, materials, and devices.

The review includes an examination of conceptual models of individualized instruction and the classification of those models. Generally, it shows that most established systems of individualized instruction are similar in terms of fundamental models and that many fundamental models are not represented by existing systems.

It reaches a number of conclusions of interest to training planners, developers, and managers. Generally, these conclusions point to the need for care in the selection of approaches to individualization of instruction, to unexplored approaches to individualization, and to the need for further research and development.

This report constitutes Part I of a two-part study. Part II will present alternative models for the individualization of armor training along with a scheme for the classification of the instructional environments (contexts) of armor training and procedures for the selection of alternative models for those environments.

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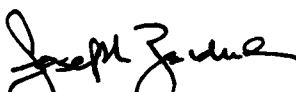
FOREWORD

The US Army Research Institute for the Behavioral and Social Sciences has had a continuing program of research responsive to the training development needs of the combat arms. Increasing sophistication of Armor weapon systems coupled with a drive to maximize the efficiency of Armor training have led to a search for training innovations.

The Armor community has recognized the potential in training management and delivery systems falling under the general category of individualized (or self-paced) instruction. Initial attempts to develop individualized programs of instruction in Armor have taken place for Turret Mechanic and Track Vehicle Mechanic MOS. Both of these efforts were hampered by the lack of a family of clear conceptual models to follow.

The literature review and analysis reported here is a necessary step in redressing the lack of clear conceptual guidance for the individualization of instruction. It pulls together the controlling factors that must be considered when planning to individualize instruction and presents models of individualized instruction from the literature. It also presents examples of systems of individualized instruction from both civilian and military environments.

This research was responsive to Army Project 2Q162722A777, Individual Training Technology, and will provide part of the technology base from which to develop specific programs of individualized instruction in the Army.


JOSEPH ZEIDNER
Technical Director

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Matlick, R. K., Swezey, R. M., and Epstein, K. I. Alternative Models for Individualized Armor Training, Part I, Interim Report: Review and Analysis of the Literature

Requirement:

For some time individualized instruction has been one of the focal points of the Army's efforts to increase the effectiveness of performance-based training. One feature of individualized instruction, self-pacing (i.e., variable time for learning under the control of the learner as opposed to the usually fixed time of conventional instruction), has been strongly emphasized by Army training developers while other promising features have received much less attention. These other features include learner repertory assessment, individual prescription, immediate and frequent feedback, successive approximations of required performances, the use of proctors, multi-media presentations, contingency management, and computer-assisted/managed instruction. But when, where, and how to integrate these in Army training is not always clear. It is apparent that a feature of individualized instruction that works well in one context of instruction may not work well in another. What is needed, then, is a systematic method for selecting forms (various constellations of features within fundamental structures) of individualized instruction that are suitable for particular contexts of instruction. Clearly, the development of such a method must begin with a review of the literature to identify both the various forms of individualized instruction and the factors that influence their effectiveness. This volume is a review of the literature of individualized instruction from that perspective.

Procedure and Findings:

On the basis of a preliminary review of the literature, it was postulated that there are eight (8) factors that strongly influence or control the success or failure of any instructional approach (including any form of individualized instruction) within any given instructional context. These factors are: (1) time available for learning; (2) the instructional personnel; (3) facilities for instruction; (4) management capability; (5) learner characteristics; (6) course content or task types; (7) instructional methods; and (8) the instructional media, materials, and devices. Thus, the instructional methods that are feasible to a particular context of instruction may not include the method of instruction inherent to a particular form of individualized instruction and that form may not therefore be a reasonable choice for that particular context. The review was therefore undertaken partly from the perspective of these eight controlling factors. But the features, methods, techniques, or strategies which in particular arrangements are seen as distinctive or identifiable forms of individualized instruction do not come together haphazardly; they are to be found within certain fundamental structures or models of instruction as defined by such basic dimensions as fixed or variable content, fixed or variable time, fixed or variable required proficiency, and fixed or variable instructional treatments. The review therefore also examined both realized and possible fundamental models of individualized instruction.

The literature reviewed supports a number of general but significant conclusions. First, the term "individualized instruction" is not at all a precise one and needs to be used with care. Second, while there are many particular instances of individualized instruction, there are few fundamental differences among them. Third, there are many possible fundamental approaches (models) to individualized instruction that have not yet been realized in any significant way but probably should be. Fourth, particular approaches to individualization within any given instructional context need to be chosen with care. Fifth, an adequate data base is an indispensable aspect of individualized instruction. Sixth, some areas of the literature of individualized instruction are sparse or ill-defined, suggesting the need for further research and developmental efforts. And finally, there are areas for future development that hold considerable significance for the design and conduct of individualized instruction; briefly, the most important areas appear to be those of mini-computer-based CAI, the training and development of instructors in the skills and attitudes necessary to individualized instruction, and institutional change to accommodate the needs of individualized instruction.

Utilization of Findings:

The findings of this review will first of all be utilized in the development of a set of alternative models for the individualization of Armor training and a method for selecting those models that are appropriate to a defined instructional context (i.e., a context whose characteristics and constraints are known). Second, it will presumably be utilized as an information base for further research into the application of individualized instruction to the needs of Armor/Army training.

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CHAPTER 1. INTRODUCTION

Interest in the area of individualized instruction has expanded dramatically during the 19 years following Lumsdaine and Glaser's (1960) classic book which summarized various approaches to the area. This burgeoning field, although certainly not new in terms of ideology, has achieved a great deal of recent popularity in both academic and applied communities due to a variety of proximal causes including: renewed interest in mastery learning, the emergence of behavioral methods for the engineering of learning, the advent of computerized technologies for presenting and managing instruction, increasing costs associated with traditional methods of instruction, renewed interest in performance evaluation, and the so-called "systems" approach to instructional development.

As a consequence of this increased interest, a myriad of research and development activities has been conducted. Among the major activities has been a move toward increased individualized training in institutional settings. The attempt has been to process students through training at a faster pace, at reduced costs, and without reduction in training effectiveness.

The term "individualized instruction," of course, implies a variety of features such as: specification of terminal student performance requirements, learner analysis, learning prescriptions, proctors, immediate and frequent feedback contingencies, mastery criteria, multi-media presentation, and the use of computer-assisted instruction, among others. Depending on the degree to which these and other features are utilized, the point at which instruction can be said to be "individualized" is indeed arbitrary. Esbensen (1968), for example, has commented that "...individualized instruction does not depend for its success upon any given arrangement of persons, materials, or environmental conditions. The formal structure that proves to be most effective in one instance may turn out to be inadequate in another. Each situation is in some ways unique, and should be treated accordingly. Having said this, however, we must also recognize that individualized instruction does not occur in a vacuum. Certain classroom settings and practices do look more promising than others. In this sense we can, without being dogmatic, recommend specific procedures that may be widely applicable" (p. 2).

Specific procedures recommended by Esbensen include: writing behavioral objectives, establishing conditions of performance, setting criterion levels, and tailoring instructional procedures and materials to stated objectives. Esbensen does not, however, address such topics as the impacts of persons, materials, or environmental conditions on the uniqueness of an instructional situation; nor does he address reasons why a formal structure effective in one instance of individualized instruction may not work in another. In general, the literature of individualized instruction appears to be somewhat deficient in this regard. The literature does suggest, however, that certain factors have had considerable impact on both successful and unsuccessful attempts to provide individualized instruction. Among these factors are:

- o The time available for segments of a curriculum. Every instructional system interfaces with other systems, and if the nature of the interface is such that time is constrained, then one common feature of individualized instruction (i.e., self-pacing) may also be constrained.

- o The instructional personnel to implement individualized instruction. Although some approaches to individualized instruction require additional instructional personnel not already present in existing structures, others redefine the role of instructors toward planning and management functions and may in fact reduce the requirement for instructional personnel.
- o The facilities required for various types of instruction. While some systems of individualized instruction can be contained within a traditional classroom, the tendency is for such systems to spill over into other areas. According to Bishop (1971), "in some schools the conventional classroom which seats 30 to 35 students is practically obsolete. It is no longer appropriate to assign a particular teacher to a specific classroom. Rather, any given teacher may occupy several different facilities throughout the week, depending on the specific instructional activity or task to be performed. Large group instruction will take place in the school's large group room, a facility shared with several other teachers who are also employing large group techniques. Small group instruction will take place in small, informal seminar rooms. Laboratory instruction will be held in rooms suitable to this instructional mode, and individualized study will be most effective in the resource centers, the instructional materials center, or in the teachers' office area" (p. 51).
- o The management of individualized instruction, which in some cases may be complex. Lindvall and Bolvin (1970) have for instance stated that ... "Experience has indicated that the starting point in the implementation of Individually Prescribed Instruction must be to make certain that teachers can make the basic 'mechanics' of the system operate. Of course, IPI, or any other structured program for individualizing instruction, would be relatively narrow and sterile if the structured system is the only part of the program that operates. But emphasizing the fact that 'operating the system' is only part of the teacher role should not cause one to lose sight of the fact that this is an essential role" (p. 40).

Thus, it appears that one reasonable way to approach the problem of applying individualized instruction is from the perspective of distinguishable types of instructional contexts in which individualized instruction may be conducted. Having done this, one might attempt to define parameters and constraints relevant to the implementation of individualized instruction in these contexts. Such is the emphasis of this review.

In addressing this approach, there would appear to be a need for a system of classification to facilitate identification of differences from context to context. Further, it is appropriate that such a classification system remain open for consideration of additional factors which may be identified at a later time. If models of individualized instruction are to be selected on the basis of their ability to accommodate to such contexts, it would also be desirable that the classification system identify sets of parameters unique to each context.

These needs appear to be addressed by the classification system conceptually modeled in Figure 1. In Figure 1, a three-dimensional matrix is employed to define instructional contexts in terms of Setting, Focus, and Time dimensions.

Settings

The dimension of Setting contains the categories Operational, Instructional-outdoor, Instructional-indoor, and Independent. An Operational setting is characterized by the performance of individual or group tasks under prescribed conditions. An Instructional-outdoor setting implies particular arrangements for teaching and learning in a field or outdoor training area. An Instructional-indoor setting refers to classrooms and/or other sheltered facilities for teaching and learning. An Independent setting delimits the activities of an individual student as he acquires skills and knowledges without supervision (i.e., by reading, by using independent learning materials, or through interaction with peers).

Focus

The dimension of Focus contains the categories Equipment, Technique, and Knowledge. The Focus on Equipment category identifies training that is concerned with such phenomena as nomenclature, maintenance, principles, functions, and operation of equipment. The Focus on Technique category refers to human functions such as methods and processes (i.e., to the "how to" aspect of instruction and learning). The Focus on Knowledge category identifies training directed toward the acquisition of knowledge that is not a direct antecedent of task performance.

Time

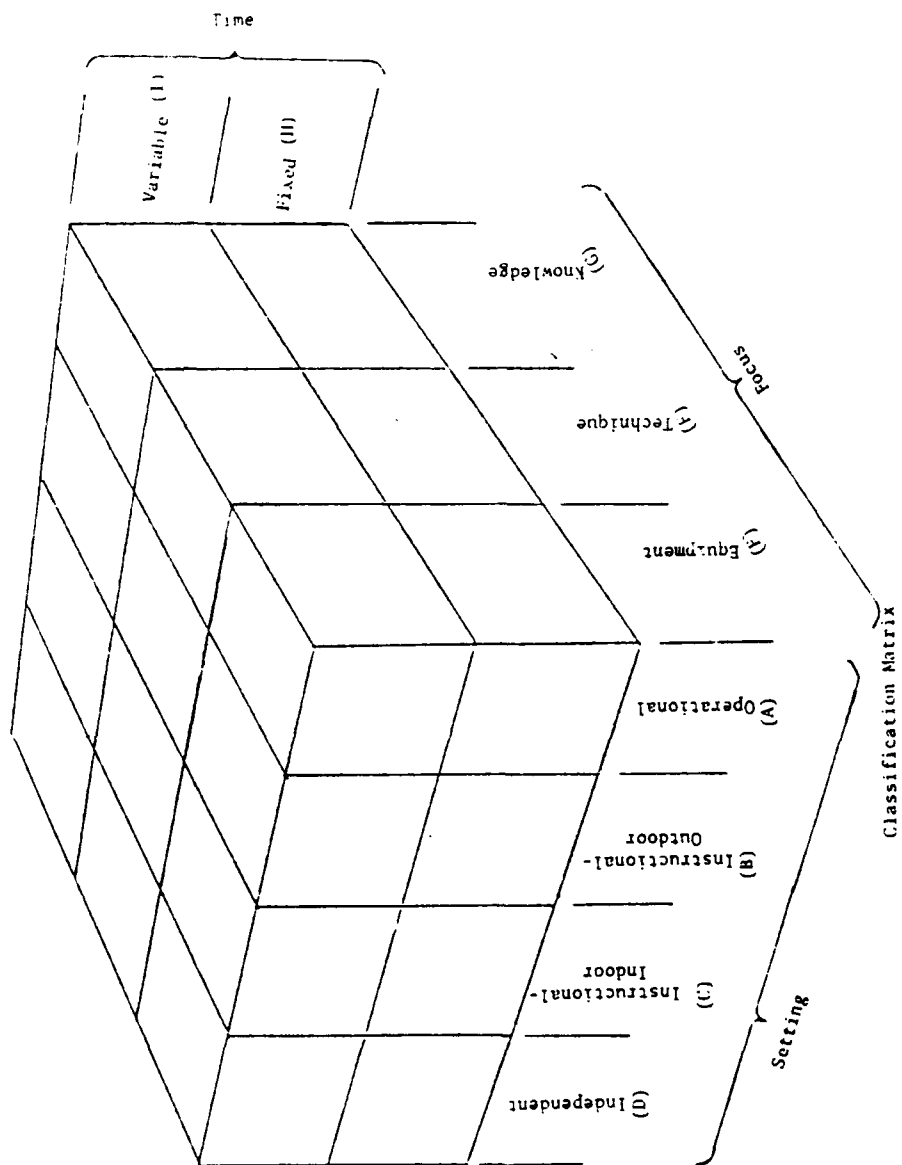
The dimension of Time contains the categories Fixed and Variable. Fixed Time implies that time for learning cannot be manipulated by designers or implementers of training beyond narrowly imposed limits (i.e., learning is a function of a given amount of time). Variable Time means that time for learning may be controlled by the designers or implementers of training within broad limits (i.e., time is a function of given learning).

Instructional Context

Each cell of the three dimensional matrix shown in Figure 1 may be termed a Context of Instruction. Each context in this model, thus, is comprised of categories on the three dimensions of Setting, Focus, and Time. One example of a given instructional Context might involve an Operational setting, having a Focus on Equipment, which allows for a Variable amount of training time. Another might involve an Instructional-indoor setting, having a Focus on Technique, with a Fixed learning time. An instructional context may therefore be defined as the three-way intersection of the dimensions Setting, Focus, and Time within the conceptual model shown.

Controlling Factors

Within a given Context, it is suggested that a variety of controlling factors or situational constraints may operate to aid in the prescription of an individualized instruction approach. The controlling factor categories are



suggested as being applicable to all instructional contexts. A context thus may, operationally, be described in terms of its applicable controlling factors, so that a system of individualized instruction which reflects certain controlling factors and is therefore effective in a defined context may be presumed to be a candidate system for other similarly defined contexts.

Eight controlling factors are postulated. These are:

1. Time Available - i.e., the amount of time available for learning the relevant skills and/or knowledge.
2. Instructional Personnel - i.e., the availability of personnel to provide the instructional functions, and/or the planning and monitoring functions associated with instruction.
3. Facilities - i.e., the availability and type of facilities for use in the instructional situation.
4. Management - i.e., the methods and/or techniques employed to manage and control the instructional situation.
5. Student Population Characteristics - i.e., the learning characteristics of the students who comprise the population to whom the instruction is addressed.
6. Course Content/Task Types - i.e., the content of the subject matter to which the instruction is addressed.
7. Instructional Methods - i.e., the types of instructional strategies and techniques which are applied to the subject matter content.
8. Media/Materials/Devices - i.e., the training media, materials and/or devices which are available and/or appropriate for use in the instructional situation.

As an example of the application of several of these controlling factors to a hypothetical instructional context, the following example is provided:

Context: Operational setting, Focus on Equipment, Variable time.

- o Time available. Assume a typical field exercise of 3-4 days in duration. In such a case, time available for individualized learning may be broadly limited to, say, 24-32 hours. While other requirements of a training exercise may have to be accommodated, an ample range for self-pacing through appropriate units of instruction would initially appear to exist.
- o Instructional personnel. Instructional personnel may in a military example, for instance, be limited to small-unit leaders, such as tank commanders, platoon sergeants, and platoon leaders; however, established military hierarchical relationships may provide a basis for a variety of instructional roles as well as for favorable instructor-trainee ratios.

- o Facilities. Facilities in this Operational setting may, in the ordinary sense, not exist; however, given the specified focus on equipment, this lack may not be unduly constraining. The presence of equipment may, for instance, establish a "laboratory-like" facility, where ratios of students to equipment items do not present queuing problems.
- o Management. Because of the operational demands which small-unit leaders (instructors) must meet, requirements for instructional management should be minimal. Thus, complex arrangements of students, instructional modes, and control processes are not feasible. The variable time for learning increases the need for simple management requirements.
- o Student Population Characteristics. Students in this military example may be Advanced Individual Training (AIT) trainees, whose ability level on relevant skills and knowledge may be relatively low. Such a situation would argue for a prescriptive approach to instruction.
- o Course Control/Task Types. If the content were aimed at a series of equipment-oriented procedural tasks (such as, for example, tank maintenance) more proceduralized instructional approaches may be warranted than if the content were more cognitive in orientation (for example, leadership).
- o Instructional Methods. Self-paced, programmed sequences in branching format as opposed to, say, illustrated lectures may be relevant to maintenance tasks.
- o Media/Materials/Devices. Workbooks may be more applicable to a relatively simple maintenance task than (for instance) Computer Assisted/Managed Instruction.

A portion of the literature review considers these controlling factors. Although in the real world such factors exist interactively, the review will address them in turn.

The review next examines general models of individualized instruction. While a great many particular instances of individualized instruction have been documented only a few general models are needed to characterize those particular instances. These general models characterize systems in terms of fundamental variables of instruction, though not all models include the same variables. This approach to the examination of individualized instruction not only yields clarifying views of existing systems but also points to unexplored possibilities.

Then, on the basis of both the controlling factors and the general models, several prominent systems of individualized instruction are scrutinized. The systems examined thus are typical of those described in the literature and may generally be taken as representative of the present form of individualized instruction.

Finally, conclusions are drawn from the literature reviewed and analyzed. Findings significant to the planning, design, and development of individualized instruction are noted, and some guidelines are suggested.

CHAPTER II. THE CONTROLLING FACTORS

Time Available for Learning

Discussions involving learning time in individualized instruction can generally address two broad concerns:

1. Time available for learning, and
2. Time required for learning.

As previously noted, time available for learning may be either fixed or variable in individualized instruction situations. Time is fixed in situations where a finite amount of available time exists in which the instruction must be accomplished. It is variable in situations where the time required for students to adequately master the content prescribes the total time available for learning.

Work by McClelland (1971) has further addressed this topic via two distinct approaches: one developed by Cronbach (1967) and another by McFann (1969). Cronbach's approach provides for a three-way strategy for use in considering individualized instruction:

1. If educational goals and instructional treatments are both fixed, one should use either sequential selections to alter the duration of schooling or train to criterion on each skill or topic.
2. If educational goals provide a student with options and the instructional treatments remain fixed for each option, then one should prepare a curriculum that fits each student for his prospective role.
3. If educational goals are fixed within a course, and the alternative instructional treatments are provided, then one can either provide remedial programs as adjuncts to the "main track" instruction, or teach different pupils by different methods, or both. (McClelland, 1971, pp. 3)

McFann's (1969) conception, however, addresses more directly the specific issue of training time in individualized instruction. McFann has provided four alternatives:

1. Fixed curriculum, fixed training time, and variable training standards. While this strategy may be attractive to a course administrator, it essentially ignores individual differences among trainees. In this alternative, something typically has to give, and what often gives is the mastery standard achieved by the students. Terminal performance is often highly variable in such a situation.
2. Fixed curriculum, variable training time, and either fixed or variable training standards. In this alternative, all students typically receive the same instruction, and some may receive all or part of it several times. Such an alternative typically makes only minimal allowance for individual differences through student recycling.

3. Variable curriculum, fixed training time, and variable training standards. This alternative typically does allow for some amount of human variability, by varying the amount of material to be mastered. In a fixed training time, more adept students typically proceed more rapidly and learn more; thus, the standards achieved above a minimal level are extremely variable.
4. Variable curriculum, variable training time, and either fixed or variable standards. This alternative obviously provides maximum flexibility; however, it is typically very difficult to administer. (McClelland, 1971, pp. 3)

The area of time to learn in mastery learning has been carefully reviewed by Dolly and Meredith (1977). According to that review, when mastery learning schemes are implemented, each student theoretically works at his or her own level of performance in a content area. In such situations one typically has a number of students at various academic levels, and the tendency often therefore exists to group students with other students on their own level of functioning. The purpose of the grouping is to reduce the time needed for mastery for some students and to increase it for others. The assumption is that, given enough time, even those students at the low end of the ability distribution will be able to achieve mastery.

Within most educational settings, a large number of problems often occur with slow students. In the mastery system, theoretically a bright student will continue to achieve and will probably accomplish a great deal since he is no longer held back by slower learners. The slow student on the other hand, is provided with the time to learn prerequisite skills, in order to proceed toward mastery in the subject. An important point to remember, however, is that the real world, generally speaking, operates on a norm-referenced system. That is, entry into the job industry and into professional schools is typically based on rank order and on time. In our society, time is a very important factor. People who do things in short periods of time are usually the people who are rewarded most.

Such conclusions have been demonstrated by Kuhn (1972). Kuhn's study addressed a hypothesis involving no difference in acquisition of information under different amounts of study time, for both low analytic and high analytic ability students on a botany task. In that study, Kuhn confirmed results previously demonstrated by Murray (1963) and by Gillette (1936) in finding significant differences in learning time required to achieve mastery between high analytic and low analytic ability students. It was further demonstrated, however, that additional study time allowed the low analytic ability subjects to close part of the gap with the high analytic individuals. Kuhn's inference was that if enough study time was permitted the learning margin between analytic ability groups could be altered considerably. This notion adds support to arguments which permit learning time to be flexible and allow the student to arrange study time to his or her own needs. Kuhn cites this capability as one of the great advantages of individualized instruction.

Anderson (1977) has recently conducted a study whose purpose was to investigate the magnitude and stability of individual differences in the amount of time required to achieve a criterion level of performance. Recent innovations in the theory of instruction and in educational measurement have led to

an increased emphasis on time and on amount learned as concepts in developing instructional techniques. Traditionally, students have been allowed a fixed amount of time to learn a particular task. The result has been a variation in the achievement level obtained. Recent innovations, however, have emphasized setting fixed achievement goals. The result of those innovations has been a variation in the amount of time needed to achieve the goals.

According to Anderson, as one examines the nature of the time to criterion concept closely, several ideas involving instructional time can be differentiated. During the period of time that is allotted to a student for learning a particular task, the student typically spends a portion of that time working on the task and a portion of that time on irrelevant activity. This irrelevant activity often consumes a substantial portion of the total elapsed time that a student requires to achieve a mastery criterion. One purpose of Anderson's research was to address the theory that students who are provided with additional time and help to attain criterion levels in the early unit of a three-unit learning sequence spend approximately the same amount of time on task to attain a criterion level on the final unit as do students who attained the criterion on the early units without extra time or help. Anderson's work, thus, involved manipulation of time on task in the first unit of a three-unit sequence. Results of Anderson's work indicated that the amount of necessary time to criterion can be altered by an effective strategy such as mastery learning. Secondly, Anderson concluded that a relatively heterogeneous group of students can become homogeneous in the amount of time required to learn a particular task after mastery of a series of prerequisite tasks. Thus, to the extent that equality of learning outcomes is a desired goal in education, such goals may be achievable by designing learning situations to allow for inequality in student characteristics. If, on the other hand, students are presented with a learning situation in which all are given an equal amount of elapsed time and instructional help, the typical result is unequal learning outcomes. This, of course, is the basic argument put forth by mastery learning advocates.

In similar research, Carroll and Spearitt (1967) examined 96 sixth grade students in a language learning context using a sample stratified with respect to intelligence and a criterion level of 100% mastery. Carroll and Spearitt found a time-to-criterion range of 1 to 4. That is, it took the slowest student approximately four times as long as the fastest student to reach the mastery criterion. Arlin (1973), in a similar experiment, found a time-to-criterion of approximately one to seven, and Block (1970) found a range of approximately one to 3.4. These studies lend support to Carroll's 1970 conclusion that the range of time-to-criterion in school learning research is approximately one to five. Evidence that this range may be manipulated was found by Block (1970), who found a decrease over a three-year sequence from one to 3.4, to one to 2.1, and by Arlin (1973), who found a decrease over a seven-year sequence from one to seven to one to four. These studies support Anderson's conclusion that time-to-criterion in a multi-unit context may in fact be manipulated.

In a Navy study, Main (1974) performed a series of experiments to determine levels of computational skills that could be achieved by Navy personnel with marginally acceptable pre-induction scores on Air Force ability measures. Effects of providing supplementary audio materials, decreasing assistance from instructors, and increasing training time were also investigated. In general, without direct assistance from the instructors, self-study training was found to be effective with as little as 15 hours of instruction. The average performance level was raised by approximately one full grade. Main also varied

printed versus audio formats for the self-study instruction. This format shift appeared to produce no advantage. Extending training time, however, allowed more trainees to complete the course work. Criterion achievement in this study was found to be related to initial levels of performance even for trainees who had completed most of the course work.

A major research effort in the area of individualized instruction in the military has been a continuing Air Force project known as the "Advanced Instructional System" (see Judd, McCombs, and Dobrovolsky, 1979; McCombs, Dobrovolsky and Judd, 1979; and Dobrovolsky, McCombs, and Judd, 1979). In one major effort in this program, McCombs et al. (1979) conducted a study to determine, first, characteristic problems which students typically encounter in a computer-managed instructional system (such as the AIS) and strategies which may effectively help students to cope with these problems. Secondly, the McCombs study involved an effort to develop and evaluate a set of self-contained instructional materials for increasing the effectiveness with which students adapt to, and perform in, a CMI environment. Thirdly, the study investigated procedures for individualizing the assignment of these modules. McCombs et al. thus developed a variety of skill modules designed to reduce training time and found that dramatic student improvement occurred both in instructional time required and in criterion scores following study skill remediation. They concluded that student skill modules can contribute to substantial improvements in student efficiency, that the effects of such training can be expected to increase over time, and that instructor workshops are a feasible method for resolving instructor frustrations with new roles imposed upon them by individualized instruction. In a similar study, DuBold et al. (1979) found an 11% reduction in the time required for students to complete six instructional segments of an Inventory Management course as a function of an orientation in time management and skill training. Given the number of students, the student flow, and the length of this particular course, this 11% savings translated into 8,600 student training days saved per year.

A large number of military and industrial studies have investigated the effects of individualized (as opposed to traditional) instruction on total training time consumed, given a mastery level performance criterion. Work by Pieper, Swezey, and Valverde (1970) showed that individualized instruction using a variety of instructional technologies can reduce total training time with no loss in task mastery on a series of electronic maintenance tasks. Similar work by Pieper, Catrow, Swezey, and Smith (1973) confirmed those results in a police performance context involving both security and law enforcement duties.

According to Judd et al. (1979), Johnson, Salop, and Harding (1972) found that Navy students who were provided with incentives based upon completion of lessons in less time than was predicted for them completed a course in 17% less than the predicted time with no differences in final performance as compared with control students. Similarly, Colton (1974) compared time and achievement scores of college students who were or were not given information about how long it took other students to finish 22 self-paced criterion-referenced tasks. Students given time information completed six tasks in significantly less time but performed significantly less well on the criterion test than did students not receiving the completion time information.

Two recent studies have investigated the effects of goal setting instructions on student achievement in conventional courses. Gaa (1971) gave a group

of English students weekly individual goal-setting conferences and a control group no goal-setting information. Students in the goal-setting group had higher scores on criterion-referenced achievement tests and better attitudes toward the course than did control group students. Freeman and Niemeyer (1974), on the other hand, found no significant differences in criterion-referenced achievement test scores as a result of goal-setting instructions.

Results of the Dobrovolsky et al. (1979), the McCombs et al. (1979), and the Anderson (1976) studies appear to imply that early task-relevant skill-training costs are amortized quickly when students begin using these skills to improve their performance. This suggests that training in time management can on its own merit reduce total training time by increasing the time students spend on task-relevant (versus task-irrelevant) activities. Judd et al. (1970) concluded that combining this skill training with completion time prediction and with progress feedback could be expected to result in even greater reductions.

Orlansky and String (1979) have commented that individualized instruction, in general, appears to save about one-third of the time required by students to complete similar courses given by conventional instruction. These authors concluded that about the same amount of student time is saved when the same courses are given by individualized instruction without computer support as by CAI or by CMI. According to Orlansky and String, the amount of student time-savings varies widely. Extreme values of -31% to 89% have been reported. Factors which influence the amount of student time saved by individualized instruction probably include such variables as: quality of the course materials, type of course, instructional strategy, frequency of testing, length and difficulty of lessons, and method of student management.

Instructional Personnel

While the effects of individualized instruction on the learner dominate the literature -- and properly so -- the training manager and the instructional developer must not lose sight of the impact on those responsible for the conduct of instruction of the new technology which individualized instruction represents. As Stewart and Love (1970) have put it: "For the teacher, the new technology represents a plethora of changes. In the old system, the teacher's role was fairly well standardized and accepted. In the new system, his role must be redefined to meet the changing technology" (p. 56).

Of course, the reverse of this proposition is also true in that instructors may have an impact on efforts to bring about change in the educational/training enterprise. Spitzer (1976), reporting a study of the impact of faculty attitudes on efforts to bring about instructional improvement, has said that:

The principal obstacle to acceptance of the instructional development concept in higher education [which may be thought of as the larger context in which individualized instruction takes place] has been the "human element." Due to the extensive commitment of time and resources that is required in the instructional development process, there have been attempts to find shortcuts where none exist.

These shortcuts have damaged the credibility of the entire concept. In addition, there has been the serious problem of the failure of instructional development personnel and administrators who support the concept to consider the characteristics of the faculty members who must ultimately determine the effectiveness of any instructional improvement program. (p. 99)

He was writing specifically about instructional development in higher education, but his remarks would appear, within limits, to be relevant to any educational/training organization that attempts to change, in any fundamental way, the instructional process. The roles of the university professor, the public school teacher, the industrial trainer, and the military instructor are not, of course, identical, but Spitzer's (1976) observation concerning the perceived insensitivity of instructional development programs to those who must conduct instruction has the ring of a general truth: "The university faculty member is the person who will make or break any instructional improvement effort, and it is he who must be the focal point of any such effort." (p. 100)

Generally, the literature of individualized instruction -- and, more broadly, that of instructional development, or change -- addresses such issues as the specific teacher behaviors required by new approaches to instruction, the attitudes of teachers/instructors, the training needs of teachers/instructors and programs for their preparation, and the diversification of instructional functions as a result of new instructional models (e.g., the use of proctors, tutors, or aides to assist the principal teacher/instructor in the conduct of individualized instruction).

Okey (1977) has reported a project designed to address two of the above issues simultaneously. While the research was intended to show the effects on the attitudes and achievement of students of the employment of mastery strategies by teachers, the stated purpose of the project was to "... foster favorable teacher attitude toward the philosophy behind mastery learning and to help teachers acquire the skills needed to use mastery learning in their classrooms" (p. 57). Because the project involved only training teachers in the mastery method and at the same time having them carry out classroom teaching projects, Okey seemed to imply that acquiring mastery teaching skills would "foster favorable teacher attitudes." Whether this interpretation is correct or not, he did conclude that training in the mastery method did result in the acquisition of the needed skills, more positive attitudes toward mastery learning, and changed behavior in the classroom. He also concluded that these changes in the teachers -- when translated into a mastery teaching plan -- resulted in positive effects on both student achievement and student attitudes.

Steward and Love (1970), on the other hand, reporting on a study of teacher attitudes toward individualized instruction, found that while teachers generally supported the individualized philosophy of their school and experienced a high level of satisfaction they also sensed a loss of status, felt that they had to work harder than teachers in traditional schools, were uncertain about what was expected of them, and felt that they had a greater need for in-service training than teachers in traditional schools (pp. 57-59). The attitude of teachers would appear to be important if not critical to the success of individualized instruction, but Eye et al. (1969), writing ten years ago, pointed out that "little is known about the effect of such individualized and

specialized instruction on the teacher's self concept...." (p. 25), and this review of the literature, at least, has suggested that that lack of knowledge persists.

The training of teachers/instructors -- as well as of supervisors and administrators -- has received considerable attention, however. Because this training must begin with the identification of the new roles imposed by individualized instruction, it may be worthwhile to consider how these new roles have been characterized.

Lindvall and Bolvin (1970), discussing the role of the teacher in a particular form of individualized instruction, Individually Prescribed Instruction (IPI), have identified, first of all, these "major functions":

1. The teacher's role in perfecting the system.
2. The teacher's role in supplementing the system to enhance adaptation to individual needs.
3. The teacher's role in providing for the achievement of goals possible only with teacher intervention.

The first of these major functions involves the following activities, according to Lindvall and Bolvin (1970, p. 39):

1. The evaluation and diagnosis of the needs and the progress of each student.
2. The development of individual study plans or prescriptions.
3. The development of immediate and long-range plans for the total class, which take individualized needs and plans into account.
4. The planning and organization of the classroom and the class period to create an effective learning environment.
5. The development, in cooperation with other members of the professional staff, of plans for any necessary large group instruction.
6. The supervision of the work of para-professionals such as technicians and teacher aides.
7. The study and evaluation of the system so as to improve its operation in the classroom.

The second major function above requires what may be called "teacher interventions" (e.g., to assess learner variables not measured by formal instruments) while the third involves essentially the counseling of learners. (pp. 40, 41)

Farley and Moore (1975), in dealing with the issue of changed roles of teachers/instructors had this to say with regard to the use of self-instructional learning packages: "Individualizing instruction through learning packages calls not for a change in the things that a teacher normally does, but

a change in the 'mix,' or frequency with which he or she does them." This statement reflects Tosti and Harmon's (1972) definition of individualized instruction (p. 77), given later in this review.

But individualized instruction -- as well as curriculum reform in general -- has implications for supervisors and administrators of instruction. Abbott and Eidell (1970) have pointed out that educational/instructional innovation occurs within the context of an overall system and that a change in any part of the system necessarily produces change in all other parts. Thus, "... modifications in the school curriculum either require or lead to modifications in the administration of the school" (p. 62). Within this context, they hold that:

A substantial increase in the individualization of instruction will require a shift in the focus of instructional decisions from supervisory and administrative personnel to instructional personnel. This does not mean, however, increased independence for teachers. On the contrary, it implies increased interdependence of specialized personnel as they use vastly increased amounts of information, superior in quality to any that is available today, to plan instructional materials, exercises and events to meet the challenges of a new approach to instruction. Thus, both planning for instruction and instruction itself will call for the cooperative efforts of a variety of persons, each possessing specialized competencies, knowledge and skills. (Abbott and Eidell, 1970, p. 64)

They concluded that educational administrators will have to learn to deal with their organizations as total systems, that administration will become more a supportive function than a controlling function, that administrators will need to develop "sophisticated use of information in educational planning," (p. 64) and that "...the introduction of new personnel specializations ... will place new demands on administrators for coordination" (p. 64).

Bailey and Gerl (1976), whose view of the supervisory function in the context of individualized instruction strongly supports that of Abbott and Eidell (1970), have proposed four guidelines for the supervision of individualized instruction programs:

1. Those responsible for supervision who seek to implement individualized instruction must make informed choices in the original selection of individualized programs.
2. Those responsible for supervision who seek to implement individualized instruction must adequately orient and prepare all persons who will be affected by the individualization.
3. Those responsible for supervision who seek to support existing systems of individualized instruction must create a school environment that is conducive to individualization.

4. Those responsible for supervision who seek to support existing programs of individualized instruction must insure that an adequate and comprehensive evaluation process is built into the system. (Bailey and Gerl, 1976, pp. 329-331)

In discussing the second guideline above, Bailey and Gerl (1976) also point to the impact of individualized instruction on the role of teachers and to the need to provide for a transition from the behaviors of traditional instruction to those required by individualized instruction.

The training of teachers/instructors for their new roles in individualized instruction appears to be accomplished largely through in-service programs, but some colleges and universities, through teacher training programs, are also involved in such specific training.

Sandberg (1977) has described a master-of education program (at Notre Dame College, Manchester, New Hampshire) that is specifically designed to train teachers in the planning and implementation of individualized instruction as it is represented by the Individually Guided Education (IGE) model developed at the University of Wisconsin and practiced in Wisconsin and in school systems within a large number of other states. Course work includes, in addition to topics specific to IGE, instructional materials, leadership skills for instructional teaming, learning theory and philosophy, and research. According to Sandberg (1977, pp. 4,5), research is an accepted part of the IGE Process. An interesting variation of this approach is the Individualized Secondary Teacher Education Program at Brigham Young University (Young and Baird, 1974). While this program is completely individualized and focuses on specific teaching behaviors, it apparently does not assure that teachers trained in it will teach in individualized programs.

Wilson (1977) has described a project (Project CLASS) intended to provide a framework whereby school systems and teacher-training institutions may jointly work out pre-service and in-service training requirements for teachers. The project emphasizes a cooperation between the schools and the teacher-training institutions leading to the use of the school classrooms as laboratories for acquiring teaching skills.

Scanlon and Brown (1970) have reported an in-service training program for both teachers and administrators in support of Individually Prescribed Instruction (IPI), another unique form of individualized instruction. The experience of the trainers led them to conclude that training about individualized instruction needed to be individualized and "...that teachers, when retrained for the specific operational procedures about the IPI program, tend to overemphasize the mechanics of the system" (p. 63). Thus, one goal of training was to help teachers to "...conceptualize a model of individualized instruction as a basis for instruction decision-making in IPI..." (p. 63). The administrative in-service training program included the learning of the operations of IPI, the learning of administrative tasks required to implement IPI, and the development of approaches to training teachers to implement IPI.

King and Harris (1976) have prepared a training manual used in the preparation of special education supervisors at the University of Texas. It notes the need to manage instructional change, emphasizes individualized instruction, and identifies the supervisor as an instructional change agent.

Individualized instruction has generally meant the differentiated staffing of instructional programs. That is, various individuals with different skills or varying levels of preparation are assigned to the various instructional functions to be found in an individualized system. Personalized System of Instruction (PSI), for example, (Gaynor, 1975) requires the use of student proctors to provide various instructional services to individual students. Without such proctors, the requirements of PSI would exceed the capacity of the instructional staff. Proctors are students, previously trained in the course or currently enrolled in it, who are assigned to work with groups of seven or eight students. Proctors may schedule meetings with individual students (though meetings during regular classes appear to be preferable), generate and administer tests, provide feedback to the individual student on his performance, and provide tutoring, which can be done individually or by groups. But Gaynor (1975) has reported some problems in the use of proctors. They may be difficult to recruit for every PSI course, and proctoring may not represent the best use of the proctor's time. Further, at the time of Gaynor's report, empirical evidence for the effectiveness of proctoring functions (i.e., providing feedback, tutoring, and reinforcement) was "... of uneven quality and incomplete" (p. 35).

But according to Robin and Heselton (1977): "Recent research has indicated that proctoring contributes positively to student achievement, attitudes, and rate of progress in personalized systems of instruction (PSI)" (p. 19). They have pointed out that regular training programs for proctors have been established and that the effectiveness of proctor-training packages has been investigated. Their own study (Robin and Heselton, 1977) showed that a large number of proctors can cost-effectively acquire proctoring skills through the use of a manual on the proctoring role and the specific behaviors required (p. 20).

It has been noted above that a proctor may be either a student previously trained in a course or one currently enrolled in it. Johnson *et al.* (1976), referring to the first type as "external" proctors and the second type as "internal" proctors, have reviewed several studies which investigated the differential effects of "external" and "internal" proctors and have investigated the effects of proctoring duties on the "internal" proctor. Generally, there are no significant differences in the effects of "external" and "internal" proctors, and Johnson *et al.* (1976) believe that any choice to be made between the two should be based on other factors, one of which would be the effects of proctoring duties on the "internal" proctor. They found that students who proctored scored higher on tests than students who did not proctor (pp. 115, 116). It would appear that the use of "internal" proctors could be regarded as an instructional strategy as well as a means of staffing an instructional system.

A closely related practice is the use of "peer tutoring" in individualized instruction. According to Ehly and Larsen (1976), who examined "peer tutoring" in the context of elementary education, the effects of "peer tutoring," on both the tutor and the learner, are generally positive.

A problem that may result from the differentiation of instructor functions as programs of individualized instruction are implemented is the possibly negative impact on the status and prestige of instructors. Bishop (n.d.) has discussed an approach to this problem from the point of view of the public school system, but the issues addressed would appear to have relevance for Army training also. The approach proposed by Bishop emphasizes peer-group evaluation and professional accountability (pp. 19-21).

Facilities

Facilities in individualized instructional settings (as well as in conventional settings) vary widely, ranging, perhaps, from a single student with a programmed home-study text to a sophisticated broad-based CAI/CMI system. Individualized instructional facilities have been considered by the U.S. Civil Service Commission (1977), using the concepts of "active" versus "passive" learning. According to that idea, one essential difference between the teacher-based approach to learning and the individualized approach lies in the relationship of the learner to the source of instruction. In the active role, a learner typically goes to the source of instruction. Conversely, in a passive role, the source typically comes to the learner. In establishing and operating an "active" individualized learning facility, the Civil Service Commission has suggested that, in order to produce a realistic facility design, a balanced relationship is needed among four components: (1) instructional requirements, (2) site characteristics, (3) trainee characteristics, and (4) budget requirements. This section will deal specifically with site characteristics and facilities.

According to the Civil Service Commission, in establishing an individualized learning site, careful consideration should be given to choosing a place where costs and hours expended in travel to and from the site by the learner may be minimized. Further, the actual size of an individualized learning center depends primarily upon six factors. These are: (1) The number and location of individual learning areas (study carrels) desired. (2) The number and location of small group learning areas. (3) The requirement for a storage area. (4) The requirement for a reception and/or lobby area. (5) The requirement for office space. (6) The requirement for media production and/or equipment servicing the individualized instruction.

In choosing an overall environment for an individualized learning center, the idea is suggested that the learning should be conducted in a conducive atmosphere. Not only should the space be adequate, but it should be comfortable, attractive, and serve human needs. The following considerations may be addressed in establishing an individualized learning facility:

1. Lighting.
2. Climate control.
3. Carpeting.
4. Acoustics.
5. The aesthetic requirements.

According to the Civil Service Commission, critical needs in an individualized learning center involve: (1) maximum trainee and instructor access, (2) close proximity to the center of the training population, (3) opportunity to monitor the activities from a single location, (4) flexibility of furniture movement, (5) zoning of conflicting activities, and (6) a non-regimented, pleasant environment. The Civil Service Commission recommends that no more than 10 students at one time be situated in a single small-group study space.

An example of a facilities design for an individualized instructional context is provided by Giordono (1975), in his discussion of the design of a "non-lockstep educational system" at Camden County College in New Jersey. The design of the Camden system, according to Giordono, was based on seven premises: (1) That a conventional education system (i.e., a lockstep system) has inherent failings; mainly that its pace is too fast for the slow students, and not sufficiently challenging for the faster ones. (2) To be responsive to individual differences, an adequate individualized instructional system must have the capability to tailor its instructional sequences to an individual student's needs. (3) Before individualizing instruction, one must first express educational objectives in a more precise manner than is typically done; that is, the educational objectives should be stated in specific behavioral terms that are measurable. (4) A student should not be allowed to proceed into more advanced work without first having achieved mastery of preceding activities. (5) Self-paced learning systems are not necessarily individualized. Their learning packages, when found to be too linear in design, should be adapted to meet the requirements of individualized instruction. (6) An adequate individualized system should be "self-enrolling," as well as self-paced. By "self-enrolling" is meant that students be allowed to start a course at any time. (7) Finally, an adequate individualized instructional system should contain open scheduling whereby students can report to study centers at self-determined times rather than to a classroom at institutionally-determined times. Giordono has quoted Dr. Donald Tosti of the Independent Learning Institute in Corte Madera, California, as stating: "A very effective learning center, therefore, may be nothing more expensive than an office or a classroom where students can come to be evaluated in the concepts they just studied (assignment)." In light of Tosti's statement, Giordono has recommended that every learning center be started simply, using the most inexpensive means possible to achieve precise objectives, no matter how much money may be available for media. More specifically, Giordono has recommended that four types of areas be considered in the design of individualized instructional facilities. The areas should be designed to contain space for: (1) study, (2) monitoring, (3) counseling, and (4) seminars.

Study Areas

According to Giordono an adequate study area should be furnished with individual carrels equipped with electrical outlets to accommodate the variety of powered devices which may be used in mediated instruction, such as tape playback units, slide projectors, film projectors, and CAI carrels. If television is utilized, space should be provided for monitors, portable videotape recorders, and video systems. The Camden study involved the use of a number of nationally-respected consultants in the area of individualized instruction. One of the few requirements for an adequate individualized learning facility agreed upon by the consultants involved the need for appropriately designed study carrels. The use of study carrels appears to be common among programs using individualized self-paced learning, because such carrels are one of the few pieces of equipment exclusively designed for self-study and at which all required hardware can be powered. Where extensive use of hardware is not the case, study carrels are less appropriate, and more conventional equipment may be used.

Monitoring Areas

Giordono recommends that, in designing monitoring areas, one consider such variables as facilitating the scheduling of students, processing mediated materials for use by students, test distribution and scoring, and record keeping.

Although such functions may be accomplished by using manual and/or machine data processing techniques, computerizing of such record keeping functions should be considered when feasible and when the load is large enough.

Counseling Areas

A counseling area should be provided in a separate space or separate room to afford the privacy needed by counselors in orienting students coming into a learning center for the first time, or for interacting with students on an individual basis during specific portions of the individualized curriculum.

Seminar Areas

Giordono suggests that areas be provided to accommodate regularly and/or irregularly scheduled groups which are assigned to use the same learning module or to hear the same presentation.

Simulation Facilities

One aspect of facilities establishment in individualized instruction which will be mentioned only briefly here involves the use of simulators. It is not the purpose of this review to discuss simulation as an aspect of instruction in detail. This has been done elsewhere (see Swezey, 1978, and Van Cott and Kinkade, 1972, for example). In terms of general comments involving simulation as a "facility" in individualized instructional situations, however, guidance has been provided by Pucel and Knaak (1975), and this guidance is briefly reviewed in this chapter under Instructional Media, Materials, and Devices.

Innovative Facilities

Several relatively innovative facilities ideas have been suggested for individualized learning laboratory-type situations. One of these, described by Reedy (1973), involves a concept known as the Maximized Individualized Learning Laboratory (MILL) at the Tarrant County Junior College. MILL was originally conceived as a communications laboratory but ultimately expanded to include all disciplines. Its primary purpose is to provide short-term remediation for students who lack the skills necessary to be successful in a particular program. It is equipped with an electronic flash-card system which gives students both visual and audio instruction in learning serial-type tasks, such as verb lists. Matlick (1974) has shown that a small institution with limited resources can develop a similar facility. Stonebarger (1969) has described a concept known as an "Ideatron," described as a "handsome Buckminster Fuller Dome" richly carpeted on the floor and up the sides just high enough to allow a student to sit on the floor and lean back against the panels of the dome. The dome is constructed such that visual images, either moving or still, appear on various panels, allowing a multi-sensory environment for the learner. Additionally, Stonebarger has described hexagonal bubble-shaped learning carrels for individualized instruction having all hardware out of sight and enclosed in an "organic form of beauty and mystery." Such ideas, although flamboyant, probably have little to do with facilitating the learning process through individualized instruction.

The literature includes descriptions of Learning Resource Centers in institutions such as community colleges (see for example, Douglas, 1970), vocational technical schools (see Collins 1968), and military training centers (see Pieper,

Swezey, and Valverde, 1970). Seidel and Kopstein (1970) have provided a discussion of facility use and resource allocation in Computer Assisted Instruction (CAI) courses. Seidel and Kopstein correctly point out that a major question which impacts the topic of facilities use in CAI (or for that matter, in any form of individualized instruction) is the question of the cost-effectiveness of the particular facilities proposed or incorporated in an instructional setting. Such a consideration implies that not only must costs of facility use be established and considered, but also that effectiveness of the instruction be assessed concurrently. Seidel and Kopstein recommend that standardized achievement tests be the criteria employed in evaluating individualized instructional systems. Such an argument has also been put forth by a number of other authors. The basic argument is that a cost-effectiveness index be established and that facilities costs be amortized over the projected life span of the particular individualized instructional situation.

Descriptions of such major and sophisticated CAI-CMI systems as PLATO, TICCIT, and the Air Force's Advanced Instructional System (AIS) are available. Esplend and Walker (1973), for example, provide a detailed description of the AIS, its facilities, equipment, and PDP-11/20 mini-computer configuration.

In general, excellent guidance on the question of facilities usage and individualized instruction has been provided by Gilbert (1960), cited by Goldstein (1974). In describing the temptations that often lead to a poor environment, Gilbert has stated:

If you don't have a gadget called a teaching machine, don't get one. Don't buy one; don't borrow one; don't steal one. If you have such a gadget, get rid of it. Don't give it away, for someone else might use it. This is a most practical rule, based on empirical facts from considerable observation. If you begin with a device of any kind, you will try to develop the teaching program to fit that device. (p. 478)

Gilbert's remarks are equally appropriate for any device, method, or type of facility, from programmed texts to CAI.

Management

Instructional management is to individualized instruction what "teaching" is to conventional, or "lock-step," instruction. To put the matter another way, the instructor who becomes involved in individualized instruction finds it necessary to adopt not only a new role but new methods as well, and these new methods are concerned largely with the management of the learning process rather than with direct involvement in the communication of the content of learning. Rather than being a medium of instruction, the instructional manager must step away from center stage and become a manipulator of the elements of the learning situation.

But a distinction needs to be made. There are management functions associated with training per se that have little to do with the learning processes to be found in a particular training/learning environment. These have to do with scheduling, the provision of resources, the assignment of personnel, and the establishment of priorities. These functions are of some concern here and

will be dealt with, but of primary concern are those activities, processes, and methods which have as their purpose the guidance of the individual learner/trainee. It is the guidance of the individual trainee that is termed instructional management.

Tosti and Harmon (1972) have defined instructional management, quite simply, as "...those activities involved in the decision to initiate a specific activity for a given student, based upon the assessment of some behavior of that student" (p. 76). Individualized instruction is clearly implied by the definition, but self-pacing is not or is group instruction necessarily precluded. Indeed, it cannot be claimed that essentially nonindividualized instruction does not involve instructional management in the above sense because nearly all instruction involves individualization to some degree. Thus, if nearly all instruction involves some degree of individualization, then individualization exists on a continuum, and it is therefore necessary to define individualized instruction in a way that makes the continuum apparent. According to Tosti and Harmon (1972), "...the degree of individualization must be defined in terms of instructional management. This means that:

Individualized instruction is a function of the frequency with which the decision to change the instructional presentation is made as a result of the assessment of an individual student's achievements, needs or aspirations" (p. 77).

It is, thus, the intensity of the instructional management that distinguishes between what, in a practical sense, we regard as "individualized instruction" or as "lock-step instruction." "Lock-step" may require little or no instructional management as defined above while individualized instruction -- that is, instruction that is individualized to a significant degree -- requires a considerable amount. For this reason, instructional management requirements and capabilities need to be considered in any decision to individualize instruction.

Instructional management requirements vary a great deal from instructional context to instructional context, but the following purposes of instructional management as identified by Tosti and Harmon (1972) are informative:

1. Aspiration Management. Purpose: To select those objectives required to meet a given student's aspirations or interests.
2. Achievement Management. Purpose: To ensure that the student has mastered the objective specified.
3. Prescriptive Management. Purpose: To ensure that a given student receives the materials appropriate to his individual characteristics to best meet the objectives.
4. Motivation Management. Purpose: To ensure alert and continual student interaction with the educational stimuli in order to increase individual learning rates and performance levels.
5. Enrichment Management. Purpose: To provide for access to additional information relevant to the objectives but not necessary for their attainment.

6. Maintenance Management. Purpose: To ensure long-term maintenance of the student's continuing ability to perform at a pre-specified criterion level.
7. Support Management. Purpose: To ensure that such data be collected as necessary to keep the instructional system operating effectively and to provide individuals outside the system with information they require to evaluate and revise the existing instructional system.

Not all of these purposes are relevant to military training, of course, and it may not be feasible to pursue all of those that are relevant -- prescriptive management, for example -- but, as Tosti and Harmon (1972) have pointed out, this list of purposes suggests the possibility of a taxonomy of instructional management strategies. Unquestionably, achievement management, the second type of instructional management in the above list, is of primary concern to Army training, but the failure of such an Army training management model as Individual Extension Training System (IETS) to explicitly deal with prescriptive management, for example, could be seen as a source of possible difficulties with the system. As will be seen later, the Air Force Advanced Instructional System includes prescriptive management.

Taylor et al. (1977) developed the IETS model and developed and field tested prototype training packages. Their overall model of the IETS helps to clarify the relationship between training management and instructional management.

Figure 2 arrays six elements on two perpendicular axes. The elements along the vertical axis constitute the command function, an aspect of training management. The horizontal axis includes the elements of the training system itself, which is primarily concerned with instructional management.

Figure 3 identifies the major management and training functions in the IETS model. Note that the first two functions of the squad leader are instructional management functions (as instructional management is defined above) while the other two, as well as the four major functions of the training managers, may be considered training management functions.

Figure 4 illustrates the activities of the instructor (the training manager as instructor of the squad leader, or the squad leader as instructor of the individual soldier), and it is thus a model of an instructional management strategy. Note that, if alternate TTPs (Task Training Packages) were available, the path from element 4 (does soldier pass checkout?) to element 5 (trainer provides training to soldier using appropriate TTP) would imply prescriptive management as defined above. Without such alternatives, this model of instructional management embraces only achievement management.

During the second year of the IETS development study, reported by Bialek et al. (1978), considerable attention was given to the development of both training management and instructional management strategies. The latter included learning hierarchies (called "road maps") to guide trainers in the selection of tasks to be trained or, more precisely, the sequence of learning for individual trainees. Interestingly, a motivation management strategy, an incentive program, was also explored and found to be probably feasible from a management point of view.

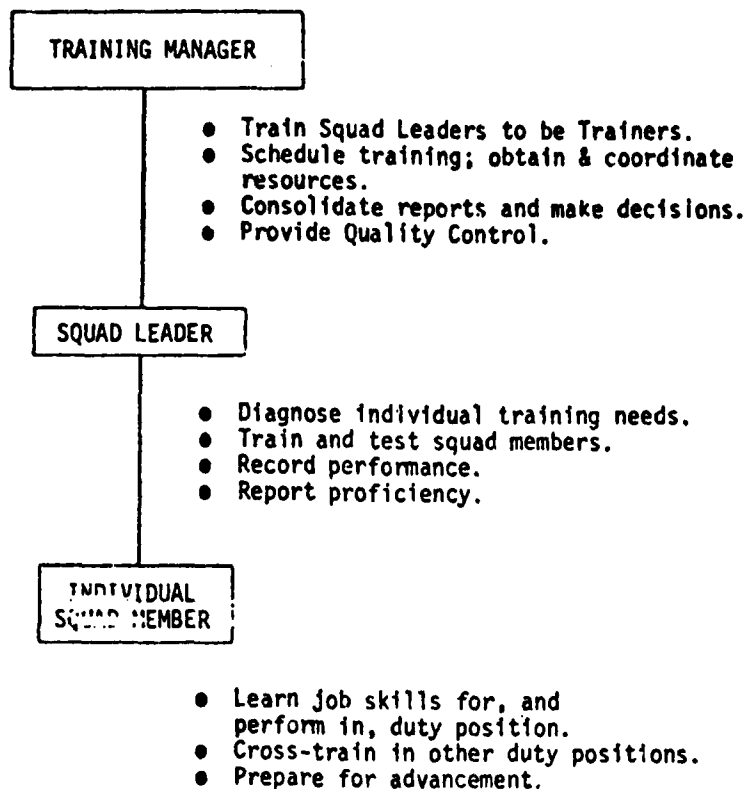


Figure 3. Major Management and Training Functions in IETS Model

(From Taylor, John E. et al., Development of an Individual Extension Training System for Managing and Conducting Training in the Army Unit, ARI Technical Report TR-77-A8, 1977.)

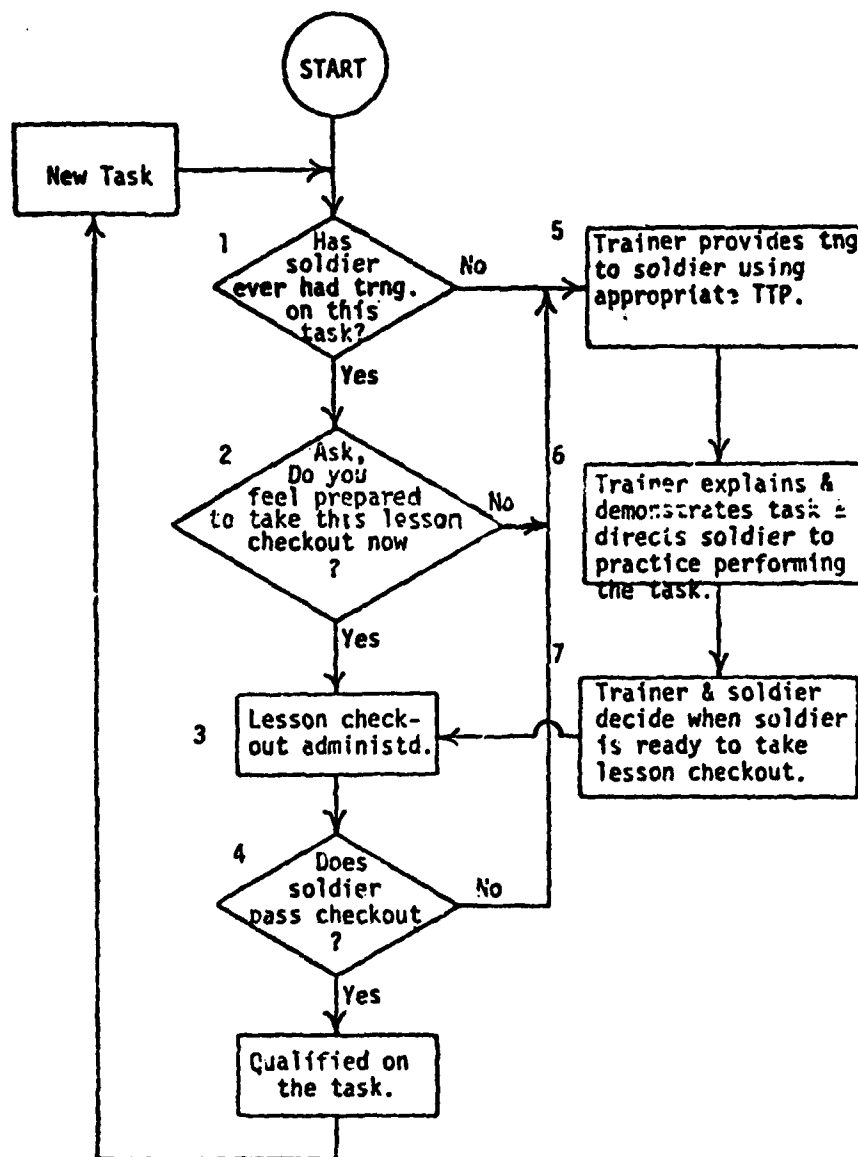


Figure 4. Sequence of Instructor Activities

(From Taylor, John E. et al., Development of an Individual Extension Training System for Managing and Conducting Training in the Army Unit, ARI Technical Report TR-77-A8, 1977.)

Record keeping, an essential aspect of instructional management, also received considerable attention with records of achievement being maintained by both trainee and trainer. Record keeping is, in fact, a persistent problem wherever individualized instruction is attempted, and this aspect of instructional management will be dealt with in more detail later.

Figure 5 is contained in Standard Operating Procedure for the Individual Extension Training System, which was intended as guidance and information for training managers and trainers. It illustrates the involvement of the entire hierarchy from battalion training manager to squad members in the management process, and it strongly suggests that, given appropriate models of individualized instruction, management capabilities adequate to the needs of individualized instruction exist within the Army unit.

Bialek and Brennan, however, reported that the IETS program was not accepted for implementation into the Army for two major reasons: (1) it was not perceived as being needed; and (2) current Army training managers (company level officers and senior NCOs) were confronted with too many and often conflicting organizational demands and job requirements. Bialek and Brennan reported that they do not believe further attempts at implementing IETS will be any more successful than the first attempt was, unless two conditions are met: (a) there is a major change in the current organization, duty allocation and duty preparation of line unit trainers and training managers; and (b) there is a greater awareness on the part of the proponent agencies of the principles of, and procedures for, bringing about institutional/organizational change.

It should be clear by now that introducing the principles and practices of individualized instruction results in much more than a shift in instructional focus from groups of students to the individual student; it results in fundamental changes in the way the business of training/education is conducted. It imposes the need to develop new strategies and techniques -- that is, essentially new management tools -- to solve such newly perceived problems as keeping track of the needs and progress of individual students, re-identifying and reassigning functions, and working out the interfaces of individualized instructional systems with the suprasystems in which they are embedded. In a very general sense, management is the essence of individualized instruction. The strategies and techniques of individualized teaching/learning also demand attention if attempts at individualization are to be successful, but these have been largely implicit in the very principles of learning whose discovery drove the development of individualized instruction in the first place. Conversely, the strategies necessary for the management of the practical demands of these new principles of learning are not necessarily apparent in the principles themselves. The principle of contingency management, for example, has always been implicit in reinforcement theory, but how does one get an instructor to adopt the principle in the first place and, having adopted it, to successfully apply it on the scale necessary in the typical instructional environment? These are, in essence, management problems.

As a matter of fact, one investigation of the benefits to be derived from the application of the new principles of learning, while it involved individualized instruction, was explicitly a study of a management system (Matheny and Edwards, 1974). That is, it was not a system of individualized instruction with a management subsystem that was under investigation but rather a management system that had available to it certain materials given to individualized

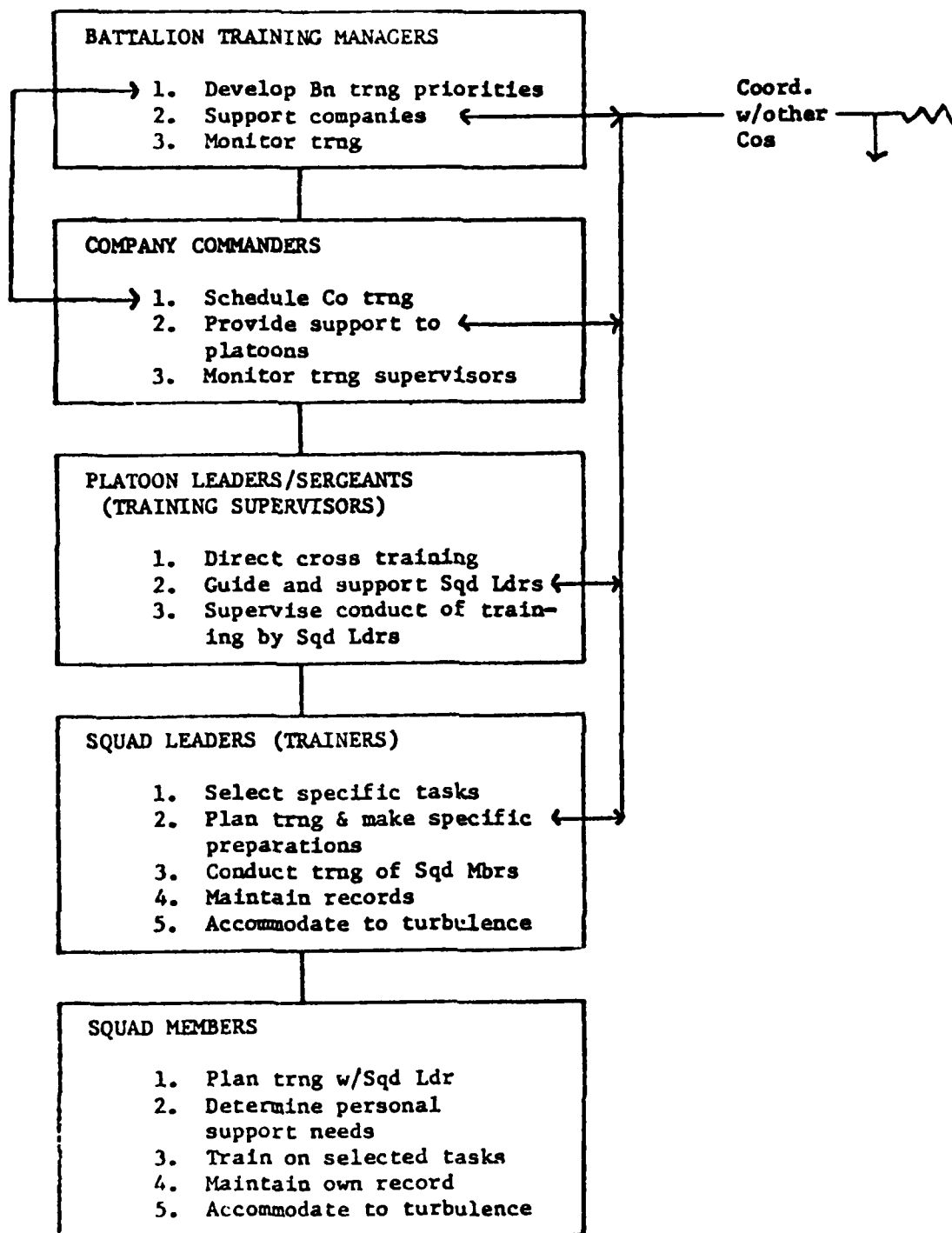


Figure 5. Diagram of Structure and Functions of IETS

(From Bialek, Hilton M. et al., Continuation of Development of an Individual Extension Training System for Managing and Conducting Training in the Army Unit, ARI Technical Report TR-78-BI, 1978.)

instruction. Group instruction was not precluded, nor was the manipulation of contingencies to promote group instruction, but the tendency was toward individual learning. The chicken-or-the-egg nature of the fundamental proposition of the study (that a particular approach to instructional management resulted in increased student achievement) raises an interesting though quite possibly semantic question. Is individualized instruction a species of instructional management or a species of instructional treatment?

Another study of management systems for individualized instruction, conducted by Bosco, Haring, and Bandy (1976), did not answer this question, but it was explicitly an investigation of management systems rather than instructional treatments per se, and it did show that teachers who have at their disposal the means of individualization (detailed guidance as opposed to efforts at philosophical persuasion) are both more likely to believe that individualized instruction represents an instructional ideal and to actually implement individualized practices. Again, the essence of strategy for change was to introduce management strategies, although particular instructional treatments were not held to be unimportant (particular treatments in the form of five commercial reading packages were compared but showed only slight differences). The overall impact of the introduction of the management system was most noticeable in the beliefs and practices of teachers; in the words of the researchers: "The impact of the Management Systems on achievement is not dramatic. While some improvement in achievement was noted, the systems have not led unambiguously to an increase in achievement" (Bosco, Haring, and Bandy, 1976, p. 264). But this limit on the effect of management systems does not reduce the value of these research findings to the Army, which is primarily concerned with the cost savings (through reduced training time) that may be realized through individualized instruction rather than achievement beyond criteria or beyond levels attainable in group/"lock-step" instruction. The problem for the Army is to get individualized instruction accepted and successfully implemented, and one conclusion of this study seems to be highly relevant to that problem:

The five Management Systems investigated in this report appear to have had an impact on teachers' beliefs about ideal classroom practices and the way in which teachers actually function in the classroom. More teachers in the Management System schools than in the Comparison schools view individualization as the ideal way to function. Similarly, a greater number of teachers in the Management System schools reported individualized classroom practices than were reported by the other teachers.

Much of the discussion about individualization has been philosophic or polemic. Generally the specifics of implementation at the classroom level have been given secondary attention with the assumption that if teachers believed in individualization they could work out the details. Each of the five approaches which were investigated in this study provided detailed procedures for the teacher. Given the complexities of individualizing instruction, such a format may be necessary if individualization of instruction is to occur. (Bosco, Haring, and Bandy, 1976, pp. 262, 264)

The re-identification and reassignment of management functions were mentioned above as a problem associated with the implementation of individualized instruction. The IETS model identifies functions, of course, and so do most other unique systems of individualized instruction, but while the essential functions (i.e., those inherent to individualized instruction at any given level of individualization) of particular models of individualization may be inferred from an examination of a number of systems built on those models, there does not seem to be a general taxonomy or catalog of individualized instruction management functions such that a training manager or designer could quickly determine the functional requirements of a set of design options. As a result of the development of an instructional management system, the Instructional Development Center at the Florida Atlantic University (Gorman, 1975) has identified its instructional management functions in a way that is suggestive but by no means generally definitive of individualized instruction management functions (Figure 6). But if communication, physical support, and monitoring are the basic management functions of any system of individualization, regardless of the particular form, one might ask what subfunctions are inherent to a particular form and to what personnel or devices within a training environment for which a form of individualization is being considered these subfunctions might be assigned.

COMMUNICATION	PHYSICAL SUPPORT	MONITORING
1. Provides an array of tasks	1. Reflects the nature of learning	1. Maintains facility and materials
2. Defines task clearly	2. Organized into a learning station	2. Monitors materials
3. Provides levels of performance	3. Supports the task	3. Provides for learner assistance
4. Rationale provided	4. Prerequisite needs identified	4. Receives learner feedback
5. Prerequisites identified	5. Items used identified	5. Provides confirmation of success and certification
6. Exit, diagnostic, prescription, capability	6. Performance models displayed	
7. Task organized	7. Staff both visible and accessible	
8. Presentation controlled by learner	8. Open for extended periods to accommodate learner needs	
9. Performance observable		
10. Provides for application		
11. Provides self-check		
12. Retention provision		

Figure 6. Instructional Management Functions

(adapted from Gorman, 1975)

Another problem associated with efforts to individualize instruction is the working out of the interfaces between individualized systems and the supra-systems in which they exist. One such problem the Army encountered some years ago was the awkward interface between self-paced systems and the personnel management system (Hunter et al., 1973). Trainees who completed training quickly by virtue of the self-paced feature were often held over at their training stations, with nothing productive to do, while awaiting assignment. This problem, now only illustrative of the interface problem, appears to have been solved through a variety of strategies but in no small part through predictions of course-completion times and progress management, two closely related techniques.

Progress management may be seen as a subspecies of achievement management. It consists essentially of predicting completion times for courses or segments of courses from certain learner characteristics, monitoring actual progress toward those completion times, and counseling students accordingly with a view to encouraging them to meet a better predicted time. In at least one case, instruction of the student in time management and in the characteristics and requirements of self-paced instruction is an aspect of progress management. In slightly different forms, progress management is practiced in a number of instructional systems, including the Air Force Advanced Instructional System (AIS), Lowry Air Force Base, the Turret Mechanic Course at the Armor School, Fort Knox, Kentucky, and the Personalized System of Instruction in the Psychology Department of Northeastern University, Boston.

In the AIS at Lowry AFB, student preassessment measures -- reading/reasoning, memory, and certain attitude tests -- are used to predict course completion dates and to establish target completion times for segments of the course. Scores on segments of the course are also predicted, and predicted scores and progress rates along with actual scores and rates are employed in guidance and counseling. It is interesting to note that the AIS also provides for prescriptive management, as defined above, through the selection of instructional strategies that best meet the needs of individual students (McCombs and McDaniel, 1978).

The approach employed at Northeastern University is based on the time elapsed from the passing of the quiz on one unit of instruction to the first attempt at the quiz on the next unit. The measure is called the interquiz interval (IQI), and somewhat like the AIS approach, it is based on a statistical analysis of data for all students. The IQI is used to recommend pace schedules to students (Lazar, Soares, and Terman, 1977).

An interesting approach to the problem of managing individualized instruction is to transfer the management to the students. Such an approach, termed "the Self-Schedule System," is described by Wang (1976). Under this system the teacher prescribes certain curricula, but the student decides when to work on these and on learning tasks which he chooses for himself. This approach may have limited relevance for Army training, but several studies have suggested that it is workable and that it produces a number of positive effects including reduced time to learn (p. 26). Wang and Fitzhugh (1977) have described the computer-based management of information in the context of the "Self-Schedule System." The computer-based "Classroom Information System" provides the teacher with information needed for regular consultations with the student and also gives the student a means of selecting learning activities and recording progress information (pp. 4-6).

It is apparent that individualized instructional management requires the keeping and manipulation of a great deal of information, but it may not require as much as is often actually collected and recorded, and the sheer effort required to manage such information can have detrimental effects, including the abandonment of efforts at individualization. For this reason, Armstrong and Pinney (1977) have suggested that benefits to be derived from information be balanced against the limited time the instructor has to collect and record information. They propose that information needs identified by performance objectives are highly important and must have first consideration while other forms of information are desirable but not a must.

But a more practical and a more and more common approach to the problem of record keeping or data management is the computer-based system. To consider the computer as an instructional management tool, however, requires that a distinction be made between the use of the computer primarily as a deliverer of instruction -- as in computer assisted instruction (CAI), computer directed instruction (CDI), and others that involve at least some direct student-machine interaction -- and the use of the computer to perform or facilitate instructional management functions. While the former type of application also invariably includes certain management functions -- such as keeping records of student achievement -- it is the latter that is of primary interest here, that is, computer managed instruction (CMI).

In the report of a study to determine the feasibility of CMI for Navy training, Middleton et al. (1974) described a view of CMI attributed to International Business Machines Corporation (IBM) and held to represent a consensus of the industry at the time of their study. This view is represented in Figure 7. Each of the five main headings in the figure represents a functional category of CMI, and it is thus readily apparent that CMI as conceived in this view is applicable to nearly every type and aspect of instruction, including CAI. Figure 8, moreover, shows what a CMI system could do. It is apparent that CMI would not necessarily have to provide all of these functions but that only one functional category depicted in Figure 8 deals with the record keeping problem referred to above.

The literature tends to draw a sharp distinction between computer assisted instruction (CAI and closely related forms of computerized instruction), in which the student interacts directly with the computer continually or frequently, and computer managed instruction (CMI), in which the computer is largely or wholly devoted to fairly high level managerial and administrative functions. But some recent developments suggest that this distinction may not be so sharp in actual practice. The Navy, for example, has developed two computer-based systems which appear to lie somewhere between CAI and CMI as they are frequently defined. One, the Computer Assisted Instruction Study Management System (CAISMS), developed by Allesse et al. (1974), provided for only a very limited amount of direct student-machine interaction while the other, called simply a CMI system (Carson et al., 1975), provided for no direct student-machine interaction at all, the interaction coming through input-output delivered by a clerk.

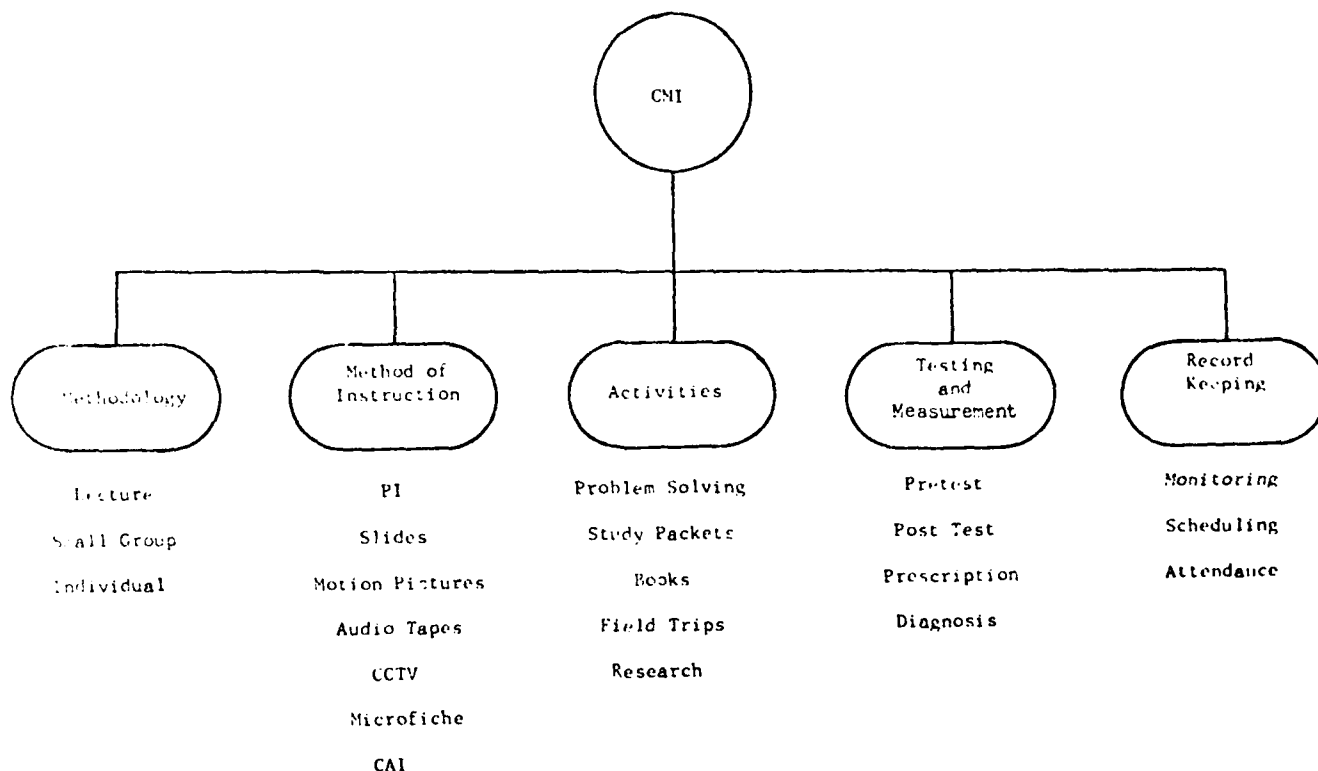


Figure 7. Computer Managed Instruction (From IBM, 1971)

(From Middleton, Morris C. et al., Computer Managed Instruction in Navy Training, TAEG Report No. 14, Naval Training Equipment Center, Orlando, Fla., 1974)

CAISMS (Allessi et al., 1974), while ostensibly a CAI system, was built on existing, ordinary, off-line materials and requires little student on-line time. Its purpose, rather than to deliver instruction as is the case with the typical CAI system, was to maintain "attentive study of instructional materials." It was based on the proposition that the behaviors essential to effective independent learning, even as exhibited by successful students, tend to deteriorate rapidly and thus need to be reinstated through a test-like event (questioning by the computer). The authors cited the demonstrated beneficial effects of "test-like events" on learning, as well as the presumed nature of the cognitive activities (information processing) that result in learning, in defense of this approach. In their view, the information processing activities of students, even good ones, "decay" rapidly during study -- as a result of a variety of factors such as difficulty or length of the material, fatigue, lack

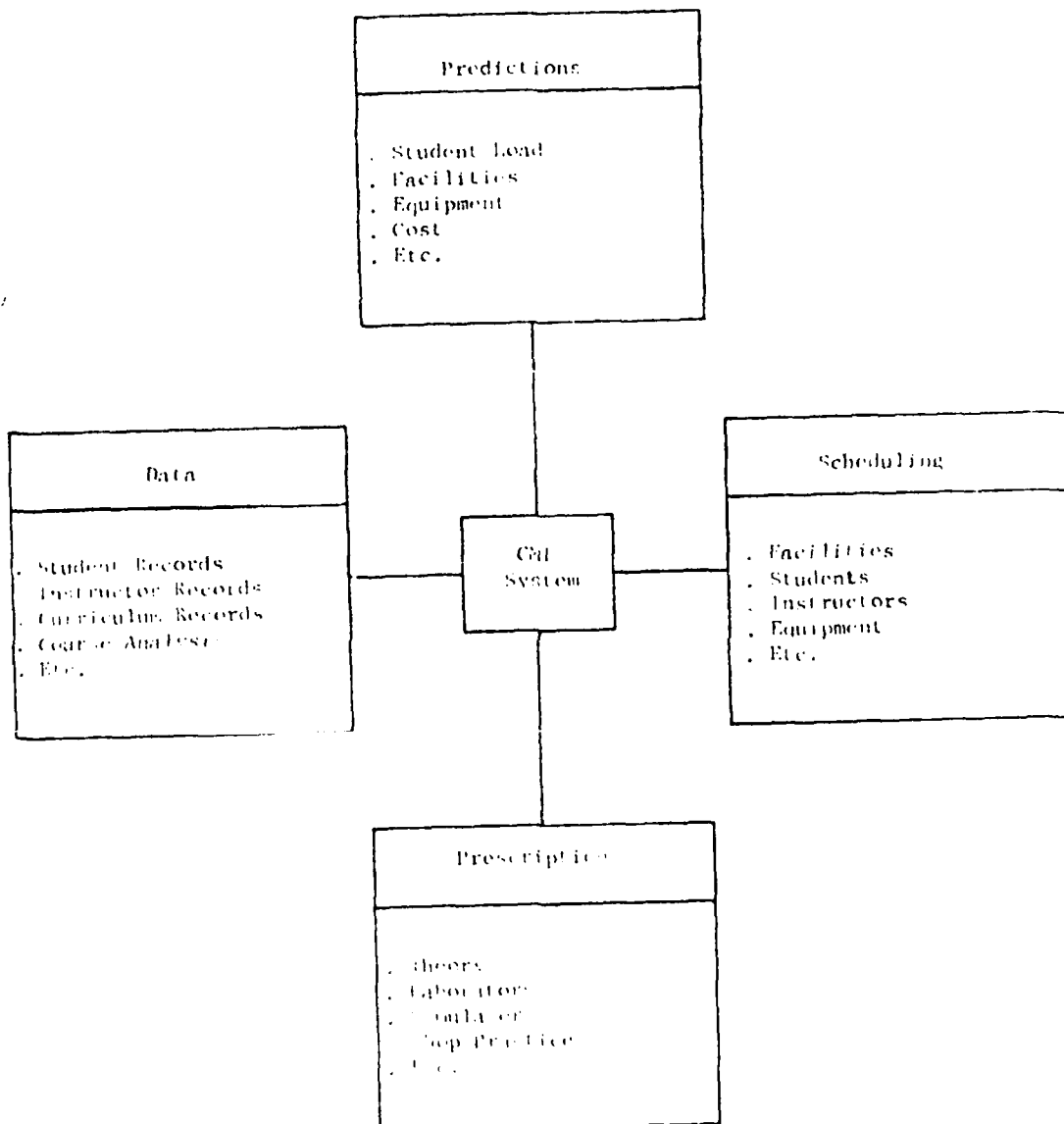


Figure 8. CMI System Characteristics

(From Middleton, Morris C. et al., Computer Managed Instruction in Navy Training, TAEG No. 14, Naval Training Equipment Center, Orlando, Fla., 1974)

of motivation or ability, and time pressure -- but can be restored through appropriate questioning. Thus, the procedure of CAISMS requires the student to sign on the computer at the beginning of study, receive an assignment from the system, carry out the assignment using conventional materials in a nearby study area, sign on again after completing the assignment, and then be quizzed by the system on the assigned reading. The system also maintains records of student progress and attendance and thereby provides for some management functions in addition to the administration of instruction.

The other Navy system of this type (Carson et al., 1975) implemented at the Naval Air Technical Training Center, Memphis, was designed to issue assignments, score tests, provide feedback to the student, and establish management data, but all of these functions were handled off-line. Test responses, for example, were recorded on machine-readable forms, and these were delivered by a clerk to the computer terminal. The clerk returned with print-out of new assignments made on the basis of test results and other necessary information. Students thus interacted with the computer only remotely, spending their time with off-line self-administered learning packages and associated tests. Some of the benefits of both CAI and CMI were thereby obtained without either the cost of continuously on-line CAI or the diminished instructional support of a CMI system devoted to high-level managerial and administrative functions. Chambers (1979) has described the transcontinental on-line use of this system noting that as many as 40,000 interactions with the system may occur each day (p. 7).

Hansen (1975) has reported the successes of CMI efforts in the Navy, in language that can only be taken to indicate a high degree of satisfaction. He has claimed course-time reductions ranging from "24 to 80 percent with a mean of 48.6 percent (p.i.)," personnel costs savings in the millions of dollars, increased performance, reduced attrition, and other benefits. From both the training management and instructional management points of view such results must be considered very persuasive. It is not surprising, then, that Hansen (1975) sees a bright future for CMI in the Navy, including increased cost-effectiveness through such developments as what he terms "adaptive management of systems so as to dynamically match resources with student requirements," by which he apparently means constantly changing allocations of costly resources in response to student needs (p. 126).

A survey of computer applications in the Army (Rich et al., 1974) did not seem to support a view as optimistic as that of Hansen. While the survey results indicated that there was some sort of use of the computer in 116 courses, many of these courses used the computer very little in CMI or some type of CAI application, and about three-fourths were reported to be less than one-fourth based on some form of computer application. Generally, those courses for which a great deal of computer use was reported were those dealing with job skills for which the computer is an important tool (e.g., engineering subjects, information management, risk analysis, test construction, and instructor training). Furthermore, even at this relatively low level of computer application, there appeared to be considerable duplication of effort and a general failure to exploit computer capabilities. Of particular interest as regards training management and instructional management was the finding that there was very little use of the computer for record keeping in support of training.

Sherron (1975), on the other hand, in a study of the use of computers in military training, found that the Army led the other services in training use of the computer in four of the five areas he studied. The source of this apparently minority view is not readily discernible, but Sherron appears to have paid considerably more attention to computer applications to training in the Army than to those in the other military services.

The Future of the Computer in Army Training (Rich and Van Pelt, 1975) is a compilation of the reports of a group of consultants invited to visit Fort Gordon, Georgia, the site of Project ABACUS, a prototype of the Army's evolving Computerized Training Systems (CTS). The consultants were asked to comment on the directions CTS should take in the near and distant future. While it is not possible to identify consensus positions among these experts, beyond certain very general concerns such as with software, it is clear that ABACUS represents a major computerized training development that the consultants treated as a beginning with the potential for developing into a state-of-the-art CTS. Should the potential represented by ABACUS be realized Army-wide there can be little doubt that the management problems associated with individualized training would be solved.

Military training is not a humanitarian enterprise -- it is concerned only with the attainment and maintenance of military skills -- and cannot be guided by the human development goals of education. Still, computer applications to education in general and to civilian instruction in particular have relevance for military training. Military training, of course, attempts to attain and maintain criterion levels at minimal cost while education aims to achieve maximum learning with more-or-less fixed resources, but this difference in overall goals does not dictate fundamentally different methods or approaches at the level of instruction. Prescriptive management, for example (the matching of learning methods to individual characteristics), has become a much-sought-after ideal in education but is very infrequently practiced in military training. (The AIS at Lowry AFB does practice prescriptive management.) But prescriptive management practiced on a large scale, as would typically be the case in military training, requires the management of a great deal of information, and such information management is not practicable without computer support. Thus, it may be that as computer applications to training in the military develop and expand methodological differences between education and military training may diminish.

The Individually Guided Education (IGE) program of the Wisconsin school system is a complex effort to provide for individual needs and abilities on a large scale (Bozeman et al., 1977). It is essentially a form of individualized instruction, but because of its comprehensiveness in the employment of relevant strategies and techniques, the records that teachers must maintain and the instructional decisions they must make are more extensive than is usually the case in individualized instruction. For these reasons, the Wisconsin IGE program is supported by a CMI system that is available to all school personnel. It is known as the Wisconsin System for Instructional Management (WIS-SIM), and it can be accessed by the using teacher through a computer terminal in his building, using ordinary telephone lines. The teacher at the classroom level is thus provided management support that makes the IGE program feasible. It is interesting to speculate on the effects of a CMI system similar to WIS-SIM, employed at the division level or higher, on the implementation of individualized instruction in the Army.

There is a possibility that even widely dispersed Army units could make use of a common CMI system. Ball and Jamison (1972) have shown that the delivery of CAI to dispersed populations through such communications facilities as satellites and telephone lines is economically feasible. It is assumed that if this is true for CAI it is also true for CMI. A system with capabilities such as those of WIS-SIM could probably be made available to widely separated Army units by such means.

While large and complex computer-based education systems have pretty much defined computer applications to education, most of the educational community does not have access to the large machines on which these complex systems depend. Rather, most educators, when they have had computer support available at all, have had to make do with time-sharing on computers devoted largely to non-instructional processing. Daykin et al. (1975) have reported the development of a system much like CAISMS, called BASMS, apparently for Basic language Study Management System. It was written in BASIC because this language is frequently used in mini-computers. It also employed teletype terminals rather than the plasma displays of the PLATO system on which CAISMS was implemented. The interesting point is that a system with most of the capabilities of a system based in a large, dedicated machine was made available through time-sharing on a small machine.

Even relatively simple systems, based in locally available computers, in time-sharing mode, apparently have the capability of making large impacts. Steffenson and Read (1970) reported the case of a system developed by a graduate student (a doctoral candidate) and installed in a machine in the University of Utah Computer Center. The system, more or less built on models of the individualization process, in the words of the authors, "placed the power of the computer at the teacher's fingertips."

An annotated bibliography prepared by Finch (1972) supports the general conclusion that while the computer is not necessary for individualized instruction "... CMI greatly increases the possibility of meeting the needs of the student because of the complexity that is possible" (p. 72).

Learner Characteristics

The most cursory examination of the literature of education and training reveals the pre-eminence of learner characteristics among the factors which most strongly influence the nature of instructional activities. Whether measured on the basis of such theoretical constructs as IQ, aptitude, attitude, and cognitive style, whether derived from such features of personal history as achievement, experience, or social background, or whether consisting of no more than knowledge of age and gender, it is learner characteristics that for the educator or trainer constitute the identity of the objects of instruction. And as the focus of instruction slowly shifts from groups of learners to individual learners, the importance of detailed knowledge of learner characteristics increases.

Growing awareness of characteristic differences among learners has clearly been a force in the shifting of the focus of instruction. In a paper entitled "Factors Related to Individual Training," delivered ten years ago to the Army

Human Factors Research and Development Conference, Taylor (1970) highlighted the significance of aptitude for Army training. As the result of certain policy decisions, the Army faced the problem of training large numbers of men in all categories of aptitude, from Category I to Category IV, and, according to Taylor, research was then being conducted "... to determine the relationship between learning performance and aptitude and to ascertain what, if any, differential training is required for achieving efficient instruction at all levels of aptitude" (p. 1). He pointed out that the established practice was to put trainees into a program together, to give them the same instruction, and to graduate them together -- except for those who did not pass the first time and were recycled through the same instruction. The usual method, Taylor reported (p. 2), was the "lecture-demonstration-practice paradigm," but he questioned the appropriateness of this approach:

A serious problem with this instructional approach, which has been accentuated with the increase in numbers of both low and high aptitude men, is deciding at what level to gear the instruction. If it is at the low ability level, then the more capable are held back with resulting boredom, poor attitude, and low efficiency of instruction. If instruction is generally geared to the upper level, the situation produces many who are failures (unduly high attrition rates) or many who are moved forward without mastering the material. (p. 2)

After outlining research findings that emphasized the needs of low ability trainees, Taylor (1970) concluded that those findings implied:

...that the efficient training of men at all levels of aptitude will depend upon (a) the recognition of individual differences in aptitude, and (b) the design of instructional programs that are compatible with these individual differences. No one single training program, particularly one committed to the group-instruction model, can effectively accommodate the spectrum of aptitude ranging from Category I down through Category IV. (Taylor, 1970, p. 3)

The individual difference variables that Taylor reported as being under investigation included aptitude as measured by AFQT score, reading skills, listening skills, arithmetic skills, certain non-verbal mental abilities, and some demographic and other data taken from the Army Classification Battery (p. 4).

One area of learning research in which concern with learner characteristics is very intense is that dealing with aptitude-by-treatment interactions (ATI). A dozen years ago Cronbach (1967), in a discussion of the adaptation of instruction to individual differences, suggested that "... we ought to take a differential variable we think promising and design alternative treatments to interact with that variable" (p. 32). And, as Boutwell and Barton (1974) have noted (p. 13), ten years earlier Cronbach had called for the design of instruction for groups of learners with similar aptitudes rather than for average learners, thus giving rise to greatly increased aptitude-treatment research, a few examples of which had existed in the literature since early in this century. Boutwell and Barton (1974) expressed the value of ATI research this way:

If educational researchers could (1) identify alternative instructional treatments A and B which lead to the same objective but which call for substantively different learning processes and (2) produce consistent evidence that learners of varying aptitudes or aptitude levels differentially learn better in the two so-identified instructional treatments, then the long awaited promise of systematically adapting instruction compatible with individual differences could become a reality. (p. 14).

But as a result of their review of ATI research, these authors concluded that the expectation has generally not been realized (p. 14). For a variety of reasons, ATI has not generally been usable as a basis for instructional decision-making in the classroom, and one of these reasons, Boutwell and Barton (1974) believed, was the way in which aptitude has been viewed. "Traditional aptitudes" have been measured with instruments designed for predicting student success in "stable" rather than in "adaptive" instructional treatments. What was needed, according to these authors, was "new aptitudes" defined as "cognitive styles." These cognitive styles are mental processes or abilities which the learner has or can acquire and can use to bring about new learning. Such an approach would "... allow the student to enter any instructional treatment at any point, limited only by his entering cognitive processes. From that point on, the student would optimally learn the subtleties of many new cognitive processes in instructional systems which not only teach him these cognitive processes, but also make ongoing instructional adaptations to accommodate his newly-won capability to direct his own learning" (p. 16). It is clear, then, that in the view of Boutwell and Barton (1974) these "new aptitudes" are not merely given learner characteristics but are mental processes that the learner can acquire as a result of instruction. What this approach to ATI is about, according to these authors, is learning to learn.

The problem with looking at the learner characteristic of aptitude in terms of a predictive test is illustrated by the experience of Jealous et al. (1975), who reported an effort to explore "... the scope of the learning capacity of marginal Army personnel...." (Project ABEL). This effort involved actually working with men (volunteers) who had been classified as Mental Category IV on the basis of the Army Classification Battery and had been trained for such jobs as cook and driver. These researchers found that, in spite of the fact that the students had been characterized in one way, that is, as "low-ability," "... there was a broad diversity of ability within the group" (p. 36). Thus, they felt that "collective descriptions" were limited in value and that it was necessary "... to be flexible in the application of the curriculum to an individual participant" (pp. 36, 37). The experience of these researchers suggests the need for a finer-grained assessment of learner characteristics than is afforded by such a standardized instrument as the Army Classification Battery, especially within the context of individualized instruction.

It may be worthwhile to explore the related issues of how detailed the assessment of learner characteristics should be and what learner characteristics should be factors in the design or selection of instructional methods or strategies. The practices established by several similar areas of research and development show a considerable range in this regard. MODIA (Method of Designing Instructional Alternatives): Volume 2, Options for Course Design (Carpenter-Huffman, 1977) employs, for example, a rough categorization of

ability similar to that yielded by the Army Classification Battery. The Air Force Advanced Instructional System (AIS) (McCombs and McDaniel, 1978), on the other hand, has assessed narrowly defined learner characteristics empirically shown to be related to learning criteria. Aptitude-treatment interaction (ATI) research has employed nearly all imaginable ways of looking at learner characteristics, frequently -- if not commonly -- based on available standardized instruments.

To lead up to the AIS approach to learner characteristics -- which appears to be an effective way of assigning instructional treatments to individual learners -- some representative and more-or-less traditional ATI research will be examined first, and then the MODIA method for classifying learners will be considered.

Koran (1972), in a review of ATI research relevant to teacher training, described an experiment in which several apparently standardized tests were used to assess the aptitudes of learners who were then randomly assigned to treatment groups. According to Koran, one of these tests, the "Hidden Figures" test, could be taken as "... an index of general ability...." or as a representation of "... some perceptual processing or analytic skills..." (p. 139). The two treatments (other than the control) consisted of the presentation of a teaching skill (the ability to ask analytical questions) through written text and through video portrayal. Significant interactions between an aptitude test score (hidden figures) and treatment were noted; students with the higher scores on the aptitude test tended to score higher on the criterion (ability to ask analytical questions) when they studied the written text than when they studied the video portrayal. Conversely, students with the lower scores on the aptitude test tended to score higher on the criterion with the video treatment than with the written text. But it is not clear that the conclusions she drew are altogether justified:

Thus, the results of this study support the initial premise that rate and level of learning of a specific teaching strategy vary as a function of model presentation, and that the effectiveness of instructional methods varies among students with such differences being related to trainee aptitudes. (p. 139)

In another study described by Koran (1972), aptitude test scores representing verbal comprehension and mathematical reasoning interacted with the treatments -- inductive versus deductive presentations of the same material through programmed instruction -- not in terms of the criterion test scores but in terms of the time required (pp. 139-141).

In addition to the above measures of cognitive abilities as information about aptitude, Koran (1972) has suggested that performance on criterion pretests could be valuable in ATI research and cited two studies that have demonstrated the superiority of certain treatments for students scoring low on criterion pretests.

Davis et al. (1970) have reported an ATI study in which the individual difference measures were largely those given by instruments "... routinely administered to entering students...." The scores employed were from the following tests:

1. the Michigan State University English Placement Test,
2. the Michigan State University Reading Test,
3. the College Qualification Tests,
4. the Michigan State University Arithmetic Placement Test,
5. the Michigan State University Mathematics (Algebra) Test,
6. an attitude-toward-mathematics scale,
7. a memory test (non-standardized),
8. an arithmetic operations test (non-standardized), and
9. a search task test (non-standardized).

The treatments employed were various modes (overt versus covert responding, constructed response versus multiple-choice) of programmed instruction. With the exception of a weak relationship between reading scores and treatments, no significant interactions were found, and the author questioned "... the utility of measures of general intelligence for prescribing instructional conditions" (p. 203). But they went beyond this assertion to state that "... a number of other more specific ability measures appear to be of questionable value" (p. 203).

Doty and Doty (1964) investigated the effectiveness of programmed instruction as a function of the following student characteristics:

1. cumulative grade-point average (GPA),
2. creativity,
3. achievement need,
4. social need, and
5. attitude toward programmed instruction (p. 335).

They found significant relationships between achievement test scores and grade-point averages, creativity, and social need. They concluded that the results supported "... a hypothesis that effectiveness of programmed instruction varies as a function of student personality variables. Students who learned most from the programmed material (i.e., those with highest scores on the test over the programmed unit) were characterized by relatively low social needs and high academic ability" (p. 336).

In a similar study, Traweek (1964) divided students (fourth grade) into two groups on the basis of their predicted versus actual performance on programmed instruction (arithmetic fractions). One group was considered to be successful and the other unsuccessful. He obtained the following results:

1. Mean score on Sarason's Test Anxiety Scale for Children was significantly higher for the successful students indicating that the successful students reported more tendencies to be test anxious than the unsuccessful students ($t=2.99$, significant beyond the .01 level of confidence).
2. Mean score of the unsuccessful students was significantly higher on the withdrawn tendencies subscore of the California Test of Personality, indicating that the successful students [sic] reported more withdrawn tendencies ($t=2.95$, significant beyond the .01 level of confidence).
3. Mean score of the unsuccessful students was significantly higher on the self-reliance subscore of the California Test of Personality indicating that the successful students reported less tendencies to be self-reliant than the unsuccessful students ($t=2.09$, significant beyond the .01 level of confidence).
4. No significant difference was found between the mean scores of the successful and unsuccessful students with respect to general anxiety, as reported by the Sarason General Anxiety Scale for Children ($t=.60$).
5. No significant difference was found between the mean scores of the successful and unsuccessful students with respect to nervous symptoms, as reported by the California Test of Personality ($t=1.00$).
6. No significant difference was found between the mean scores of the successful and unsuccessful learners with respect to intelligence quotients, as measured by the California Short-Form Test of Mental Maturity ($t=.07$). (Traweek, 1964, p. 219)

His conclusion appears to be of particular interest, pointing as it does to the personality characteristic of degree of adjustment rather than learning ability:

In conclusion, programmed instruction appears to be a promising method of teaching those students whose personality test reports indicated poorer adjustment. Programmed instruction appeared to be an effective method of instruction for the slow learning, as well as those who are average and above. (Traweek, 1964, p. 220)

The effects of individual aptitudes on learning strategies and the interaction between these two phenomena and complex performance is currently a very popular topic in skill learning. Reviews by Bracht (1970) and by Cronbach and Snow (1969) have indicated that the overall effects of aptitude-treatment interactions on skill learning are minimal. In a further review, Cronbach and Snow (1977) found that aptitude-treatment interaction research has generally attempted to determine which learner characteristics can be used to predict the effects of treatments on groups of students with those characteristics. According to a review by Maxey (1973), the following conclusions are warranted:

- o Few or no individual difference/treatment interactions have been solidly demonstrated.
- o The frequency of studies in which disordinal interactions have been found is low.
- o The empirical evidence is often non-convincing in studies that do claim to show such interactions.

Tallmadge and Shearer (1970) have suggested that "despite the evidence of some apparent consistency in the research literature, an overview would certainly uncover more negative than positive findings, and more inconsistencies than consistencies" on aptitude/treatment interactions. Similarly, according to Maxey (1973), the comparative literature on programmed instruction versus other instructional methods is equally nebulous. When taken together, it is suggested that approximately 50 percent of the reviewed studies found that programmed instruction was associated with superior post-instructional criterion performance. In general, the remaining 50 percent found that there were no differences in post-instructional performance of programmed and conventionally instructed students. This is consistent with the findings of Pieper and Swezey (1972), and of Pieper, Catrow, Swezey, and Smith (1973).

The above-cited research -- as well as a great deal of research not cited -- has identified a large number of learner characteristics with some kind of empirically demonstrated relationships with specific instructional treatments. Given that these relationships are generally valid, a question that must arise is this: What are the consequences -- in terms of such training resources as instructor time, media, facilities, and equipment -- of attempting to provide a number of instructional alternatives matched to learner characteristics? It would appear to be a question that ultimately would have to be answered by the teacher or instructor independently designing and implementing instruction in a single classroom as well as by the training manager responsible for a large-scale training program.

One approach to the question for the training manager is MODIA (Volume 2, Options for Course Design, Carpenter-Huffman, 1977). MODIA is essentially a computer-based system for simulating the impacts or results of the host of decisions ordinarily made during the design of instruction. How the student population which is to be the object of instruction should be characterized is one of these questions. MODIA, perhaps reflecting the belief of its developers about how far designers can go in accommodating learner characteristics, provides for no more than four (4) categories of ability and only two (2) categories of some other characteristics (such as male-female, young-old) (pp. 42-44). Thus, the designer could characterize students in terms of ability ("... defined as the competencies required to learn the subject ...") (p. 42) as: "slow" or "fast"; "slow," "average," or "fast"; or "slow," "slower than average," "faster than average," and "fast" (p. 43). If he needs a characteristic other than ability to describe learners, he may add such dichotomous categories as male-female or young-old but still only to a total of four categories. He could therefore, for example, categorize students as "slow and female," "slow and male," "fast and female," and "fast and male" (pp. 43, 44). On the basis of such categories "diverse approaches" (instructional alternatives) are planned and the consequences examined. But MODIA does not make choices of instructional alternatives on the basis of learner characteristics; the designer must make the choices while MODIA reveals the impacts (resources required) of those choices (pp. 2 and 42-44).

McCombs and McDaniel (1978) have examined the state of ATI research, summarized the methodological and theoretical problems that may have inhibited the application of ATI findings to the design of individualized instruction, and identified a methodological approach to ATI which has been developed within the context of the Air Force Advanced Instructional System (AIS) (pp. 1-9). Briefly, this AIS approach can be described as "... one of identifying the particular combination of cognitive and affective, trait and state characteristics that are most related to successful task performance on particular tasks within an instructional sequence" (p. 9). They defined traits as "relatively stable individual difference characteristics" and states as "transitory individual difference characteristics which are influenced by changing situational factors" (p. 8).

The AIS approach to ATI is too complex to be adequately treated within the scope of this review, but for the sake of establishing a comparison with traditional ATI research and with the fairly gross matching of learners and treatments represented by MODIA, a rough summary is attempted. The AIS methodology did involve going to the literature -- and appealing to expert judgment -- to identify instructional alternatives suited to particular needs of learners, but the design variables of instructional alternatives were empirically developed for each instance of a lesson requiring alternatives. The AIS procedure apparently began with the identification of lessons that had "... demonstrated excessive first attempt failure rates or large variabilities in times or score -- indicating that one treatment was not effectively meeting the needs of all students" (p. 14). Then multiple step-wise regression was employed with certain student characteristic predictors on the criterion variables of time to criterion and test scores. "The best predictors became the design variable for the alternative modules, and they represented various combinations of cognitive and affective variables most related to performance on specific lessons" (pp. 14, 15). Thus, "... if reading ability were less important than memory ability in predicting student performance, increasing the amount of drill and practice and adding specific memory aids or organizers would be suggested over strategies designed to compensate for reading deficiencies" (p. 16). This procedure does not, therefore, select an instructional alternative from among a set of alternatives on the basis of learner characteristics, but rather, on the basis of an empirically demonstrated relationship between relevant learner characteristics and certain criteria of a particular lesson, suggests what the design of an alternative should incorporate.

The learner characteristics employed to develop several alternative strategies (in this case called "compensating strategies" -- see McCombs and McDaniel, 1978, p. 6) for AIS were memory abilities and pre-course motivation, in terms of anxiety and curiosity, as measured by the pre-course test battery administered to all students. The "compensating strategies" developed were generally effective for students with low memory ability, low curiosity, or high anxiety, but it is important to note that McCombs and McDaniel (1978) considered the highly developed, computer-based environment of the Air Force AIS to have been an important factor in the success of this methodology:

In an instructional context of this nature, it appears obvious that a methodology which can utilize actual student performance data on particular learning tasks in the selection of where and what kinds of strategies to develop, will lead to the development of more efficient and cost-effective

alternative strategies than an approach based purely on judgment and/or prior research. (McCombs and McDaniel, 1978, p. 74)

Because of the prominence of perceptual-motor learning in Army training, it may be worthwhile to briefly examine some aspects of the work of Fleishman (1967), though the bulk of it appears to have been done more than a decade ago. The individual difference variables examined by Fleishman in a number of studies appear to have relevance for the development of alternative individualized instructional treatments.

In Fleishman's view (1967), abilities are basic and "relatively enduring" traits that are related to both the learning and the performance of a variety of tasks. Skill, on the other hand, refers to the level of proficiency achieved on a particular task, but skill can be "... described in terms of the more basic abilities" (p. 167), and the level achieved may depend on the basic abilities involved. Thus, the rate of learning and the skill level achieved with practice will differ for individuals who are different in terms of their basic abilities (pp. 167-170). Further, knowledge about basic skills permits predictions about future performance, and there is the suggestion in Fleishman's work that basic abilities should be developed early in life because of their stability in the adult (p. 168).

Fleishman and his associates have devoted a great deal of effort to the study of specific human motor abilities, including such aspects as fine manipulative performance, gross physical proficiency, positioning movement, static relations, etc. This work has revealed a tentative taxonomy of human motor abilities. Nineteen abilities are called out by this taxonomy. They include: control precision, multi-limb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity, finger dexterity, arm/hand steadiness, wrist/finger speed, aiming, extent flexibility, dynamic flexibility, static strength, trunk strength, gross body coordination, gross body equilibrium and stamina.

There is no need here to reproduce Fleishman's (1967) taxonomy of motor abilities; it is enough to offer a few of the individual difference variables as examples and to point out that in many studies these variables have accounted for human performance on a large number of tasks (p. 174). Several of these individualized difference variables which appear particularly relevant for Army training are:

- o Control precision. This factor is common to tasks which require fine, highly controlled, but not overcontrolled, muscular adjustments, primarily where larger muscle groups are involved....This ability extends to arm-hand as well as to leg movements. It is most critical where such adjustments must be rapid, but precise.
- o Response orientation. This ability factor has been found general to visual discrimination reaction psychomotor tasks involving rapid directional discrimination and orientation of movement patterns.... It appears to involve the ability to select the correct movement in relation to the correct stimulus, especially under highly speeded conditions.

- o Rate control. This ability involves the making of continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving target or object....This factor is general to tasks involving compensatory as well as following pursuit, and extends to tasks involving responses to changes in rate. Our research has shown that adequate measurement of this ability requires an actual response in relation to the changing direction and speed of the stimulus object, and not simply a judgment of the rate of stimulus movement alone. (Fleishman, 1967, pp. 174, 175).

Because Fleishman and a colleague have developed a successful training program on the basis of their knowledge of the ability requirements of a complex tracking task (p. 182), it is interesting to speculate on the probable results of employing something like Fleishman's taxonomy (and associated instruments) within the AIS methodology for developing alternative ("compensating") learning strategies.

Fleishman's approach to training in motor skill areas advocates experimental investigation of the basic abilities underlying the requisite skills and a training program aimed at tutoring subjects in the relevant abilities. This approach has been shown effective in a variety of studies (Parker and Fleishman, 1960; Pancer and Fleishman, 1961; Fleishman and Fruchter, 1960). His work is aimed primarily at the identification of relevant individual differences among trainees in terms of their abilities and at the development of training programs around these individual difference characteristics.

Course Content or Task Types

The purpose of this section is to briefly review the content areas or task types that have most typically been approached through individualized instruction. Because individualized instruction has been so widely implemented, however, such a review can be no more than suggestive. (Chapter IV of this review lists the content areas or task types typically associated with specific systems of individualized instruction, and Chapter III and Chapter IV consider the structure of content.) Since skill learning is most likely to constitute the content of any military system of individualized instruction, the nature of skill learning is also briefly examined.

The major conclusion is that the benefits of discovery learning or problem solving are most effectively utilized in situations where a great deal of adaptivity and a broad assimilative set are required. Guided or prompted learning, on the other hand, is best utilized in more structured situations resulting in narrow requirements for subject assimilation.

In a major treatise on learning skills, Fitts and Posner (1967) have suggested that skill learning is essentially a three-stage process. The first phase is generally a cognitive phase, in which the student attempts to understand the task and its demands. In this stage, attention to perceptual cues and response characteristics and knowledge of results as a training strategy are important. Attention to various kinesthetic and visual aspects of the task is important in the cognitive phase of skill learning. Here, instructions and demonstrations, as well as structured programmed techniques, are appropriate.

The second stage of skill learning, according to these authors, is the intermediate or associate phase. During the intermediate phase of skill learning, old habits which have been learned as individual units during the early phase of skill learning are tried out and new patterns begin to emerge. Errors (grossly inappropriate subroutines, wrong sequences of acts, and responses to the wrong cues), which are often frequent at first, are gradually eliminated. This phase lasts for varying periods of time, depending on the complexity of the skill and extent to which it calls for new subroutines and new integrations.

During the second stage, proper scheduling and sequencing of practice on the component aspects of the task are important. For example, Koch (1923) asked subjects to type finger exercises using two typewriters simultaneously. The groups that began by practicing with each hand separately before attempting to use both hands simultaneously made faster initial progress and maintained this superiority when they went on to practice the two-hand task than did the groups that began by using both hands. This result clearly favored training in the separate components to training for the whole task from the start.

The final stage of skill learning, according to Fitts and Posner, is the so-called "autonomous" phase. During this phase of skill learning, component processes become less directly subject to cognitive control and, therefore, less subject to interference from other ongoing activities. In this phase, skills require less processing. This means that they can be carried on while new learning is in progress or while an individual is engaged in other perceptual and cognitive activities. Appropriate training strategies for this stage suggest that practice not only renders an activity less susceptible to interference from a second task but permits the subject to allocate more of his capacity to the second task, thus indirectly enhancing performance on that task as well.

In a CAI setting, Phillips and Berkhout (1977) addressed the relative effectiveness of different formats of CAI in teaching a psychomotor performance task. In that study, a control group received instruction, based on the study of written materials and unstructured practice sessions, on a gear shifting task. Two experimental groups, however, were trained under similar practice conditions with the addition of computer-aided (a) monitoring of performance and (b) feedback of supplemental information to the students. Both forms of CAI proved to be significantly superior to control teaching procedures in this psychomotor task. In this particular study, both experimental groups received feedback regarding their performance. One group received terminal feedback of numerical performance quality scores. The other received continuous feedback of an analytic display concurrent with each trial. This approach is considered to be unique in that CAI is generally not utilized to give subjects immediate feedback of psychomotor output parameters, although it has been demonstrated by others that feedback of information indicating the relationship of a student's performance to a control model can serve to improve performance. Holding (1965), for example, demonstrated the beneficial effects of performance feedback in air-to-air psychomotor gunnery skills; and Kelly (1968) employed augmented displays in which subjects were able to predict how their control actions approximated those necessary to achieve system goals in a psychomotor task. Augmented displays and controls, such as those employed by Kelly, were determined to effectively impact psychomotor performance tasks.

Welford (1968), in a monumental work on skill acquisition, has suggested that the durability of learning is much firmer and more resistant to extinction in motor contexts than in cognitive ones. Having reviewed the literature on the

question whether information provided in training about a given task should concentrate on general principles or, alternatively, detailed rules of procedure, Welford determined that the research findings suggest that for complex tasks instruction in principles yields better results than does laying down a detailed, repetitive drill type of instruction. For simpler tasks, the drill approach is at least equally effective. The reason, as suggested by Welford, is that a complex task commonly involves a number of alternative sequences of actions, each appropriate to particular varieties of a circumstance under which a task is carried out. Attempts to reduce this to drill type learning, will require, at best, that a variety of drills be learned. This in turn introduces competition and ambiguity among the components of learning. Welford has suggested that the predomination of initial experience is important in skill learning situations. This has been affirmed through other studies (Bilodeau *et al.*, 1964; Welford *et al.*, 1950). First experience, thus, is seen as being very important in skill learning contexts.

The theory behind this approach is that experience is presumably bound up with a cumulative nature of learning. When a person encounters an entirely new problem, he must construct his solution from past experience dealing with different problems. Once he has done this an outlined method exists for use in dealing with similar problems on subsequent occasions. Even if the constructed method is not the best possible, it is generally more efficient than it would be to work out new methods for each possible situation in skill learning.

Welford has suggested that very little learning occurs when the student is a passive spectator (or even a passive performer). The student must be involved in active decisions and choices about what he is doing, in order to retain information about alternative strategies which are right or wrong in various skilled performance contexts. Welford's review of the literature on knowledge of results of actions, and on aims and incentives, concluded that, other things being equal, the more precise the knowledge given of the results of action, the more accurate the actions will become over a series of trials. As regards incentives, Welford suggested that speed of learning is substantially influenced by relevant incentives (including, as one type of incentive, knowledge of results).

Content Area Variety

The wide variety of tasks and content areas to which individualized instruction has been successfully applied is demonstrated by such studies as those by Dupuis and Bell (1974), who developed a modular individualized approach to a vocational curriculum in automotive repair, which consisted of 281 separate tasks. The tasks called for varying degrees of theoretical study, practice, and demonstration along with demonstrated competency. Dupuis and Bell were able to establish that modular organization permits efficient use of staff, is easily transferable to general education, and tends to ensure the careful handling of individual differences in their automotive maintenance situation. Combs (1975) reported on an individualized instruction project applied to an electrical engineering curriculum. Combs concluded that "individualized self-paced instruction is a viable model that can optimize achievement of the sometimes conflicting goals of the student, the instructor, the institution, and the public, which ultimately pays the bill" (p. 406). A unique aspect of Combs' program involved a method for dealing with student procrastination. Combs attacked this problem by requiring individual conferences with students and by posting periodic student progress charts. Combs, like Craver (1974) and Roth (1973), found individualized instruction to be particularly appropriate for college level electrical

engineering courses. Shakhashiri (1975) has described an individualized instruction project in an undergraduate chemistry course at the University of Wisconsin-Madison. The program, termed CHEMTIPS (Chemistry Teaching Information Processing System), was designed to monitor student progress, to identify specific student weaknesses and strengths, to prescribe individual study assignments, and to obtain student feedback for use as a guide in modifying teaching strategies and efforts. The CHEMTIPS program was determined to be effective and is currently in use in a variety of undergraduate courses at the University of Wisconsin's several campuses. In a university-level food and nutrition course, Boren and Foree (1977) employed a personalized, competency-based instructional strategy and evaluated it as an alternative to a traditional teacher-directed method. Sixty-four students were exposed to either a teacher-directed (control) or experimental (self-paced) group. Data from pretests and post-tests indicated that the control and experimental teaching strategies were similar when cognitive objectives were evaluated. The experimental strategy, however, was superior to the control method in teaching psychomotor competencies. The basic conception of individualized instruction in this situation was Keller's (1968) PSI approach.

An article by Lunetta and Dyrli (1971) has reviewed the topic of individualized instruction in science curricula. Lunetta and Dyrli provided an in-depth discussion of the "Winnetka Plan" (Washburn and Marland, 1963). According to Lunetta and Dyrli, large-scale projects like the Winnetka Plan have not survived for two very good reasons. First, too much responsibility is typically placed on teachers for the development of individualized materials, while they have also been required to devote full time to normal classroom duties; second, teachers involved typically are not well prepared to develop the required supporting individualized materials. Goodlad and Anderson (1963) similarly have reviewed curricula in numerous "nongraded" elementary schools. However, those authors have concluded that few such schools make significant departures from tradition in attempting to individualize instruction. One particularly good example of an individualized instructional program in an elementary school, however, was conducted at the Oak Leaf Elementary School by the Learning Research and Development Center (LRDC) at the University of Pittsburgh. The Oak Leaf project used the University of Pittsburgh's Individually Prescribed Instruction (IPI) method. Additional evidence of the effectiveness of IPI has been reported by Cohen and Shepler (1962), who cite a study by Heathers which "appears to support the basic assumption that the tests used in the IPI structure for diagnosis and self-assessment on the part of the pupil are not nearly as great a threat to the student as the tests utilized within a typical school environment."

In secondary school applications, Lunetta and Dyrli have cited effective individualized science programs developed by DeRose (1968), Mim (1967), and Ashenfelter (1969). One proposal which represents a radical departure from tradition and which appears to have potential for promoting individualized instruction was suggested by Swartz (n.d.). According to Lunetta and Dyrli, in the Swartz plan the student proceeds through each individual goal at his own pace, directed by a "teacher-counselor" who uses various diagnostic devices to assess competency. The student operates from a "home base carrel" in a school environment similar to a modern library, and an individualized curriculum is developed to support the school operation. This particular plan appears to be somewhat comparable to the Army's widespread TEC (Training Extension Course) program employed throughout the United States Army in numerous content areas.

A study by Leffert (1976), with the intriguing title "Nine Ways to Individualize MacBeth or Anything Else," described a model for individualizing instruction based on the interaction between students, content, and strategy of teaching. Incorporated into the model were considerations of students' degree of socialization and independence. This was reflected in the ways in which students were grouped. A study by Mink and Watts (1973) addressed the topic of Reality Therapy and personalized instruction. In that situation, a program was developed which attempted to internalize the external orientations of non-traditional students through individually styled instructional components and reality-based counseling strategies. It was determined that "control orientation" for the individualized students generally shifted toward greater internality, and that approximately 78 percent of the students entering the individualized program completed the spring quarter (a higher than average persistence rate).

Miller (1976) has reviewed research on individualized instruction in mathematics and has found 145 studies which met his definition of individualized instruction in mathematics curricula. A large proportion of the studies he reviewed (31 out of 145) dealt specifically with the University of Pittsburgh's IPI program. Of the 145 studies he reviewed, Miller concluded that 15.9 percent were negative, 36.4 percent positive, and 47.7 percent neutral toward the topic of individualized instruction in terms of student achievement. He arrived at these conclusions by rating each of the studies on a five point scale as follows:

- 0 = Significant results in favor of control groups.
- 1 = Mixed results; some significant, some not significant in favor of control groups.
- 2 = No significant results for either individualized instruction or control groups.
- 3 = Mixed results; some significant, some not significant in favor of individualized instruction.
- 4 = Significant results in favor of experimental (individualized instruction group).

Using a similar rating on student attitude, he found that approximately three percent of the studies were negative, approximately 76 percent neutral, and approximately 20 percent positive, in terms of student attitudes toward individualized instruction.

Miller identified five studies which addressed the question of retention in individualized instruction in mathematics. Bazik (1972) and Smith (1972) both found no significant differences with prospective elementary teachers in terms of retention. Hirsch (1972) found no significant difference for retention when comparing a guided discovery method with an individualized instructional method in an algebra course. Chatterley (1972) also found no differences in retention among seventh grade students. Kontogianes (1972), however, did find a significant difference favoring an individualized group of prospective elementary school teachers. Miller concluded that the question of retention in individualized instruction has not been adequately considered in the mathematics context and that the results reported by the cited studies are equivocal.

He has reported only three studies which addressed the issue of transfer of learning as it relates to individualized instruction in mathematics. Hirsch (1972) found that a guided-discovery group performed significantly better than did an individualized group in terms of transfer of learning. The two additional studies did not employ control groups. Beemer (1970) found that transfer of learning was positively related to intelligence in individualized instruction; and Lipson (1966) found that probability of learning transfer increases as a student's background in arithmetic increases. Miller reported an interesting trend in individualized instruction in mathematics when the duration of the study was compared to student achievement. Of 88 studies on achievement cited by Miller, duration was specified in 66. Eight of those ran for less than a semester, 19 for a semester, 29 for a year, and 10 were longer than one year. It appears, according to Miller, that "as duration of the individualized instruction studies increases, the achievement average decreases." Thus, according to Miller's review, the shorter the experiment on individualized instruction, the higher the student achievement.

Miller found 36 studies which addressed effects of student ability level in individualized instruction in mathematics. Of the 36, 12 studies found that no particular ability group was favored, and five indicated that high ability students in an individualized method did better than high ability students in a control group. Seven studies favored average ability individualized students, and 9 favored low ability individualized students. Miller found six studies which stated specifically that one teaching method was better than another in terms of rate of progress for learning the mathematics material. Three of these (those by Crangel, 1971, Crosby, 1960, and Drake, 1935) found that control groups required less time. Two studies (Bull, 1971, and Fisher, 1966) found that individualized methods were faster. One study (Frase, 1971) compared two individualized programs and found that a guided-discovery approach was significantly faster than an individualized approach.

Military Studies

A recent application of Keller's PSI program in the Navy has been reported by Brock, DeLong, and McMichael (1975). Brock et al. applied PSI along with a job task analysis approach to a propulsion engineering course in Navy schools. They concluded that, under the PSI approach, Navy students learned well and in approximately 20 percent less time than under the lockstep methods previously used. These results confirm others reported by Kulik, Kulik, and Carmichael (1974), and by McMichael and Corey (1966), in college psychology courses.

In addition to the Training Extension Course (TEC) program, the Army has reported successful individualized instruction programs at the Transportation School (Training, 1975), in the area of helicopter maintenance, and at the Ordnance and Chemical Center (Oliver, 1977) in the area of automotive maintenance training. A recent Army study by Bialek and Brennan (1978) has described results of attempts to implement the Army's Individual Extension Training System (IETS) in two infantry battalions. According to Bialek and Brennan, the IETS program is designed to operate at the squad and/or platoon level and below. The IETS system includes six characteristics which make it consistent with and responsive to current Army training doctrine. These are as follows:

1. The system interacts well with the Army's Enlisted Personnel Management System and its supporting Skill Qualification Tests.

2. The system is MOS-duty position oriented.
3. The system is tailored for application in units.
4. The system decentralizes training responsibility.
5. The system calls for the conduct of job training at the level of the individual squad member.
6. The system calls for self-pacing of instruction.

Instructional Methods

In their essential form, the methods of individualized instruction appear to be those which have evolved from reinforcement theory. Hess and Lehman (1976) have identified eight major methods of individualized instruction and suggested that six of them "... share common roots with programmed instruction both through relation to a common reinforcement theory framework and by close professional association among the tradition founders" (pp. 16,17). By "tradition" Hess and Lehman (1976) mean "major methods" (that is, well established and extensively investigated approaches to individualization), and they have identified the following "major methods" or "traditions:"

1. Mastery and Modular Instruction. According to Anderson (1978), "Mastery learning can be described as a set of group-based, individualized, teaching-learning strategies which is based on the premise that virtually all students can and will learn what the schools have to teach." Hess and Lehman (1976) attribute the use of behavioral objectives and the hierarchical ordering of objectives to this "tradition."
2. Individually Prescribed Instruction and/or Learning Activity Packages. Perhaps the most characteristic feature of IPI is the assessment of the characteristics of the learner and the use of this assessment to develop a prescription for learning that matches the instructional approach with the learner's characteristics.
3. Contingency Management and Contracting. This method involves the identification of "... appropriate reinforcers in the natural educational environment..." and the careful arrangement of them "... as explicit consequences for desired performances..." (p. 19). A contract between teacher and learner may also be negotiated.
4. Programmed Instruction. PI is characterized by "... the sequencing of instructional materials with particular attention to the use of prompts, fading, and branching to achieve gradual transitions from one step in the instructional sequence to another in order to produce the lowest possible student error rates..." (p. 19).
5. Audio-Tutorial Method. This method (sometimes known as the Postelthwait method) "... is most distinctive in its attention to the presentation of instructional content through a variety of media available in a 'self-instructional carrel' equipped with the

necessary hardware. The method's strength lies in its attempt to present instructional activities in the sensory mode preferred by the learner and to integrate experiences from various modes into a meaningful whole" (p. 19).

6. Computer-Assisted Instruction and Computer-Managed Instruction. Since about 1961, "... the computer has increasingly served as a problem-solving tool, a tutorial device, an automated information retrieval system, and as a data management aid" (p. 19).
7. Personalized System of Instruction (PSI). According to Hess and Lehman (1976), the central feature of PSI (Keller Plan) "... is its use of proctors to reverse the difficulties attributable to high faculty/student ratios" (pp. 19, 20). According to Robin (1976) the approach is also characterized by self-pacing, unit mastery learning, lectures and demonstrations as motivators rather than sources of information, and emphasis on written material to communicate content (pp. 314, 315).
8. Precision Teaching. "As it is employed in higher education, precision teaching is distinguishable from PSI only in its use of response rates for the criterion test of terminal performance rather than proportion of correct discrete responses" (Hess and Lehman, p. 20).

While Hess and Lehman (1976) examined only individualization in higher education, their list of major methods appears to be complete as regards individualized instruction at all levels of education. As they have pointed out, all of these methods are now the common property of elementary, secondary, and higher education, though they were originally developed for particular levels. "The traditions of Precision Teaching, Contingency Management, Individually Prescribed Instruction, and Mastery Learning were implemented extensively at elementary and secondary levels of education prior to their introduction in higher education. Personalized instruction and Audio-Tutorial traditions were developed first in the context of higher education and later extended to lower educational levels" (p. 18). But their list does not seem complete as regards military training. Adaptive learning models and progress management, as employed in the Air Force Advanced Instruction System, for example, could be seen as creating unique methods. The question is whether those innovations should be regarded as new methodological approaches or simply as new features of individualized instruction developed within the framework of an existing major method.

Hess and Lehman (1976) claimed that the following features of individualized instruction are most frequently found in the literature:

1. Outcome Specification: Stating desired terminal student performance in clear measurable terms which can be reliably observed by all persons involved in instruction.
2. Repertoire Assessment: Determining the number, kind, and degrees of skill and experience available to student prior to his entrance into a given instructional sequence.

3. Individual Prescription: Tailoring the content and procedures of an instructional sequence to the capabilities, interests, and prior experience of the learner.
4. Learner Selected Objectives: Desired outcomes of an instructional sequence are specified by the student rather than the instructor.
5. Active Responding: Frequent observable responses to or manipulation of materials employed in the instructional sequence.
6. Explicit Contingencies: Systematically arranging for rewarding or aversive consequences to follow precisely defined behaviors of the learner.
7. Immediate Feedback: Minimizing the delay between a learner's behavior and information to the learner about the quality, quantity, accuracy, or completeness of his performance.
8. Frequent Feedback: Maximizing opportunities for the learner to assess adequacy of his performance.
9. Successive Approximations: Arranging for each step in an instructional sequence to require an achievable increment in the learner's performance toward the desired outcome of the sequence.
10. Self-pacing: Progress through an instructional sequence across time is controlled by the learner rather than the instructor or an arbitrary schedule.
11. Mastery Criterion: Requiring a high level performance of the outcome specified for a given step in an instructional sequence as a condition for progress to the next step in the sequence.
12. Use of Proctors: Providing repeated testing, immediate scoring, unavoidable tutoring, and a marked enhancement of the personal-social aspect of the educational process by using students who have already mastered a step in an instructional sequence to monitor, prompt, and praise the performance of students at work on that step.
13. Critical Information Written: Presenting skills or concepts, which a student will be required to demonstrate at a later time, in a form permitting the student to recycle through the material until a performance criterion has been reached.
14. Multi-media Presentations: Matching the media used in an instructional sequence to the types of objectives specified and to the characteristics of the learners engaged in instruction.
15. Computer-Assisted Instruction: Using computers to display and sequence instructional activities, and to evaluate, consequence, and prescribe remediation for a learner's performance. (Hess and Lehman, 1976, pp. 15, 16)

Within a matrix with instructional methods arranged along one coordinate and features of individualized instruction arranged along the other, they showed which features were usually present in which methods. From this point of view, adaptive learning and progress management might be seen as features of CAI and progress management as a feature of contingency management.

Robin (1976), in an extensive review of the literature pertaining to Personalized System of Instruction (PSI or Keller Plan), took the position that Personalized System of Instruction and Precision Teaching, above, as well as three very similar "methods," represent alternative approaches to what he called "behavioral instruction," implying their common "... derivation from principles of contingency management and reinforcement theory" (p. 314). He listed the characteristic features of behavioral instruction in its original form as given under Personalized System of Instruction, above, and then described that original approach as follows:

The instructor incorporates these features into a course by breaking the reading material down into a series of small units and preparing materials for each unit which consist of instructional objectives, study guide questions, and clarifications of ambiguous points. A student reads the unit materials and learns the answers to the study-guide questions. He then comes to class, where he takes a written quiz consisting of a subset of the study questions themselves or closely related questions. A proctor evaluates his answers and provides immediate feedback. If the student has answered the questions to a high level of mastery, typically above 80%, he can advance to the next unit at his own pace. If he fails to reach the mastery criterion, he restudies the materials and retakes the quiz until he does reach criterion. Grades are based primarily on the number of units mastered, with a small percentage based on midterm and/or final examinations. The proctors are typically advanced undergraduates who have recently completed the course at a high level of mastery. Attendance at the occasional lectures by the instructor is optional.

The above description applies properly to PSI, or Keller Plan. Shortly after the development of this approach, variations began to appear. One substituted oral interviews for written exams during which the student answered essay-type questions or discussed readings before a proctor, instructor, or another student. Satisfactory demonstrations of mastery of the content permitted the student to go on to the next unit while an unsatisfactory performance resulted in restudying the material before another interview (Robin, 1976, p. 315).

Another, called the Performance Session (pp. 315, 316), also substituted oral responding for written exams, but the rate of correct responding was measured rather than simply the number of correct responses. The student would read a number of randomly selected fill-in type questions out loud as a proctor noted the time required and the number of both correct and incorrect responses. To pass, the student had to be within a minimum rate of correct responding and a maximum rate of incorrect responding. Both rates were empirically developed. The Group Remediation System, a third variation of PSI, involved teacher-paced,

group-administered quizzes with immediate feedback provided by the instructor. The first of two weekly quizzes was on new material while the second was a make-up. The student who failed the first quiz had to take the second in order to receive credit, but the second quiz was the final one (p. 316). A fourth variation assigned point values to a large number of activities representative of role behaviors of psychologists (the approach was evidently implemented in a psychology course), and the final grade was determined by the accumulated points.

Robin (1976) found that PSI and its four variations shared: (1) short units, (2) behavioral objectives, (3) frequent testing, and, (4) immediate feedback (p. 316). Four of the five also shared unit mastery, self-pacing, and proctors (p. 317).

He also reviewed research on the effectiveness of these approaches, collectively considered as behavioral instruction. He reviewed 30 studies comparing behavioral instruction with lecture-discussion methods and found that 30 of them favored behavioral instruction. Of the remaining nine studies, two partly favored behavioral instruction, six reported no differences, and only one favored lecture-discussion (p. 320). His analysis showed a 9% difference between the mean achievement scores of behavioral instruction and the lecture-discussion methods. He also found that behavioral instruction was superior to lecture-discussion in providing for long-term retention. Seven of the studies he reviewed included tests administered 2 to 24 months after instruction, and all seven showed that behavioral instruction was superior in this regard, with an average between-groups difference of 13%. Two other studies suggested that students exposed to behavioral instruction may perform better in lecture-discussion courses than students exposed only to lecture-discussion (p. 321), and 14 of the 16 studies that included attitude surveys favored behavioral instruction while two showed that students were equally positive (p. 322).

On the negative side, Robin (1976) found that behavioral instruction has historically been troubled by higher student withdrawal rates than those found in comparable lecture courses, that students typically spend more time studying in behavioral instruction courses than in comparable lecture courses (p. 322), and that the studies yielding effectiveness evaluations show certain methodological weaknesses (p. 323). Still, he concluded that behavioral instruction is consistently superior to lecture-discussion methods (p. 327).

Having reviewed research that assessed the overall effectiveness of behavioral instruction, Robin (1976) turned to an examination of the contributions that the various features of behavioral instruction make to that overall effectiveness. He examined, in turn, (1) self-pacing, (2) the mastery requirements, (3) emphasis on written content, (4) the use of proctors, (5) the use of study objectives, (6) assignment length and frequency of testing, (7) grading, (8) the use of lectures, and (9) student-treatment interactions. His findings in regard to several of these features are summarized below, and his conclusions follow.

Procrastination tends to be a problem when self-pacing is a feature of instruction, and two basic kinds of approaches to the problem have led to evaluations of self-pacing as an aspect of behavioral instruction: deadlines have been imposed, and prompts and reinforcements have been provided to encourage acceptable progress. Generally, students working under deadlines make faster

and steadier progress than students under the pure self-paced condition. While deadlines appear to increase rates of progress, they do not seem to affect achievement. But this finding may reflect the much higher drop-out rate in the self-paced condition. Such prompts as student self-monitoring and such reinforcements as the promise of early final exams or points awarded for early completion of a course have improved progress through courses without influencing performance on tests. Several studies reviewed by Robin (1976) suggested that the rate at which students under a reinforcement condition take tests is fairly tightly controlled by the reinforcement contingencies. He concluded that in the literature there is "... a consensus that (a) self-pacing is often associated with procrastination; (b) both deadline and positive incentive systems can effectively combat procrastination and produce steady, evenly distributed rates of unit completion; and (c) limiting self-pacing has no effect on academic achievement" (p. 330). Robin (1976) reviewed a study by Bijou, Morris, and Parsons (1976), who also found that incentive systems can be employed to modify self-pacing in order to reduce procrastination.

Robin (1976) reviewed studies in which the effect of the unit mastery requirement was examined through designs that compared various levels or kinds of criteria. One study found that a requirement of 100% mastery resulted in achievement superior to that produced by a 50% requirement and that, while students with low grade-point averages scored less well on review tests than students with high grade-point averages, the students with low grade-point averages studied sooner and more regularly under the 100% mastery requirement (p. 331). He concluded that the four studies he reviewed demonstrated "... that the unit-perfection requirement contributes significantly to behavioral instruction" (p. 331).

He also reviewed several studies which investigated the effects of the length of study units and the frequency of testing. Because of methodological problems in the studies, however, he was not able to draw definite conclusions. Still, the findings of the studies, especially the one that avoided confounding frequency of testing with unit length, appear to favor the pairing of short units and frequent testing (pp. 338, 339).

Robin's (1976) attitude toward the lecture as a possible feature of behavioral instruction is interesting. He acknowledged that behavioral instruction has been demonstrated to be superior to lecture systems in producing student achievement, but he pointed out that the differences in achievement may be the result of certain important features of behavioral instruction not found in lecture systems. That is, lecture systems of instruction may be less effective than behavioral instruction because of what they do not contain rather than because of what they do contain. He apparently believed that there are uses for oral presentations within behavioral instruction (p. 342).

As regards the contributions of the various features of behavioral instruction, Robin (1976) concluded that: "Frequent testing, proctoring, the unit-perfection requirement, and study objectives have been shown to contribute to the effectiveness of behavioral instruction. The evidence is unclear for short unit length. Self-pacing and optional lectures are not necessary for behavioral instruction to be effective, and both written and oral test formats are equally effective" (p. 343).

It seems reasonable to assume that the findings that apply specifically to the systems of individualized instruction which Robin (1976) has collectively

called "behavioral instruction" are broadly generalizable to other systems of individualized instruction built on behavioral principles. Still, it may be well to recall Hess and Lehman's (1976) warning about the SLI (Something Like It) course. "The SLI course may have involved many modifications not derived from reinforcement theory, upon which PSI is based, or from experience with this method. Due to mislabeling of the effort, a promising method of instruction may be banned from that institution for years. In contrast, systematic modifications based on results obtained through the application of appropriate experimental designs are desired and expected" (p. 13).

Williamson et al. (1976) have reported a study involving more than 150 students and a two-year time span, in which various lecture and discussion approaches were compared with an arrangement they said was "... very similar to that described by Keller" (p. 20). In fact, the arrangement described in the report of their study appears to be the SLI mentioned by Hess and Lehman (1976, p. 13). It cannot be concluded on the basis of the description provided that this SLI included any of the elements of Keller Plan, or PSI, as described by Robin (1976). Not surprisingly, Williamson et al. (1976) found that their lecture and discussion approaches generally produced better final exam performances than the arrangement which they regarded as PSI (p. 21).

Similarly, Schoen (1974) reported a study of an attempt to combine the lecture method with a form of individualized instruction that might be characterized as an SLI. In a college-level mathematics course for freshmen elementary education majors the established practice had been to provide two one-hour lectures each week followed by a problem-discussion period. Because some students expressed dissatisfaction with the problem-discussion sessions, it was decided that, as an alternative, the course content would be incorporated in self-paced modules with multi-media learning activities. This alternative arrangement, requiring completion of all modules by the time of the final examination but with no time or attendance requirement, became the experimental treatment of the study with the established practice as the control. On the basis of final exam scores, no significant differences between groups assigned to the two treatments were found. Though this study lacked methodological finesse (there was no random assignment of subjects to treatments, for example), the findings seem reasonable enough until it is noted that 80% of the grade of each student in the experimental treatment was based on examinations on the content of the lectures and only 20% of it on performance in the "individualized" modules (p. 648).

Thus, the concern of Hess and Lehman (1976) about the SLI course would seem to have some basis in the literature, and caution in appealing to the research literature for empirical support of one methodical approach or another would appear to be needed.

It will be recalled that mastery learning, as one of the discrete methods of individualized instruction identified by Hess and Lehman (1976), was not included by Robin (1976) in the set of methods which he described as "behavioral instruction." But mastery learning, because it is regarded as a form of individualized instruction, can be both group-based and teacher-paced, and may be more appropriate to some instructional contexts than so-called behavioral instruction, needs to be examined in some detail.

Block (1977), one of the leading figures in the development of the tradition or method known as mastery learning, has claimed that mastery approaches

have worked so well that they provide worthwhile guidelines for the individualization of classroom instruction. The four such guidelines he has formulated are:

1. Variety is not necessarily the spice of classroom life;
2. Individualized classroom instruction need not necessarily be individual-based and student-paced;
3. Start small; and
4. Respect the ecology of the classroom; strive for what can be the case.

By the first guideline, he meant that individualized instruction must not be thought of as merely the providing of a "variety of ways" to learn but rather as the providing of effective ways well correlated with learning goals. In his view, mastery learning strategies have sought uniformly high levels of both achievement and learning rates through techniques which minimize individual differences. The second guideline refers to the practice of individualizing group-based, teacher-paced methods through what he has called "feedback/correction" procedures. These procedures consist of diagnostic tests to provide feedback to both student and teacher and to redirect learning efforts to alternative strategies, or "corrections," some of which are group activities and some of which are individual but with apparent emphasis on group activities. The third guideline reflects both the difficulties, such as disinterest on the part of teachers, that frequently attend efforts to promote or establish the individualization of instruction and his practice of directing his ideas about mastery learning to teachers who seem interested and encouraging them to try out mastery techniques in "bits and pieces." The fourth proposes that attempts to individualize instruction be neither intrusive nor aimed at rapid change.

Brandt (1976), in an interview with Block (James H.), has revealed some of the notions that underlie mastery learning. There is the conviction, for example, that the techniques of mastery learning have greatly reduced the significance of individual differences. Underlying this conviction is the assumption that nearly all individuals can learn what the schools have to teach given the appropriate treatment. Thus, the tendency is toward homogeneous achievement, and as regards achievement, at least, individual differences are lost sight of. As a matter of fact, ability differences in students appear to be seen, in Block's view at least, as a function of instructional practices rather than of individual psychological characteristics. If, therefore, the appropriate instructional treatments are provided for each individual, each individual will learn as well and as quickly as all others. The appropriate treatment for one individual, however, may be group-based, teacher-paced instruction while for another it may be individually-based, self-paced instruction. But there seems to be a preference for group instruction, which is considered to be highly effective, especially as a means of controlling procrastination. Anderson (1975) has explained the assumptions implied in these views in considerable detail.

Hess and Lehman (1976, pp. 17, 18) have claimed that mastery learning as well as the audio-tutorial approach "... may be clearly differentiated from the other traditions by noting that: (1) their practitioners have not generally been trained in behavioral technology, and (2) applications of their instructional features are not systematically derived from reinforcement theory."

They have also quoted Keller as saying, apparently in reference to the mastery and audio-tutorial traditions, that "... these are examples of psycho-technology in the absence of the psyche, or perhaps, the role of the Zeitgeist in educational innovation." Robin (1976), for his part, did not include mastery learning and audio-tutorial instruction in his review of what he termed "behavioral instruction" because they were "... not originally derived from reinforcement theory" (p. 314).

There would therefore appear to be at least hints in the literature of at least one methodological/philosophical division of which the instructional developer should be aware. Block and Tierney (1974), as a further example, reported a study in which Keller's PSI and Bloom's mastery learning strategy were characterized as "... the two best known approaches to mastery learning..." (p. 962). The study indicated that a certain feature of Bloom's strategy (a "correction" procedure) was effective while the corresponding feature of PSI was not. What effect the assumed equivalence of these two methods might have had on the validity of conclusions drawn from this study is a question the instructional developer should consider.

Still, there would appear to be evidence that mastery learning strategies are effective in doing what they propose to do. Taylor (1975), citing Block (1971, 1973) and Bloom (1973), stated that there is "... considerable evidence that mastery learning procedures work well in enabling about 80% of the students to reach the same high level of performance usually attained by less than 20% of the students under non-mastery conditions" (p. 1). In her own study, however (1975), she failed to find differences in achievement attributable to differences in the effects of the mastery and non-mastery models which she investigated, though she did find that an adaptive mastery model (one which adjusted the amount of practice provided on the basis of learner performance) reduced the time required to learn.

Mastery learning strategies appear to depend heavily on the effective use of available time and the closely related assessment of achievement on which instructional decisions are based. Besel (1971) and Denton and Seymour (1978) offer representative studies of these problems.

Individually Prescribed Instruction (IPI) has been identified as a major instructional method by Hess and Lehman (1976), but it was not included by Robin (1976) in the group of methods which he characterized as "behavioral instruction," though Hess and Lehman (1976) apparently did regard it as having been based on reinforcement theory. Because of its strong emphasis on individual differences, furthermore, it is clearly not akin to either mastery learning or the audio-tutorial tradition. How, then, should IPI be characterized?

Bolvin and Glaser (1968), in a discussion of the goals and needs that guided the development of IPI, identified themselves (and apparently also other IPI developers) as educational technologists. Perhaps this orientation, as opposed to the psychological orientation of the developers of "behavioral instruction" or the classroom-teacher orientation of the developers of mastery learning and audio-tutorial instruction, accounts in part for the distinctive nature of IPI. Certainly, as Hull (1973) has put it, IPI is "... a very systematic approach to individualization" (p. 169).

Bolvin and Glaser (1968) identified the "working aims" of the development of IPI as the following: "(1) to provide for reliably assessable individual differences among learners, (2) to develop mastery of subject matter as the child moves through the curriculum, (3) to develop self-directed and self-initiated learners through instructional procedures which provide for self-selection and self-evaluation, and (4) to provide opportunities for the child to become actively involved in the learning process" (p. 829). One of their assumptions, as was the case in mastery learning, was that most students could master the subject matter if the instruction could be adapted to their needs. As they described it, IPI incorporated these features:

1. Behavioral objectives.
2. Detailed diagnosis of entering learners (prerequisite behaviors, aptitude, learning styles, and perceptual and motor capabilities).
3. Adaptive, alternative instructional procedures.
4. Continuous monitoring and assessment of performance.
5. Optimization of desired learning gains (retention, transfer, gain scores, motivation, etc.).
6. System self-improvement capability.

Hull's (1973) description noted also IPI's guidance of the learner through written prescriptions for learning, a large amount of sequenced material, program evaluation through curriculum-imbedded tests, and commercially available packages. He also pointed out that the IPI teacher's time is spent mostly in management activities and that evaluations of IPI are generally positive, both as regards the affective domain (students' self-concepts and motivation were generally improved, for example) and the cognitive domain (the performance of IPI students, for example, is as good as or better than the performance of other students on standard tests). It is interesting to note that Hull (1973) has claimed that IPI "... has produced the most encouraging results with disadvantaged, rural, special education, Indian, and Mexican-American children" (p. 170).

Glaser and Nitko (1970) have placed IPI in perspective by examining the "... major patterns of adapting to individual differences" (p. 14), both those that exist and those that are possible. These patterns, as described by Glaser and Nitko (1970, pp. 14-16), may be summarized as follows:

1. Relatively fixed educational goals and instructional methods.
2. Student is provided with curriculum on the basis of his assumed future role.
3. Instructional treatments vary according to individual needs, but two extremes are possible: one is represented by the provision of a mainstream of instruction from which students are branched for remediation; the other begins with detailed diagnosis of the learner's characteristics and on this basis, develops instructions specifically for him.

It was their view that IPI "... falls somewhere between the extremes of the third pattern, that is, between remedial branching and unique tailoring" (p. 17). They added, however, that all models of individualization are limited by "... technical capability and the extent of knowledge about human behavior" (p. 86).

Programmed instruction (PI) has been around long enough that it probably does not have to be defined or described, but because it apparently no longer gets the serious, intense attention it once did, a brief examination may be worthwhile. Espich and Williams (1967) have offered this definition of PI:

Programmed instruction (PI) may be defined as "a planned sequence of experiences, leading to proficiency, in terms of stimulus-response relationships." This definition, although not complete, is a very adequate general statement.... By this definition, a program is an educational device that will cause a student ... to progress through a series of experiences that the programmer believes will lead to the student's proficiency (p. v).

The term proficiency points to the need to answer such questions as how well, how quickly, and with what aids while stimulus-response relationships identify the techniques of PI as those of behavioral science (p. v).

Briggs et al. (1967) have reviewed some of the research concerned with the comparative effectiveness of PI as well as some utilization studies. Very generally, they found that about half the studies they considered showed no difference between PI and conventional instruction while the other half favored PI. Further, utilization studies indicated that when PI was added to other means of instruction there was a positive effect on achievement attributed to PI, and that PI tended to be teacher-independent in that PI alone was as effective as PI plus a teacher.

Davis et al. (1970) reported that the type of PI (overt versus covert or constructed versus multiple-choice responses) had no effect on achievement. Doty and Doty (1964) found that there was a "modest" relationship between social need (recognition and approval) and achievement in PI, while Traveek (1964) has reported that PI appears to be effective for both the poorly adjusted and the slow learner. Maxey et al. (1972) found that the results of a study comparing programmed text, platform lecture, and multimedia instruction in an Army course (supply procedures) favored the programmed text, and they concluded that this superiority derived from the greater control over the learner inherent in programmed instruction as compared with the other methods (p. 23). They also found that a test they developed was reliable for predicting which students would most likely derive more benefit from programmed instruction than from the other methods.

A methodological examination of computer-based training -- as a major method of instruction in the sense of Hess and Lehman (1976) -- is difficult, both because of the broad range of computer applications in training (see, for example, Rich et al. 1974) and because of the extent to which it incorporates features that are common to most other major methods (see Hess and Lehman, 1976). To add to the difficulty, the examination of a large number of particular systems of computer-based education/training leads to the impression that

most such systems lie somewhere on a continuum between the pure form of CAI (in which the learner spends all of his time interacting with the computer through a terminal) and the pure form of CMI (in which the computer provides management support for the learning process but no direct interaction between the learner and the computer). Because, as Hess and Lehman (1976) have pointed out (p. 17), there is a close affinity between CAI as a method and programmed instruction (PI), such a continuum would imply that the further a particular system lies from CAI the less its techniques of instruction would resemble those of CAI and PI (that is, those consisting of the very deliberate application of principles derived from reinforcement theory). Conversely, it would also imply that the closer a system lies to the CMI end of the continuum, the more its techniques would be drawn from methods that are not computer-based. PLATO (Smith and Sherwood, 1976) and TICCIT (Rockart and Morton, 1975) appear to represent CAI in a more or less pure form while WIS-SIM (Wisconsin System for Instructional Management, Bozeman et al., 1977), which operates remotely from instructional activities, appears to represent the extreme of the CMI end of the continuum. Somewhere between these extremes would be the Army's Computerized Training System (CTS) (Seidel et al., 1978), close to PLATO and TICCIT in its early CAI form but then shifting toward the other-end of the continuum as its purpose shifted from CAI to CMI. CAISMS (Allessi et al., 1974), with its very limited on-line time would perhaps lie closer to CMI than CAI. The Navy CMI system described by Carson et al. (1975), with no on-line time at all, would be found not far from WIS-SIM, while the Air Force AIS (Advanced Instructional System) (Judd et al., 1979) would apparently be somewhere between CAISMS and the Navy CMI system.

It may also be informative to methodologically compare computer-based systems of instruction on the basis of the third of the three broad patterns which Glaser and Nitko (1970) have identified in educational practice and theory (above). Within this third pattern, it will be recalled, two extremes are possible: one is characterized by a mainstream of instruction from which students are branched for remediation while the other consists of instruction designed specifically for the individual learner on the basis of a detailed diagnosis of his characteristics. The Army's CTS (Seidel et al., 1978) apparently employs strategies more representative of the first extreme than of the second: students who fail post-tests are assigned off-line remediation (pp. 75, 76) -- that is, they are branched out of the mainstream -- though in one course there is a limited attempt to address individual differences by classifying students as "high," "low," or "medium" performers (p. 68). The "high" performers tend to get less detailed instruction than the lower performers while the "low" performers get more audio-visual instruction than the "high" performers (p. 68). The Air Force's AIS, on the other hand, would appear to represent the other extreme in that it attempts to select from among available alternative learning modules the one "... which is most appropriate..." for a given student (Judd et al., 1979, pp. 12, 13).

The methods of computer-based training/education systems are considered in more detail in Chapter IV of this review, Systems of Individualized Instruction. The computer as medium and training device is examined in this chapter under Instructional Media, Materials, and Devices. Furthermore, adaptive learning techniques and the special form of contingency management which is called progress management are considered to be features of particular systems of individualized instruction and are thus dealt with in some detail in Chapter IV.

Contingency management in general, however -- at least according to Hess and Lehman (1976) -- may legitimately be considered as method and is thus treated below.

A common function of individualized instruction is adaptation of the learning situation to individual needs and characteristics, but the term adaptive training appears to apply properly to a special form of such adaptation. McCombs (1978), in a discussion of aptitude-treatment interactions (ATI) as an approach to adapting the learning situation to the individual learner, has said that "... adapting instruction to the individual learner requires that one know the student's characteristics -- his/her unique aptitudes, abilities, attitudes and interests -- as well as the unique characteristics of differing instructional alternatives" (p. 2). Thus, when something in the learning situation has been designed or prepared to accommodate the characteristics of the individual learner, the term adaptation would appear to be suitable. When something in the learning situation (a learning variable) is altered in response to learner performance, however, the term adaptive training applies. According to Wheaton et al., (1976) "'Adaptive training' is a more modern term for part-training where the 'parts' chosen and/or the advancement of learning are a function of the trainee's performance" (p. 63). Then designing or preparing instruction in response to assessed learner characteristics would not be an instance of adaptive training. "Simply sequencing problem difficulty from easy to difficult is not 'adaptive training;' some variable must be altered as a function of [learner] output to be adaptive" (p. 64). Crooks (1978) has reported a study of automated adaptive skill training that provides a useful illustration of adaptive technique. He found, incidentally, that the effectiveness of adaptive techniques in motor skill training is open to question.

The term adaptive training appears to apply particularly to the automation of instructor functions, especially in the realm of simulation. In a discussion of adaptive training as applied to flight simulation, Caro (1969) has identified instructor functions that he considered desirable candidates for automation:

1. problem selection or determining what the trainee is to do,
2. briefing the trainee on the problem to be performed,
3. demonstrating ideal or desired performance to the trainee,
4. scoring or evaluating the trainee's performance against a standard,
5. modifying or shaping trainee behavior, and
6. debriefing or providing feedback to the trainee concerning his performance (p. 571).

But he concluded that adaptive training was a suitable approach to only the first of these, problem selection. On the other hand, the developers of the Army's Adaptive Computerized Training System (ACTS) (May et al., 1977; May et al., 1978; and Crooks et al., 1978) have apparently embraced also at least aspects of the third and fifth of these instructor functions in an "intelligent" CAI system. ("Intelligent" CAI systems are further discussed under Instructional Media, Materials, and Devices.)

Riedel et al. (1975) have reported the development of a non-automated adaptive training system within the context of an experiment, but their position was that this was done because of resource constraints and that if the techniques employed were successful the system would be automated. The experiment was designed to determine the effect of adaptive techniques on performance on an arc-welding simulator, but no significant difference between adaptive and non-adaptive (fixed) strategies was found (p. 6).

In a similar study Cote et al. (1978) examined augmented visual feedback on performance within the context of an adaptive training system. No effects attributed to the feedback condition were found though subjects trained in the automated adaptive condition exhibited less tracking error in the transfer task. It should be noted, however, that these findings are at odds with those of other researchers and that Cote et al. (1978) have carefully qualified their negative results. The question of the effect of augmented feedback in an adaptive training system, however, apparently remains open (p. 108).

Hansen et al. (1973), in a report of the development of adaptive instructional models for the Air Force Advanced Instructional System, have presented a taxonomy of adaptive instructional models (pp. 10, 11). It is the final category of this taxonomy, Automation Models, that appears to account for adaptive training as defined above; the other classes of models apparently relate the learning situation to learner characteristics rather than to ongoing learner performance. From this perspective, adaptive training models would be a subset of adaptive instructional models. But Hansen's taxonomy suggests that all such models are feasible only in computer-based training programs when large numbers of trainees are involved. Even adaptive learning models implemented in -- and studied in -- public schools (presumably with relatively small groups) appear to depend on the computer (Colbert and Wang, 1978, and Taylor, 1975). In brief, while adaptive instructional models (of which adaptive training models are a part) appear to approximate Glaser and Nitko's (1970) ideal of individualized instruction uniquely tailored to the individual, they represent advanced instructional technology and appear to require a high level of effort, including computer support. Casmey (1976), in a discussion of computer-based education as an approach to adaptive learning, appears to contend that the computer is an essential aspect of adaptive educational programs.

Contingency management (or reinforcement management) has been widely applied in education but apparently has seen more limited use in military training. Matheny and Edwards (1974) have reported a large-scale study of a classroom management system that included contingency management. While their study shows that contingency management can be misused (e.g., simply to control a class of students rather than to promote learning), these researchers concluded that contingency management employed in connection with other classroom practices "... can lead to improved reading achievement" (p. 231). Their study is interesting for the distinction it made between group contingencies and individual contingencies:

Positive contingency management is a tool, and, just as with any tool, it can be used effectively to benefit the student or just to make the teaching process easier. Teachers should evaluate constantly the contingencies present in their classrooms in order to insure that they are designed to promote learning and not simply to facilitate large-group instructional procedures (Matheny and Edwards, 1974, p. 232).

Cassileth (1969), on the other hand, got mixed results in a study of the application of contingency management to a clerk-typist course. Oddly, he found that a contingency management procedure (awarding points that could be exchanged for time off) was effective only with students of high initial ability; lower ability students showed no significant differences in achievement. He concluded, however, that his "unexpected findings" resulted from an unsatisfactory research setting in which "... it became obvious that certain factors in the military training operation were in conflict both with the aims of self-paced instruction and with those of reinforcement management" (p. 10).

While the Cassileth study (1969) is now ten years old, and the Army has presumably changed some in the meantime, it may be worthwhile to consider the summary of his discussion of the problems he encountered in conducting his study:

In summary, the effectiveness of contingency management, no less than the effectiveness of any innovative educational program, is dependent on many complex factors in the training environment. Successful innovation requires preparatory modification of the entire administrative system. Such new techniques as self-paced instruction cannot be effective when they are superimposed on, or forced to fit into the context of, an existing system. Successful implementation requires that administrators be trained in the operation of the new technique, that detailed guidelines for administering it be made available, and that checkpoints for monitoring management of the innovation be incorporated into the program (Cassileth, 1969, p. 10).

Contingency management, the systematic use of reinforcers to enhance learning, requires an inventory of rewards or reinforcers. But, as Geis and Chapman (1971) have pointed out, the search for such rewards or reinforcers should be informed by B. F. Skinner's warning that designing effective contingencies is more important than finding new reinforcers. Geis and Chapman (1971), in a fairly extensive review of the literature bearing on knowledge of results as a reinforcer in learning, have also identified a number of other, less cited, reinforcers (e.g., a demonstration of mastery, discovery, and progress). They concluded, however, that knowledge of results, though "most frequently cited as the reinforcer in self-instructional systems" (p. 48), is not clearly and universally a reinforcer.

Eaton (1978) has reported a study to identify rewards or reinforcers effective for the training of tank crews. He investigated the effects of recognition, tangible rewards, intrinsic reinforcers, and self-actualization on learning motivation. He found that "for tank commanders, drivers, and loaders, performance generally was positively related to recognition-based motivation and negatively related to motivation based on tangible reward. For gunners, however, performance was negatively related to recognition-based motivation." In spite of this one apparently negative effect, he felt that recognition may have a positive overall effect on tank crew performance (p. 34).

Wagner et al. (1974) have presented a number of "motivational tactics" for use in PSI (Personalized System of Instruction) courses. Because, in their view, success is the key to motivation, these "tactics" appear to be designed

to assure success, and a central feature of them is the detection and solution of problems before they begin to affect motivation. One tactic, for example, involves monitoring student progress and finding out why certain individuals are not making adequate progress.

Instructional Media, Materials, and Devices

Koerner (1977), in a paper descriptive of the state of educational technology (based on the Sloan Foundation's Technology in Education program through which the foundation funded the testing of "new communication technologies" in colleges and universities), has made some interesting observations about self-paced instruction. "Everywhere that educational technology is found," he has claimed (p. 20), "its natural collaborator, self-paced instruction, is found." He has also claimed that such methods as audio-tutorial instruction, the Keller Plan, and their many variants (he apparently did not regard IPI and similar systems of individualized instruction as unique methods) established "...the framework for most of the instructional materials associated with educational technology" (p. 21). But he added that self-paced instruction does not necessarily involve the use of machines and that self-pacing with no more than printed materials is common. In contrast to computer and television technologies, which tend to be emphasized in educational technology, he identified a number of educational media (e.g., film loop, audio-cassette, microfiche) which he characterized as "low technology" (p. 18). He cited as an example the extensive development of self-instructional "packages" using such media. But, oddly, he put the relationship between the instructional content and the communications media of individualized instruction this way: "It simply happens that when instruction is undertaken with the help of machines standing between the instructor and his students, an old pedagogical theory asserts itself: many students learn many subjects most effectively when the material is broken up into small units that have a logic and coherence of their own and that can be mastered by the student at his own speed" (p. 21).

But individualized instruction does not begin with machines or with other assumed media types; rather, the selection of media to present individualized instruction begins with the analysis of the learning needs. According to Interservice Procedures for Instructional Systems Development (TRADOC Pamphlet 350-30), candidate media alternatives are identified on the basis of the stimulus requirements derived from learning activities; final selections are then made on the basis of certain criteria, which include complexity of the learning, the form of the stimulus, the training setting, and administrative considerations (Phase III, Develop, pp. 106-109). While the special concerns of individualized or self-paced instruction are involved in this media-selection procedure, there is no special procedure for individualized or self-paced instruction. Some media, such as CAI and teaching machines, may be regarded as unique to self-paced instruction, but most media could be as appropriate to conventional instruction as to individualized instruction.

An earlier, and also well known, guide to media selection, Handbook of Procedures for the Design of Instruction (Briggs, 1970), suggests that media be selected on the basis of both learner characteristics and the nature of the task to be learned. Learner characteristics lead to a consideration of the research evidence regarding the interactions of media with characteristics,

and the nature of the task to be learned leads to the identification of the stimulus needed to produce a learning event. Thus, following this procedure, an attempt is made to select media which optimally serve both learner characteristics and the stimulus requirements of the task to be learned (pp. 94-98). Individualized instruction becomes a factor in media selection as a result of applying the selection procedures to individuals rather than to groups (p. 114).

Appendix A of Phase III, Develop, Interservice Procedures for Instructional Systems Development (pp. 163-172), lists more than seventy means or methods of instructional delivery. Some of these, such as television and motion picture projection systems, should be regarded as media systems; some, such as programmed texts and CAI, are probably best thought of as methods, while others, such as the traditional classroom and the individual carrel, should probably be considered as particular arrangements or facilities for learning. But of these 70 or so means or methods, about 50 appear to be likely candidates for the presentation of individualized instruction in some form, and only about 20 seem to be uniquely adapted to the needs of individualized or self-paced instruction. And these 20 or so uniquely individualized or self-paced media and methods include variant forms of the same basic form, such as the several forms of programmed texts and the several forms of the closely related teaching machines and CAI. Thus, it seems reasonable to conclude that only a few basic approaches to or means of presenting instruction are uniquely adapted to individualized or self-paced instruction, while many are common to both individualized and traditional instruction.

Some media or methods from Appendix A commonly found in use as means of delivering individualized instruction include the following:

- o Audio tape system, with or without printed material.
- o Filmstrip projection system with audio, with or without adjunct equipment for hands-on training.
- o Sound slide projection system, with or without adjunct equipment.
- o Computer Assisted Instruction (CAI), in at least half a dozen forms.
- o Simulators, to represent a number of aspects of operational equipment.
- o Printed materials, in a number of forms including self-scoring exercises.
- o Programmed text, in a number of forms.

Briggs (1970) has briefly reviewed the characteristics of several of these media, and it may be worthwhile to consider these:

- o Filmstrip (and slide) projectors can be easily accessed by the student and can be "... programmed to utilize the same characteristics contained in programmed instruction booklets" (p. 109). Slide projectors (and presumably also filmstrip projectors) with controlling audio tapes result in "multimedia programmed instruction."

- o Computer assisted instruction (CAI) consists of programmed instruction in machine form. It can present each learner a different series of content based on entering competencies and errors in responses, often in less time than a linear program intended for a number of learners. Time-sharing permits students to work at their own rates, and remote terminals permit instruction at considerable distances from the computer. The computer can store and make use of student information such as history of past performance on programs. Project IMPACT, an early effort to develop a CAI system for the Army, is documented in the following reports: (Project IMPACT: Description of Learning and Prescription for Instruction, HumRRO Professional Paper 22-69, June 1969; Project IMPACT -- Computer-Administered Instruction: Description of the Hardware/Software Subsystem, HumRRO Technical Report 70-22, December 1970; and Project IMPACT -- Computer-Administered Instruction: Preparing and Managing the Content of Instruction, IMPACT Text Handling Subsystem, HumRRO Technical Report 71-21, September 1971. Longo and Giunti (1972) have reported an evaluation of CAI in U.S. Army basic electronics training.)
- o Programmed instruction can be defined "... as any form of systematically designed and validated instruction" (Briggs, 1970, pp. 101, 102), but Briggs referred to a "...more narrow, more conventional ..." meaning of the term, to include: stimuli in the form of print and graphics; small segments of information with student responses and feedback to students interspersed; typically, small step size, though the term "step size" has a range of meanings; branching around material not needed or to material needed; and self-instructional and self-pacing capability. While reading ability is required to some extent, programmed instruction may be better for poor readers than conventional text because of the feedback provided (pp. 101, 102).

MODIA (Method of Designing Instructional Alternatives): Volume 2, Options for Course Design (Carpenter-Huffman, 1977), Appendix B, also lists characteristics of typical media, but these are mostly physical characteristics such as size, weight, audience size, and mode of operation. Costs and some descriptions are also included.

A seminal work on the use of teaching machines and self-instructional devices within the context of individualized instruction is Lumsdaine and Glaser's Teaching Machines and Programmed Learning (1960). While this work is now nearly twenty years old and interest in programmed instruction and some kinds of teaching machines has faded somewhat (the computer is a teaching machine, of course), it may still be seen as a sort of starting point of individualized instruction, at least as regards the media of individualized instruction, and may be used as a gauge of recent progress in the development of the means of individualized instruction.

Wheaton et al. (1976) have reviewed the literature on training devices, especially as regards effectiveness. While their review was intended to be an initial stage of a research effort to develop a method for predicting training device effectiveness, it appears to constitute a reasonable background for the consideration of training devices as a means of individualized instruction.

Some specific media applications or approaches to the delivery of individualized instruction are worth some attention here. The use of media in a number of successful systems of individualized instruction is dealt with in some detail in Chapter IV of this review, *Systems of Individualized Instruction*, but the following discussion will serve to define certain special media terms found in the literature.

McCombs et al. (1974) have described a use of media termed media adjunct programming (MAP). This was a special adaptation of adjunct programming, which combined adjunct questions with multi-media presentations. Adjunct questions were presented by means of a "modified random access projector," while a printed guide provided the course outline, directions, and routed the student to the media devices which presented the course content. These latter were slide-tape and motion-picture devices. This media combination was intended to decrease learning time.

The terms learning package, learning packet, and learning guide, as used in the literature, appear to overlap or to identify many different formats. Guidance material distributed to the individual student may, for example, be called a learning package but contain no more than course or unit objectives and the means of evaluation. Pucel and Knaak (1975), however, make a distinction between the learning package or packet and the learning guide. "The learning guide defines the objectives, steps, procedures, and resources required to master the content of that guide. If we take the learning guide, the audio-visual software and print material associated with it, an instrument for evaluating mastery, and combine it into an envelope or box, with a special library resource number for the entire lot, it becomes a package or packet" (p. 128). Smith and Kapfer (1972) have pointed to the difficulties that can arise in connection with the implementation of individualized instruction based on the learning package. While their discussion referred specifically to the elementary school setting, it may be generally relevant to the use of learning packages. Their essential point was that "... the development of new behavioral competencies in students is extremely important to the success of a curriculum based on learning packages" (p. 80). Murry (1976) has presented a case study of the design, development, and implementation of learning packages used in an external degree program. His experience should be useful to the consideration of learning packages in programs intended for mature adults.

Another approach to the delivery of individualized instruction that deserves some attention here -- one that typically employs a broad range of media -- is the individualized learning center. The learning center may also be regarded as a facility, of course, and in a previous section, Facilities, it is dealt with from that point of view. Because learning centers exist in many forms, from very simple to very elaborate, it is difficult to characterize or define them, but Giordano (1975), in the report of a wide-ranging study of individualized instructional practices at the college level, offered this definition:

Since learning can take place anywhere, a learning center is merely an area that makes the learning process easier by its conveniences. It may contain display media in the form of hardware, but this is not the reason why it is a learning center. It is one because it provides for more intense student activities....

So, a learning center could be a classroom or an elaborate learning-resource center into which libraries have lately evolved. As long as it is a course for information that the student needs, where a student can respond to this information when it is presented, and where provisions are made for frequent and well-informed evaluations and prognoses, the area can be called a learning center. (p. 58)

Giordano (1975) has also described the practices of a number of successful learning centers, discussed certain problems and issues inherent in the use of learning centers, and offered recommendations for their development.

Sullivan et al. (1974) have surveyed a large number of learning centers (28) to determine the state of the art in their establishment and operation and found that they "... are both effective and efficient approaches to instruction" (p. 10), and that they "... are a more effective and more efficient approach than the conventional group-paced forms of instruction they have replaced" (p. 10).

They have defined the learning center as follows:

A learning center is primarily an instructional system.... [but it] differs from the common conceptualization of an instructional system in that it counts facilities, personnel, and production capabilities as more important characteristics than do other expressions of the instructional systems concept. In a learning center the management/organizational structure within the center and within which the center functions becomes much more important than in less structured instructional concepts.

A learning center is a program or environment in which instructional technology (including the ISD process) is specifically directed at the instruction of individuals or small teams. While the most visible aspects of a learning center are generally the devices and carrels, the software development aspects are of equal importance (1974, p. 7).

But the concept of the learning center can go even beyond this definition. Swanson and Willet (1977) have seen the learning center concept not only as a system or environment for learning but as a model for the reorganization of the school itself. They believe that a "capital-intensive, man-machine system" (the learning center) could be both more efficient and more effective than the "traditional model of schooling" (p. 32).

The individualized learning center may also be called "the learning laboratory" (Reedy, 1973, and Matlick, 1974). The difference in labels apparently points to a difference in origin (the learning laboratory seems to have evolved from the earlier language laboratory) rather than to a difference in purpose or method.

Yet another name for this approach to the delivery of individualized instruction is center for self-paced learning. A booklet prepared by the Civil Service Commission (TET-311, 1977), discussed elsewhere in this review, provides

guidance for the establishment of the center for self-paced learning as a means for providing individual employee training.

A third specific and special approach to the delivery of individualized instruction that requires attention here is the Army's Skill Performance Aids Program, once known as Integrated Technical Documentation and Training (ITDT). This program:

... combines the development of technical documentation [technical manuals] and associated training materials into an integrated package. The technical documentation provides fully proceduralized, highly illustrated instructions which enable soldiers with minimal training to perform complex tasks with minimal supervision. The training material, when used with the technical documentation, teaches selected skills and knowledge which may be necessary to operate and/or maintain the equipment. (Viereck, 1968, p. K-2)

Shriver and Hart (1975), in the report of a study of the "improvement of military technical information transfer methods" (presumably the research on which the current Skill Performance Aids Program is based, at least in part), identified three ways to reduce the personnel costs associated with the maintenance of Army equipment (they concluded that it costs the Army more to own equipment than to procure it) (p. 1):

1. By reducing non-productive hours spent in formal classrooms.
2. By reducing work force through improved performance on the job.
3. By reducing false removals through improved performance on the job.

The solution proposed -- which addressed all three of these ways -- and implemented to prototype form was what is now referred to as the Skill Performance Aids Program.

Simulators, closely allied to instructional media, are instructional devices "... the operation of which will be almost like 'the real thing'" (Pucel and Knaak, 1975, p. 119). Generally, simulators are expensive and the decision to employ them must be carefully considered, but Pucel and Knaak (1975, p. 120) list these compelling reasons for their use:

1. The instructional equipment is inherently dangerous in the hands of the trainee until he has developed the knowledge and skill to adjust quickly to emergency situations.
2. The instructional equipment is too expensive to be used for the entire training process.
3. The instructional equipment has a mechanism that is so complex it must be learned separately before a totally integrated performance is required.

4. A particular learning situation does not occur frequently enough in normal operation [to allow a trainee] to acquire a sufficient degree of skill.

Pucel and Knaak (1975) have written from the perspective of vocational and technical training, but the questions they proposed to guide the decision to employ simulators appear relevant to military training. Their questions are these (pp. 120, 121):

1. What part of the instruction involves critical skills that are difficult to teach on standard instructional equipment?
2. What is the potential difference in costs between real equipment and a simulator?
3. Can simulation be programmed as a part of the total instruction?
4. Can the degree of positive transfer from the simulation training be measured?
5. What is the possibility of improper skills being learned and practiced?

Fink and Shriver (1978), in an extensive review of the literature of maintenance training and the use of simulators and low-cost devices in maintenance training, have found that while there is a great deal of research evidence to show that simulators are cost-effective in a variety of training situations "... there still is a reluctance to employ maintenance simulators; a tradition of usage has still to be established" (p. 1). They identified a considerable number of good reasons to employ simulators in maintenance training, but the most salient of them appears to be contained in this statement:

Maintenance personnel are trained to work on real equipment. Why then not use real equipment for maintenance training? In the first instance, real equipment is designed to serve an operational need not related to training. Therefore, real equipment does not contain the desired features of a training device. Secondly, real equipment is almost always more costly than a representative training device. Finally, operational requirements take precedence over training requirements. Therefore, training centers often have difficulty getting equipment and spare parts because these are sent to the field (1978, p. 4).

The review by Fink and Shriver (1978) is far too extensive to be fairly summarized within the scope of this review, but certain issues and problems are of particular interest to the consideration of simulators as devices for the delivery of individualized instruction and are thus treated in some detail below.

The term simulator may suggest complexity and high cost, but Fink and Shriver (1978) have pointed out that research has shown that simple and inexpensive trainers (mock-ups) are effective in training procedural tasks. They cited a study that showed that such a representation of the instrument panel and driver's controls of a tank "... was as effective as an expensive mock-up and the real tank for teaching starting and stopping procedures, and the names,

locations, and functions of driver instruments and controls" (p. 16). But the effectiveness of such inexpensive and simple training devices does appear to be limited to fixed-procedure tasks.

Before a simulator (whether simple or complex) can be designed, developed, and incorporated in a training system, the simulation requirements must be determined. It is apparently still very difficult to make this determination. Fink and Shriver (1978) have found that some researchers have questioned job and task analysis as a means of arriving at training requirements, have expressed concern about current means for determining necessary features of training devices, and have found considerable difficulty in developing training devices for existing weapon systems and especially for developing weapon systems (pp. 18, 19, 25-33).

Even if (or when) the perfect training device or simulator is developed there will still be a problem in that its effectiveness will depend on its acceptance and use by students and instructors. Fink and Shriver (1978) found evidence that instructors typically misuse or underuse training devices. They may, for example, fail to make use of a capability of the simulator or simply use it as a demonstrator for a classroom presentation and not let students practice with it. They may essentially accept a simulator -- that is, be impressed by it -- but still prefer actual equipment, or they may accept and use simulators so long as actual equipment is not replaced (p. 34). But Fink and Shriver (1978) have also suggested that acceptance of simulators by instructors can be increased. They indicated that this end can be achieved by making simulators reliable and easy to use and by employing "... an instructor station which allows the instructor to be a 'good' instructor" (p. 35). One researcher, they pointed out, also believes that "... instructors should have the final say with respect to the design of a simulator, and should be responsible for preparing the plan for integrating the device into the training program" (p. 35), though they also identified other researchers who are of the belief that, while instructors should be involved in the design of simulators and planning for their use, their inputs should be minimized (p. 36).

The cost-effectiveness issue is still a difficult one, according to Fink and Shriver (1978). So far as effectiveness is concerned, the "... evidence seems convincing: simulators are more cost-effective for teaching malfunction location techniques than are actual equipment trainers; low-cost, low-fidelity mock-ups for teaching nomenclature, parts location and procedures may be more cost-effective than more expensive three-dimensional aids, animated cutaways, or real equipment trainers" (p. 37). (Italics are those of the author of this present review.) But Fink and Shriver (1978) were not aware of any studies that showed that the use of maintenance simulators has resulted in greater student proficiency which has transferred to the job. They were able to cite only "anecdotal evidence" that "... students trained with simulators can perform acceptably in the field" (p. 38). Likewise, Fink and Shriver (1978) were unable to find in the literature any evidence of cost savings resulting from the use of simulators (pp. 37,38).

While simulator technology apparently has not progressed a great deal in recent years, instructional computer and video technology has enjoyed considerable progress if not wide application. But if computer and video technologies develop as some writers believe they will, their application to training and education will certainly increase. Fletcher and Zdybel (1977), for example, have discussed the development of "intelligent instructional systems" for

military training. These are CAI systems that employ techniques of artificial intelligence to automate the development of instructional content, to adapt learning experiences to such learner characteristics as achievement and cognitive style, and to provide a variety of simulations. A representative system of this type is the Warfare Effectiveness Simulator (WES), a project of the Navy Personnel Research and Development Center that simulates naval engagements. "The program is therefore a gaming medium that represents the current state of affairs, provides appropriate opposition to the student-player, and performs some of the functions of a referee. WES is intended to provide real-time interactive experience for decision making and tradeoff analyses within a wide range of realistic and dynamic environments" (p. 7).

Bennion (1974), Bennion and Schneider (1975), and Schneider (1975) have written papers on the applications of videodisc technology to individualized instruction. CAI systems employing videodisc technology promise to greatly expand CAI capabilities through such features as motion and freeze-frame pictures, sound, and random access of visual information. The limitations of present CAI systems will to some extent be overcome, and costs will be reduced as a result of simpler and less costly hardware and much less costly software. Further, Ingalls (1977) has discussed the possibility of linking videodisc equipment with microprocessors in order to produce inexpensive CAI. He emphasized the ability of such systems to enhance learning by providing experiences that simultaneously involve both linear learning, such as reading, and visually oriented, or conceptual, learning. Citing research on brain lateralization (i.e., evidence that the left hemisphere of the brain is the focus of linear-based learning -- e.g., reading -- while the right hemisphere is the focus of conceptual thinking, of which visual learning is an important aspect), he pointed out the need to further develop instructional approaches that exploit this knowledge.

May et al. (1977) have reported the development of a minicomputer-based CAI system (Computerized Diagnostic and Decision Trainer, or CDDT, also called ACTS for Adaptive Computerized Training System) that also employs principles of artificial intelligence. This system does not make use of the videodisc, but it does have a visual display -- a cathode ray tube -- that provides a simple kind of simulation. The purpose of the system is to teach an electronic troubleshooting task by shaping the diagnostic and decision-making behavior of the learner until his behavior matches that of an expert. Using artificial intelligence techniques, the computer program determines how the learner makes troubleshooting decisions, compares his decision-making behavior with that of an expert, and then adapts the instructional sequence to bring about the desired change in the behavior of the trainee. This system seems to demonstrate the feasibility of minicomputer-based CAI with artificial intelligence capabilities.

Videodisc and microprocessor computer technologies show considerable promise in regard to the widespread delivery of CAI, but an alternative to the approach implicit in these technologies is remote CAI (i.e., terminals located at considerable distance from a large, central computer), already briefly mentioned in this chapter under Management. Ball and Jamison (1972) have discussed the possibility of delivering remote CAI through a number of communications facilities, and Schwartz and Long (1967) reported the successful application of remote CAI to industrial training some time ago. Furthermore, Hoyt et al. (1977) have reported the potential effectiveness of CAI as a means of delivering

Training Extension Course (TEC) instruction to units in the field. Thus, CAI with artificial intelligence capabilities and such features as sound and highly flexible visual displays (motion picture, freeze frame, random access of visuals, print messages over visuals), delivered in decentralized fashion through mini-computers or microprocessors or in centralized fashion through remote means, would appear to be a real possibility for both the school and units in the field.

It would appear to be necessary -- or at least desirable -- to characterize the materials of instruction (as distinct from the media of instruction) in a way roughly comparable to the way, for example, that Briggs (1970) characterized media in terms of what they do or how they meet certain instructional needs. Walberg et al. (1972), in the context of an EPIE Report (Educational Product Report of Educational Products Information Exchange), have described an approach to the evaluation of individualized instructional materials that is based on a characterization of instructional materials:

In moving toward a systematic procedure for assessing individualized instructional materials, EPIE instructional materials evaluators have identified sixteen variables that characterize most instructional materials. Developers of instructional materials either explicitly or implicitly select from among these variables. It is the combination of these variables that differentiates one set of instructional materials from another. Certain combinations of variables tend to make one set of instructional materials more amenable to individualizing instruction than another (p. 12).

The 16 instructional variables given by Walberg et al. (1972) follow, with brief paraphrased summaries of their descriptions in parentheses:

1. Selection of objectives. (Objectives define philosophy, purpose, and rationale for materials as well as intended learning. These range from explicit to vague and may be missing altogether.)
2. Specification of Outcome Goals. (The part of the objectives associated with intended learning. These may be fixed -- as in the case of learning to operate a machine -- or variable -- as in the case of the range of acceptable behavior implied by the term "good citizenship." Though they are a part of the objectives, they are discernible as a separate variable in the description of instructional materials.)
3. Population Specific. (Materials are intended for certain populations, though a population may be fixed -- as in the sense of a particular age or grade -- or variable, if they address interests or abilities without regard for age or grade.)
4. Structure of Subject Matter. (Structure refers to both what is selected for inclusion and how it is arranged, as determined by the approach to a topic. Science, for example, may be approached as a process, as history, as mathematics, or as a topic.)

5. Sequence. (Sequence refers to the order of arrangement of instructional materials. There may be either a fixed or differentiated entry point in the materials.)
6. Scope. (Refers to breadth and depth of content.)
7. Branching. (Branching is the provision of multiple routes through instructional material rather than linear routes only. Multiple routes apply to specific problems encountered by the learner or to individual learning style.)
8. Recycling. (The provision of alternative routes to mastery when a learner fails through a linear route.)
9. Selection of Materials. (Refers to additional or supplementing materials that may be required. These may or may not be provided or identified.)
10. Learning Environment. (Organization of materials and the suggested approaches to instruction. Groupings, placement of materials, movement by the learner may be explicit or implicit.)
11. Methodology. (The design of the material implies a method of instruction.)
12. Time. (May be fixed or flexible. A fixed time for completion is by implication norm referenced. Flexible time implies self-pacing.)
13. Pacing. (Refers to internal programming for going through the material. Pace may be fixed by developers or allowed to vary with decisions made by instructor.)
14. Modes. (Refers to means of communication or presentation).
15. Evaluation of Learning. (Norm-referenced or criterion-referenced evaluation suggestions may be provided by the materials.)
16. Evaluation Approaches. (Approaches to evaluation are explicit or implicit to materials. These may be teacher-centered and teacher-informative or student-centered and student-informative.)

An examination of each of these variables can determine the extent to which the characteristics of each do or do not support the objectives of the materials, and this is one of the approaches to the evaluation of individualized instructional material employed by EPIE evaluators. It seems apparent that instructional designers could profitably consider each of these during the design of materials.

Reports of evaluations (either developmental testing or field testing) of individualized instructional materials are infrequently found in the literature, but one such report has been offered by Lambrecht et al. (1972). Their

study was designed to determine the relative levels of achievement of students enrolled in post-secondary courses designed to permit individualized instruction and to identify those courses or instructional aspects considered effective or ineffective in achieving objectives. Not surprisingly, they found that students characterized by previous experience in the subjects, graduation from high school, and enrollment in an associate degree program got higher grades and had fewer course incompletes than students without these characteristics. The most effective course characteristics included student-pacing of their own programs, use of pretesting to place students within a course, student selection of special study topics, and the use of a variety of testing procedures.

Another such study is that of Fallentine et al. (1974), who have described the development and evaluation of individualized instructional materials employed in an Air Force Advanced Instructional System (AIS) course. Their results indicated that the individualized materials increased efficiency with no loss of achievement.

Spangenberg et al. (1973) have examined the state of knowledge as regards selection of cost-effective methods and media. While they concluded that existing procedures for the selection of methods and media were inadequate for Army training needs, they did produce a comprehensive overview of present possibilities.

CHAPTER III. MODELS OF INDIVIDUALIZED INSTRUCTION

This chapter of the review describes some general models of individualized instruction. It begins by considering a definition and the general characteristics of individualized instruction, and then reviews several previous attempts to categorize models for individualized instruction and define some of the important variables which distinguish between different models. Finally, it suggests an approach which allows theoretical and existing models for individualized instruction to be categorized and compared.

Everyone involved in instruction probably has his or her unique definition of individualized instruction. The term, however, generally refers to how students interact with instruction as unique individuals or to how instruction is altered to meet individual student needs or desires. Definitions differ in the manner in which they treat student interactions and modifications of instruction.

To a certain extent, all instruction is individualized. For his part, "each learner brings his own ideas and experiences into the learning process" (Walberg et al., p. 8). Thus, each individual student will react to instruction in a unique manner. On the other hand, Cronbach (1971) points out, teachers form impressions of the individual needs of students and adapt their behaviors to accommodate those needs.

As has already been noted, Hess and Lehman (1976) have argued that "the degree of individualization is related to the frequency with which decisions are made to alter the instructional presentation and to the number of variables altered in response to individual differences among students. Since all teachers consider or ignore these characteristics to some degree, the point at which we regard instruction to be 'individualized' is an arbitrary one on a long continuum" (p. 15). In addition to the frequency of decisions and the number of variables altered, the number of students involved in such decisions or alterations forms a continuum of individualization. "Thus, at one pole on the continuum from individualized to unindividualized instruction is a program with all pupils in one large group, with age and group achievement level (i.e., high or low track) as the essential determinant of the curriculum, and with objectives, learning experiences and pacing the same for all pupils. At the other pole is a program wherein each child is working individually, with information about the particular pupil serving as the basis for establishing a program for the pupil, and with different objectives, learning experiences, and pacing for the pupil. Programs vary between these polar types" (Bosco, Harring, and Bandy, 1976, p. 253).

Another common theme throughout the literature is that in order to individualize instruction changes must occur in the classroom procedures. Hence, Carrier and McNeigney (1979) discuss the process of individualizing as "tailoring instruction to fit the needs and abilities of different persons" (p.40), and Pucel (1974) states that "individualized instruction attempts to adapt the educational program to allow for individual differences" (p. 3). It is this idea that systematic change occurs that provides the criterion for differentiating between individualized and unindividualized instruction. That is, the teacher reacting to his or her students' needs in an informal and unsystematic fashion is not usually considered an example of individualized instruction even

though the instruction may closely match the needs of each student. On the other hand, a systematic approach to meeting any of the large variety of student needs will probably be considered an example of individualized instruction. We will therefore define individualized instruction as:

Any systematic approach to instruction which varies the teaching/learning process (in any way) according to the needs, abilities, or desires of individual students.

The definition suggested is very broad to allow for the consideration of a wide variety of approaches to instruction. It is narrow enough, however, to exclude the individual who decides to study some topic for his or her own pleasure or the excellent teacher, who can always seem to find a way to reach his or her students. In other words, the definition is intended to restrict consideration to a program, approach, or set of procedures which can be well defined and replicated in a variety of situations.

Consideration of some of the most common features of individualized instruction (Hess and Lehman, 1976; Gagne and Briggs, 1979) may help to explain the definition more concretely. A fairly comprehensive list of these has been given in Chapter II of the review (after Hess and Lehman) under Instructional Methods. It is unlikely that one would find all of these features in any one program, but any example of individualized instruction is likely to exhibit at least several of them. Several papers discussing military applications of individualized instruction (Mizenko and Evans, 1971; Weingarten, Hungerland, Brennan and Allred, 1970; Bialek, Taylor, Melching, Hiller, and Bloom, 1978) have some important features to add to the previous list which reflects primarily the civilian literature:

1. Strict quality control of the instructional materials.
2. Rapid and detailed feedback to the instructor concerning the adequacy of the instruction and any problem areas.
3. Emphasis on instruction leading to the ability to perform the various tasks that make up the job.
4. Emphasis on learning in a functional context, "hands-on" training, and on-the-job training.
5. Preparation of self-contained instructional materials which can contribute to a decentralization of training.

While the list of features appears formidable at first glance, it actually represents alternative approaches to a relatively small number of basic variables underlying individualized instruction. These variables concern: (1) the content or objectives to be learned, (2) the proficiency or skill required of the student, (3) the time available to each student to master the objectives, and (4) the instructional treatments or methods used to facilitate learning. The next part of this chapter illustrates the basic variables through a consideration of several approaches to defining and categorizing models of individualized instruction.

One of the earlier papers to address the problem of categorizing models for individualized instruction is Cronbach's 1967 discussion of aptitude as an important variable in choosing educational treatments. Cronbach defined five procedures for meeting individual needs: selection, training to criterion, differentiation of goals, remediation, and individualization of teaching method. Cronbach's discussion treats the first four procedures primarily in terms of administration. The last procedure is discussed in terms of individual differences in aptitude and the necessary modifications in instructional technique to meet those differences.

Selection in the broadest sense refers to the practice of deciding on the basis of past performance or performance on predictive mental tests which students should be allowed to continue their education. It implies fixed educational goals for all students and a fixed instructional treatment. Individual differences between students are defined in terms of the likelihood that they will perform well in more advanced topics. Those students not expected to do well are simply eliminated from future consideration. This model describes much of higher education today.

Training to criterion also implies fixed educational goals and fixed instructional treatments. The logic is that there are certain common topics that everyone should master before leaving school. Cronbach points out that this model is rarely followed in its pure form since the period of time devoted to formal education must eventually end. The ideas implied by training to criterion are seen in the policy of keeping children back in the early grades and in non-graded primary classrooms. Programmed instruction, mastery learning programs, homogeneous grouping, and self-pacing are also examples of this model. An interesting derivative of these ideas is the recent legislation pertaining to minimum competency requirements for high schools. While these requirements may explicate the common topics that everyone should master, it appears as though insufficient thought has been given to deciding how all students will master them.

Cronbach's third procedure is to allow for options in educational goals. Instructional treatment within any set of goals is, however, fixed. This procedure refers to curriculum-level goals and describes the practice of multiple curricula. For example, a student could choose between an academic or vocational curriculum, with the expectation that the instruction within one curriculum would be more suitable than that in the other. This model is also seen in the selection of college majors. An important implication of this procedure is that it implies more than a purely educational decision; it is often a decision that will have a great deal to do with the role an individual will play as an adult.

The fourth procedure, remediation, implies fixed educational goals within a course or program but does provide alternatives in the instructional treatment. Cronbach describes this procedure as attempting to erase individual differences or at least minimize the nuisance of them. There are two general types of remedial treatments, microtreatments and macrotreatments. The microtreatment strategy attempts to identify specific gaps in a student's understanding or skill and provide a short, concentrated instructional package to eliminate the gap. This may be accomplished through special classes, tutoring, special purpose programmed instruction, or remedial loops or branches in a large-scale program of instruction. Macrotreatments refer to long term and broader based programs such as compensatory education programs or programs such as Head Start. The hope in these programs is that appropriate and timely help will develop the intellectual

skills and attitudes necessary for acceptable performance in the regular curriculum. Cronbach criticizes the microtreatment strategy because it usually focuses on plugging rather narrow gaps in factual content. What is needed is help in the application and transfer of knowledge skills not normally addressed by such remedial programs. Compensatory programs could be very useful, but the necessary theory concerning the kinds of skills that one would like to teach in such programs was lacking when Cronbach wrote his article and remains a problem (see, for example, Glaser, 1976).

Cronbach's last procedure, and the one he argues deserves more attention and research, is individualization of teaching method. The logic behind this procedure is that individuals are different and that they must be treated differently. The important problem is to decide how to differentiate between students. Cronbach cites several studies and argues that general ability or aptitude is not the appropriate variable. Rather, promising differential variables should be identified and treatments designed for them. Another implication of Cronbach's argument is that the goals for which the instruction is designed should be at a higher level than simply learning content. For example, an educational goal might involve analytic and problem solving skills. One could differentiate among individuals on the basis of spatial ability and design instruction for those with high spatial ability using geometric examples. Those with low spatial ability who might be expected to have difficulties with the geometric proofs could progress toward the same goals with content based on mathematical or logical proofs. Cronbach also suggests that different instructional treatments might be designed on the basis of personality characteristics. Despite considerable theoretical interest since Cronbach's paper was published, few practical examples of programs of individualized instruction can be found and much work in the area remains to be done (Tobias, 1976).

Cronbach's approach to categorizing individualized instruction models focused on existing practices. A similar approach was taken by Walberg *et al.* (1972). They identified three general classes of models: traditional models, diagnostic models, and a third category which allows for multiple courses of instruction.

According to Walberg *et al.* (1972), the traditional models include Selection, Enrichment, and Acceleration, with Selection being essentially the same as Cronbach's selection model. They divided selection into a Platonic eugenic model, where instructional decisions are made at birth, and selection for instruction, which eliminates students deemed unfit. "Both variants are potent enough, but for the many educators who do not wish to reject the unborn or born they are essentially conservative defeatist doctrines" (p. 46).

The enrichment model implies that all students spend the same amount of time in instruction but are allowed to vary in their achievements. That is, the more talented students achieve better test scores than their less fortunate classmates. Enrichment programs could also allow more talented students to go more deeply into some areas than the rest of the students. Walberg *et al.* addressed neither this possibility or the possibility that slower students could study less material more completely.

Walberg *et al.* define the acceleration model as mastery learning. The criterion performance is fixed at some, presumably high, level for all students and the time spent in instruction varies with the needs of the learner. The

logic of this approach is that by providing sufficient time, individual differences in aptitude or previously attained skills or experiences can be compensated for.

Walberg et al. defined two diagnostic models. The first, called hierarchical, is very similar to the traditional acceleration model. The criterion performance is fixed and the time spent in instruction is allowed to vary. There are three differences. The first is that a hierarchical structure describes the content of the material. It is assumed that students must learn the content at a lower level of the hierarchy before moving to subsequent units. The other difference is the incorporation of pretesting to determine the level of the hierarchy at which each student should begin studying. The final difference is that each student's performance is measured at the end of each unit, and he or she is recycled through a unit until the mastery criterion is met. The random model is precisely the same with the exception that the hierarchical structure is not assumed. Thus, students must be pretested before each unit to determine whether or not it is necessary for the student to study it. The random model also allows some flexibility in organizing course materials.

Two models are included in the third category of Walberg et al., the multi-modal model and the multi-valent model. The multi-modal model has a fixed starting point and common goals for all students, but it provides for more than one educational treatment or method to meet the goals. The treatments could follow any one or any collection of the previously discussed models. The multi-valent model adds the possibility of different goals for different students or groups of students. These two models exactly parallel Cronbach's fifth procedure which calls for matching the instruction to the needs of the individual.

The categorization scheme of Walberg et al., particularly as regards the diagnostic models, is an excellent illustration of the argument put forth in a paper by Kingsley and Stilzer (1974). The Kingsley and Stilzer paper deals with an attempt to begin the development of a comprehensive theory of individualized instruction. They identify five components that must be modeled to support such a theory: (1) the structure of the subject matter to be taught, (2) the educational goal of the program, (3) the initial state of the student, (4) the changing state of the student as he moves through the instruction, and (5) the teaching system. The two diagnostic models given by Walberg et al. directly address points one through four, and the multi-modal and multi-valent models open the possibility of investigating the teaching system itself.

A different approach to the problem of describing models of individualized instruction is represented in a paper by Pucel (1974). Pucel defined a three-dimensional scheme for categorizing models of instruction. Each dimension can take two values, leading to a 2x2x2 cube. Pucel argues that one can use the eight cells defined by these dimensions to categorize and discuss models of individualized instruction.

The first dimension is content. This is simply the content that the students will study. It can be fixed or variable. A fixed content program requires all students to study the same content. A variable content course could allow each student to choose his or her own area to study within more or less broadly defined guidelines, or it could have a fixed core content and variable electives or enrichment work.

Pucel's second dimension is time. Time refers to the length of time given to students to learn any particular content. Time can also be either fixed or variable. With time fixed, all students must move through the material at the same pace, often the pace of the hypothetical average student. With variable time, students take different amounts of time to complete course material. A middle ground, considered to be an example of variable time, would be to fix the total time presented in some particular course while allowing the students to vary in how they break their time up. Thus, students could devote extra time to material that was particularly difficult for them and move quickly through material they found easier.

The third dimension is proficiency. Proficiency can also be either fixed or variable, and it refers to how much skill or knowledge students are expected to show as a result of instruction. For a fixed proficiency program, all students would be expected to reach the same level of performance. Variable proficiency programs would allow student performance to be different for different students.

Pucel's eight models follow. Models 3 through 8 are, according to Pucel, individualized instruction models. Model 1 is infeasible and model 2 describes "traditional" instruction.

1. Fixed-content, fixed-time, fixed-proficiency. This model is infeasible because of individual differences. Theory and experience both show that one cannot expect all students to achieve the same skills in the same time.
2. Fixed-content, fixed-time, variable-proficiency. This is the traditional classroom model. Everyone is taught the same material in the same amount of time. Final skill levels differ and the differences are reflected in different grades.
3. Fixed-content, variable-time, fixed-proficiency. This is the most common model of individualized instruction. It describes self-pacing procedures, mastery learning, and similar programs where students move at their own pace toward a common goal.
4. Fixed-content, variable-time, variable proficiency. This model describes a program where the students might be expected to explore, as far as their own interests dictate, some particular field. An example might be in a career-education program where students are introduced to a particular field.
5. Variable-content, variable-time, fixed proficiency. This model describes a program in which each student may choose his or her own content and study at his or her own pace, but where final proficiency is fixed. This might describe self-directed study or enrichment programs.
6. Variable-content, variable-time, variable-proficiency. This model is the epitome of self exploration models. It allows students to choose their own topics, to study them as long as they want, and to learn them as well as they want.

7. Variable-content, fixed-time, fixed-proficiency. This model is almost as hard to imagine as the first model. It could only work if students could find a content area that interested them that they could be sure they could finish in a fixed time interval.
8. Variable-content, fixed-time, variable-proficiency. This model represents the kinds of programs where time is fixed, perhaps because of administrative needs, but where students can explore a variety of content areas to the depth they desire.

The similarities of these three approaches to categorizing models of individualized instruction are much more apparent than their differences. Cronbach uses educational goals and instructional treatments as variables to describe the general characteristics of his models. Walberg et al. discussed their models in terms of time spent in instruction and criterion performance. They also pointed out the importance of multiple instructional treatments and goals in their multi-modal and multi-valent models. Pucel categorized models based on content, time, and proficiency variables.

All three approaches can be brought together if the dimension of instructional treatment, fixed or variable, is added to Pucel's cube and his dimensions are changed slightly. The four new dimensions are: (1) objectives which serve to specify the content explicitly, (2) proficiency, defined as Pucel defined it, (3) time, defined as Pucel defined it, and, (4) instructional treatment according to Cronbach's definition. This 2x2x2x2 space, having 16 cells, represents most of the models discussed thus far. The exceptions are the Cronbach and Walberg et al. selection models, the Cronbach remediation model, and the Walberg et al. diagnostic models. It can be argued, however, that these exceptions are not models in the same sense as the other models. Selection is a procedure that occurs before instruction takes place. If a student is not selected for instruction, the instructional model makes no difference. For students who are selected, the instruction could follow any one of the models described by the 16 cells.

The diagnostic models of Walberg et al. are different because they refer to the structure of the content primarily. A hierarchically structured content, for example, could be taught by several of the models in the 16-cell space. While content structure is important, it is different conceptually from the other dimensions. The diagnostic models and Cronbach's remedial model also refer to the structure of the instructional delivery system. In other words, they suggest that pre-testing, recycling, remediation, and post-testing are important parts of individualized instruction. These variables are also important but are, again, different conceptually from fixed and variable objectives, proficiency, time, and treatment. Various combinations of management systems could be part of several models as defined by the four-dimensional space. In fact, the list of characteristic features of individualized instruction presented earlier vastly increases the variations on the 16 basic models that could be implemented in any particular program.

The approach suggested for classifying and describing models of individualized instruction is based on four basic dimensions and a large number of descriptive variables. The approach assumes at the outset that instruction is to be offered. That is, selection for instruction is not treated as a model. Rather, it should be considered in terms of management decisions taken prior to instruction.

The four basic dimensions are objectives, time, proficiency, and instructional treatment (see Figure 9). Each dimension can be either fixed or variable. The 16 cells defined by this four-dimensional space are the categories for classifying existing or theoretical models for individualizing instruction. While any of the 16 cells could, theoretically, describe a real system, there are only two critical models which probably account for the bulk of existing systems. The first is the fixed-objective, variable-time, fixed-proficiency, fixed-treatment model (Pucel's model 3). This model describes most of the self-paced learning programs, many mastery-learning programs, much of what has grown out of the programmed instruction tradition, and other derivatives of the mastery and self-pacing ideas. The differences among such programs lie in the particular approaches taken to implementation, not in the basic model. The second critical model is the fixed-objective, variable-time, fixed-proficiency, variable-treatment model. This is precisely the same as the first critical model with the exception that multiple treatments are implemented. While there are few, if any, good examples of this model, according to authors such as Cronbach (1967), Glaser (1976), and Tobias (1976), this is the type of model that should be of interest in the future.

Two types of descriptive variables will be useful in discussing specific applications of the 16 general models. The first set of variables refers to the structure of the content. The hierarchical and random models of Walberg *et al.* are examples of this. Gagne and Briggs (1979) draw heavily on a variety of structural schemes in recommending principles that should be applied in instructional design projects. There is no doubt that the structure of the content to be taught will be useful both in describing models and suggesting procedures for implementing them.

The second type of descriptive variable refers to the details of any particular program. These might include how pre- and post-testing is used, how recycling and remediation is accomplished, what class sizes are used, how and when feedback is delivered, and how proctors and instructors support any given program. Such information will be necessary to describe programs completely and to make fine-grained discriminations among programs that fall within a common cell.

Most individualized instruction is concerned with teaching well defined bodies of knowledge or specific skills. For such instruction the proposed approach to categorizing models of individualized instruction appears to be adequate. However, the increasing interest in artificial intelligence as an instructional tool, the use of measures of cognitive processes (Glaser, 1976) and cognitive style (Dudgeon, 1976) as diagnostic tools to choose instructional treatments, and the hope that cognitive strategies can be taught may necessitate an expansion of the basic dimensions. It may be useful to distinguish between models of individualized instruction which are designed to teach traditional content and those which deal with higher mental processes. For example, Brown and Burton (1977) in describing some of their work in artificially intelligent instructional systems have stated that, "the kind of instructional system we are investigating does more than spew forth its knowledge as factual information. It uses its knowledge base and problem-solving expertise to aid the student in several ways. First, it answers his questions and can evaluate his theories as well as critique his solution paths. Second, it can form structural models of his reasoning strategies" (p. 1).

TREATMENT PROFICIENCY OBJECTIVES TIME		FIXED		VARIABLE	
		FIXED	VARIABLE	FIXED	VARIABLE
FIXED	FIXED	1	2	3	4
	VARIABLE	5	6	7	8
VARIABLE	FIXED	9 *	10	11 *	12
	VARIABLE	13	14	15	16

* = a critical model. See text.

Figure 9

Classification of Models of Individualized Instruction

This chapter of the review has attempted to define individualized instruction and has described the most common characteristics of examples of individualized instruction that have been implemented. Three approaches to categorizing models of individualized instruction were discussed, and a common, comprehensive approach was proposed. The approach appears to be adequate for most of the examples of individualized instruction now available, and it can be expanded to accommodate expected future advances as research in artificially intelligent instructional systems and the relationship between cognitive style and instructional treatment becomes applied to practical systems.

CHAPTER IV. SYSTEMS OF INDIVIDUALIZED INSTRUCTION

This part of the review is an examination of a representative selection of individualized instructional systems. The inclusion of such systems here does not constitute a judgment about their suitability for Armor (or Army) training but rather is intended only to suggest the variety of individualized systems that have been successfully implemented. Only a few selection criteria have been considered in deciding which to include here: the system, whether it still exists or not, has gotten beyond the experimental stage and has actually been used to instruct the general learner population for which it was designed; the system is, or has been, characterized by enough of the generally accepted features of individualized instruction to clearly mark it as an "individualized instructional system" (that is, it fits the definition of individualized instruction given in Chapter II and elsewhere); there is enough information in the literature (or available through other ready resources) to permit a reasonably detailed description of it; and, on the basis of reasonable criteria, it has been shown to be more effective than a conventional alternative.

Each system is described in terms of the eight (8) factors treated in Chapter II of this review and in terms of the generic models treated in Chapter III. While these factors do not constitute either mutually exclusive or exhaustive categories for the description of instructional systems, they are believed to adequately delimit the concerns the instructional developer, the training manager, or instructor must address as he decides what can or should be done within a particular instructional environment (context). For example, if neither the instructional personnel nor the information processing capability associated with highly complex, school-type systems of individualized instruction are available within a given instructional environment, then a highly complex, school-type system would probably not be feasible for that environment. Similarly, if the tasks being taught within a particular instructional environment are predominantly of the psycho-motor type, then a type of individualized instruction which has dealt exclusively or largely with cognitive tasks (precision teaching, for example) should be considered for that environment only with all due caution. In brief, then, the description of realized systems of individualized instruction on the basis of these eight factors and the generic models is believed to facilitate the analysis of them as exemplars of individualized instruction.

The Tank Turret Mechanic Self-Paced Course at the Armor School, Fort Knox, Kentucky

Because it was recently implemented (early in 1969) and is presumably receiving even now a considerable amount of evaluative attention, the Tank Turret Mechanic course at the Armor School may not yet qualify as an exemplar of individualized instruction, but the relative completeness of the descriptive material pertaining to it that is available to the authors of this review makes it a tempting point at which to begin the examination of systems.

The self-paced Tank Turret Mechanic course, or more precisely, the system of individualized instruction through which it is provided, is by no means the first or only experience of the Armor Branch with systems of individualized instruction, but it can be said to exist within an institution still largely

characterized by -- and perhaps philosophically dominated by -- traditional, "lockstep" forms of instruction. This point, of course, can be made about most systems of individualized instruction -- and most institutions or other organizations that contain them; it is made to emphasize the still emergent status of systems of individualized instruction.

Because the objectives, the proficiency levels, and the instructional treatments of this course are fixed while time to learn varies, the instructional system appears to be an example of the fixed-objectives, variable-time, fixed-proficiency, fixed-treatment model discussed in Chapter III (see Cell 9 in Figure 9). Variable instructional treatments could be inferred from the liberal approach to remediation, but, basically, all students study the same material. Selection does occur but primarily outside of the system; some students are apparently eliminated because of repeated failure of tests. Content seems to be structured hierarchically.

The following information was derived from the course Training Management Plan and the Student Learning Guide (U.S. Army Armor School):

1. Time Available for Learning. According to information provided by course managers/instructors the time allotted for this course in its "lockstep" form was thirteen (13) weeks. While the maximum time permitted any student to complete it in its present self-paced form apparently has not been precisely set, the student whose rate of progress indicates that he will take longer than thirteen weeks may be removed from the program. The mean time for completion of the self-paced course is a little less than ten (10) weeks.

Students engage in learning activities for eight (8) hours each workday except for lunch breaks and time spent on clean-up details. Learning is the full-time job of students, however, any interruptions of learning are apparently minimal.

2. Instructional Personnel. The instructional personnel of this course are mostly non-commissioned officers. (At the time of the interview, one, apparently a supervisor, was a civilian.) These non-commissioned officers appear to regard themselves as "lockstep" or "platform" instructors, are trained by their peers in the methods of individualized or "self-pace" instruction, and may be uncomfortable in their roles as managers of individualized learning. (One instructor, a Station Manager responsible for "facilitating" the learning of students assigned to the turret trainer lab, was overheard speaking to two students in the strident voice of a "platform lecturer.")

According to reports, at least some of these non-commissioned officers are trained as instructors through a program offered at the Armor School, but they are trained as "platform lecturers," however, (that is, in platform mannerisms, effective use of visual materials, etc.) and receive no instruction in the teaching behaviors required by individualized instruction. But the assigned duties of the instructional personnel assigned to this course explicitly include such functions as "counseling

problem students," assisting students with the planning and management of their learning activities, the prescription of remedial training, and tutoring.

According to the Training Management Plan (U.S. Army Armor School, n.d.), student tutors may also be used though "... sparingly and only in cases where success is positively indicated" (pp. 14, 15).

3. Facilities. The facilities provided for this course (instructional system) consist primarily of a large classroom, where instructional materials, media devices, and the principal course management functions are housed, and a "Trainer Lab," a very large indoor area which contains the tank turret trainers. Workbenches near the trainers hold tools and equipment.
4. Management. The organization of the instructional staff is hierarchical with four levels of responsibility being discernible in the Training Management Plan. The Self-Pace Course Coordinator is responsible for overall management and administration; the Shift Supervisor manages the course during his shift (the course operates on two shifts, one from 6 a.m. to 3 p.m. and the second from 3 p.m. until midnight); the Area Manager (one for the trainer lab and one for the classroom) is "responsible for the student flow through his/her area;" and the Station Manager, who is in the most direct and continuous contact with students and is assigned to the turret trainers and apparently also to learning stations in the classroom, is responsible for facilitating "... the day-to-day learning activities of the students."

Figure 10 represents the management of student learning as described by the Training Management Plan. But there are nuances that would be difficult to represent in such a diagram. The Station Manager -- and presumably also the Area Manager -- has considerable discretion, for example, in deciding what to do about a student who has gotten a No Go on a test. Further, because of the practice activities embedded in the lessons and his opportunity to directly monitor the student's progress toward the test (the student decides when he is ready for the test), he has ample opportunities to assure that the student is indeed ready to take a test. The manager can also -- if he has time and if there is a need -- tutor the deficient student. The Shift Supervisor can consult the student's Progress Index (or Cumulative Progress Index) and apparently also other records in deciding what to do about repeated failures (No Go's) on the same lesson.

The Progress Index (PI) is the ratio of actual lesson time in minutes (for any given student) to the "standard" lesson time (the lower the PI, the more rapid the progress). "Standard" times are normative and continuously updated as more and more students complete the course. PIs are categorized as "Above Average," "Average," "Below Average," and "Problem." They are also publicly displayed on a "Student Progress Board."

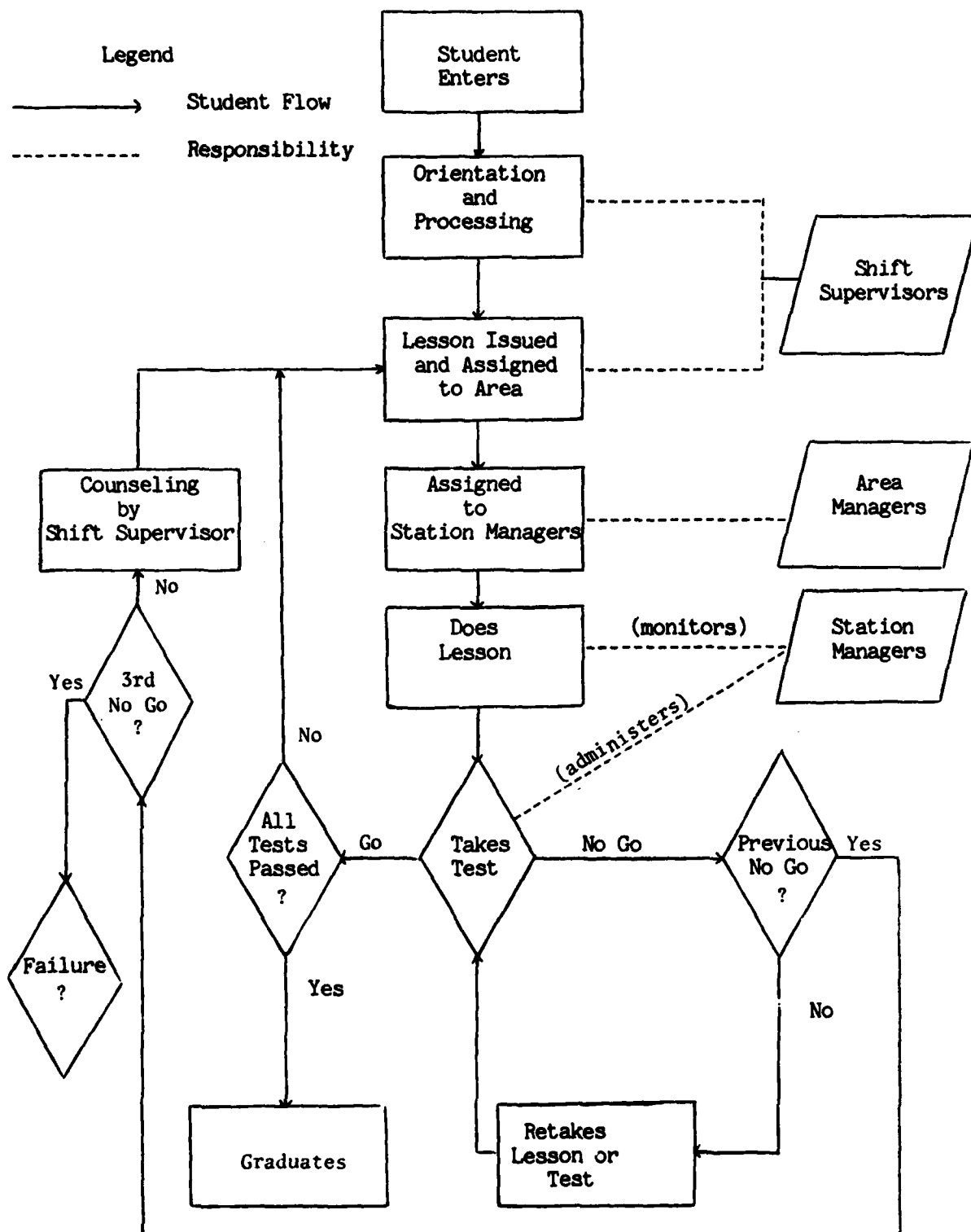


Figure 10

Management of Learning, Tank Turret Mechanic Course

Student entry and exit times are open. The PI is used to predict a student's course-completion time in order to provide lead-time for administrative processing.

5. Learning Characteristics/Student Population. This course has been designed for entry-level (Skill Level 1) Armor personnel. The Training Management Plan states that it has been "... intentionally designed to accommodate a wide variety of student abilities," but a minimum score of 95 on the General Mechanics Aptitude area of the Armed Forces Qualification Test (AFQT) is required. Presumably, students enter the course immediately after Basic Training.
6. Course Content/Task Types. It is clear that psycho-motor tasks are the predominant concern of this course, but cognitive tasks are also important. The turret mechanic must also, for example, use technical manuals, parts manuals, and various forms. He must comprehend some fundamentals of electricity and apply certain diagnostic (troubleshooting) procedures. But the emphasis is on performance; the student is told:

You only need to learn how to DO the maintenance tasks. You do not need to learn any theory in this course. So you don't need to know how the equipment operates, but you may need to know how to operate the equipment to do maintenance.
(Student Learning Guide, p. 14)

The tasks learned thus appear to be highly proceduralized.

7. Instructional Methods. The overall instructional method of this course is similar to Personalized Systems of Instruction (PSI, also called Keller Plan). It is characterized by self-pacing, unit mastery learning, and an emphasis on written material to communicate content, but it does not -- as PSI usually does -- make use of lectures and demonstrations as motivators. To the extent that Training Extension Course (TEC) and similar materials are used, it may also be considered to employ the method of programmed instruction. Further, the use of the Progress Index introduces an element of contingency management; the consequences of performance are frequently brought to the attention of the individual student.

The features of individualized instruction to be found to some degree in this course include the following:

- a. Outcome specification. Each lesson includes a behavioral objective.
- b. Repertoire assessment. It is the duty of the Shift Supervisor to evaluate the background of each student.

- c. Individual prescription. There is very little of this feature, but "problem students" are occasionally tutored, assigned peer-tutors, or given other forms of remediation.
 - d. Active responding. Students are frequently observed as they make active responses, especially in the turret trainers.
 - e. Explicit contingencies. Both time to learn and test performances are under the control of explicit contingencies.
 - f. Feedback. Both immediate and frequent feedback appear to be present, especially when the student is working in the turret trainer.
 - g. Self-pacing. Self-pacing within fairly broad limits is present, but the limits are clearly normative. Self-pacing is also somewhat constrained by the pairing of students for work in the turret trainers, but if one student is markedly slower or faster than the other he may be paired with another student closer to him in learning rate.
 - h. Critical information written. Students must learn to use a variety of documents, and all lessons apparently include a good deal of printed material.
 - i. Multi-media presentations. Sound filmstrip, videotape, and film-loop presentations are all used, but it is not clear how well these are matched with objectives or learner characteristics.
8. Instructional Media, Materials, and Devices. Individual carrels are equipped with audiovisual devices (see above), but learning packets contain much of the content as well as the usual objectives, directions for learning, and self-check tests. The principal training device is the turret trainer, which is the turret of an M60 or M60A1 tank modified for use in an indoor setting. Twenty (20) of these are located in a "lab," where pairs of students learn or practice maintenance tasks together under the supervision of a Station Manager, who puts the trainer into the "configuration" required by the particular lesson.

The Air Force Advanced Instructional System (AIS) at Lowry AFB, Denver

The AIS has been described by Yasutake and Stobie (n.d.) as "... a prototype computer-based multi-media system for the administration and management of individualized technical training on a large scale. The primary function of

the AIS is to provide training and management for up to 2100 students per day in four selected courses currently being taught at the Lowry Technical Training Center" (p. 1). The four courses are Inventory Management, Materiel Facilities, Precision Measuring Equipment, and Weapon Mechanic. They represent considerable variability in course length, content, complexity, and numbers of students.

Because the objectives and the proficiency levels of this instructional system are both fixed while both time to learn and instructional treatments vary, the system appears to be an example of the fixed-objective, variable-time, fixed-proficiency, variable-treatment model discussed in Chapter III (see Cell 11 in Figure 9). The content of the courses implemented through this system is arranged hierarchically (Judd et al., 1979), and some degree of selection is apparently practiced.

1. Time Available for Learning. The four courses of the AIS are self-paced, but they are considered to be of the following lengths: Inventory Management and Materiel Facilities, 5-6 weeks; Weapons Mechanic, 12 weeks; and Precision Measuring Equipment, 30 weeks (McCombs and McDaniel, 1978, p. 11). Because the AIS constitutes a school environment, students presumably spend eight hours each workday in learning activities. But AIS courses are considered to be "self-paced" only in a very limited sense, and the system includes a progress management function that, in order to save training costs, prompts students to complete courses as quickly as is consistent with individual abilities and the achievement of criteria (Judd et al., 1979).
2. Instructional Personnel. Instructional personnel apparently consist primarily of training-center instructors accustomed to their role as lecturers (Yasutake and Stobie, n.d., p. 6). Much of the work of managing student learning is done by the computer part of the system, but instructors are assigned to "learning centers" where students obtain learning resources and study in individual carrels (Judd et al., 1979). The function of the AIS instructor appears to be much like that of the proctor in PSI.
3. Facilities. AIS is a CMI system and therefore requires a computer facility, but most of the learning activities are off-line in individual carrels.
4. Management. The learning management functions inherent to AIS include "... diagnosis, prescription, resource allocation and scheduling, guidance and counseling, [and] progress management.... These functions are supported by a set of computer programs that comprise the Adaptive Model and Applications Programs Components of the AIS" (McCombs and McDaniel, 1978, p. 9)(see Figure 11). The Adaptive Model selects alternative instructional strategies on the basis of learner characteristics while the Resource Allocation Model included in it schedules learning resources needed for those strategies. The Applications Program Components provides information on projected course completion dates and rates of progress for

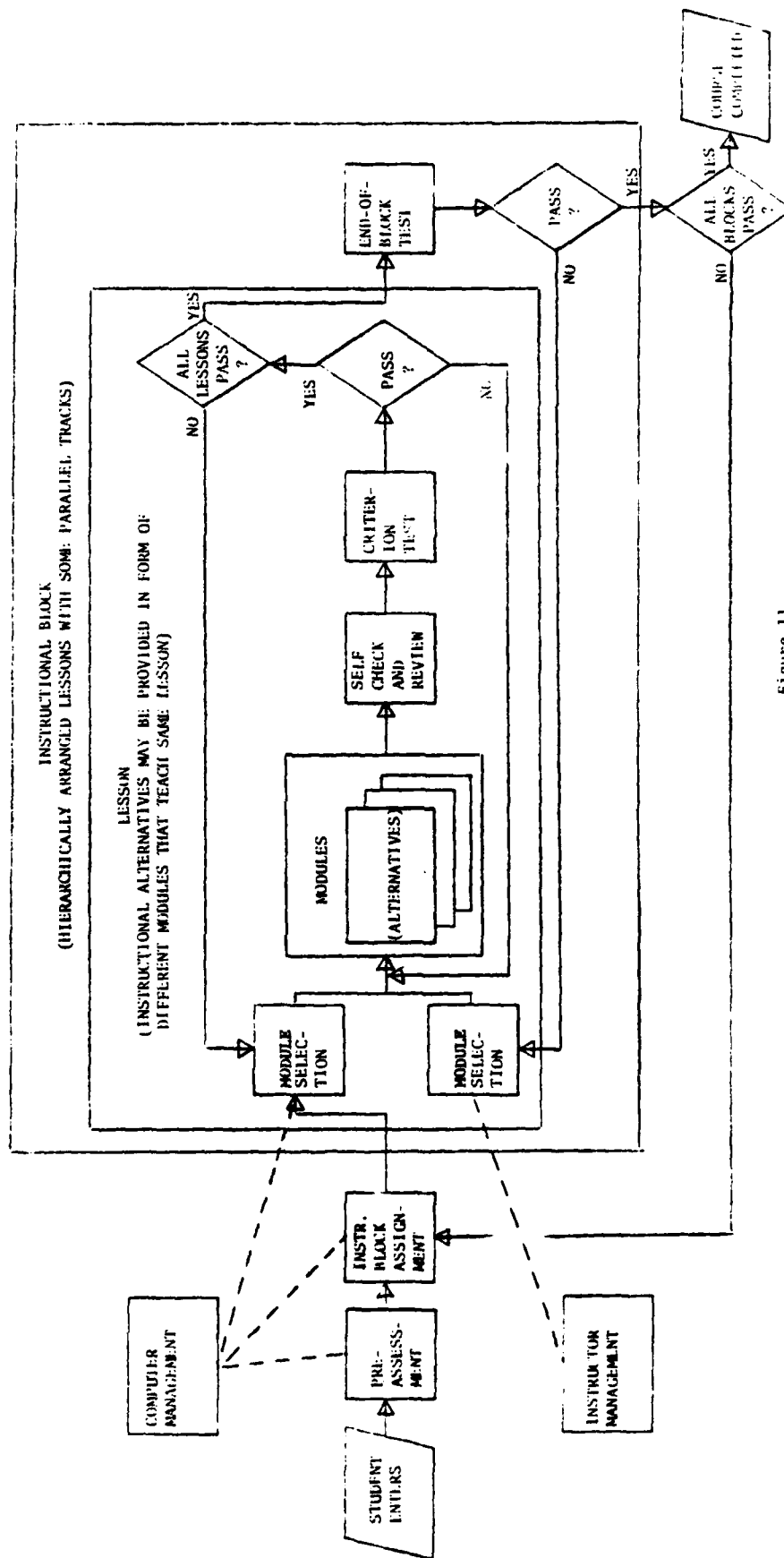


Figure 11

Management of Learning, AIS*

*This figure was inferred from
Judd et al., 1979.

individual students (p. 10). The system does include a Student Progress Management Component (computerized), which supports the progress management function mentioned above.

5. Learner Characteristics/Student Population. Students are generally Air Force trainees in technical fields. The characteristics of interest in AIS, for the purposes of predicting course-completion time, learning rate, and, in some cases, matching learners to instructional alternatives, are those measured by a course preassessment testing battery. Typically, the characteristics assessed include traits and states, such as reading/reasoning ability, memory, anxiety and curiosity states, and anxiety and curiosity traits (McCombs and McDaniel, 1978, p. 25).
6. Course Content/Task Types. The content of the courses implemented within AIS varies widely, but the task types can be characterized as ranging "... from clerical to mechanical and motor to problem solving skills" (McCombs and McDaniel, 1978, p. 11).
7. Instructional Methods. In that it employs a specific procedure for matching instructional/learning strategies with individual characteristics, the instructional methodology of AIS resembles that of Individually Prescribed Instruction (IPI). AIS methodology also includes mastery and modular learning, and contingency management is present to some extent in the form of both progress management and the mastery requirement. Programmed instruction is represented in at least the form of programmed texts. The adaptive learning feature of AIS is computer-based: "An adaptive instructional decision model utilizes state-of-the-art computer hardware and software, as well as currently available statistical methodologies and instructional procedures, to provide instructional management and individual assignments to alternative instructional materials" (Judd et al., 1979).
8. Instructional Media, Materials and Devices. AIS apparently makes use of nearly all standard forms of film, videotape, and audiotape. Devices necessary to task experience are also present (Yasutake and Stobie, n.d.). Materials include programmed text, illustrated (pictures, schematics) programmed texts, illustrated texts (a picture book that may be accompanied by printed or audiotape narration), and illustrated script (illustrations with frame-by-frame printed narration, essentially a back-up for audiovisual presentations).

The Computerized Training System (CTS) at the
U.S. Army Signal Center and Fort Gordon

The CTS (Project ABACUS) has not been as successful as might be expected on the basis of its early planning and development (Gaddis, 1973) or its antecedents (i.e., the PLATO and TICCIT experiences as well as successful CAI experiments conducted by the Army appear to have established the basis for its planning). Still, the selection criteria noted above would seem to warrant its

inclusion here. It could be that the shift in purpose of the system from CAL to CMI (Seidel et al., 1978, pp. 7, 15) has resulted in the development of a base of experience broadly applicable to individualized training in the Army.

This course also appears to be an example of the fixed-objective, variable-model discussed in Chapter III (see Cell 9 in Figure 9). Again, the way in which remediation is handled suggests some variability of treatments, but basically all students study the same material. The structure of the content seems clearly to be hierarchical, and pre-tests are employed at the lowest level of instruction while post-tests are employed at all levels. Because the course involves a prerequisite, selection is implied.

The following information is based largely on Seidel et al., Evaluation of a Prototype Computerized Training System (CTS) in Support of Self-Pacing and Management of Instruction (1978). Other sources are noted:

1. Time Available for Learning. CTS courses were compared with equivalent courses in self-paced format; this comparison revealed that both CTS students and self-paced students progressed through the courses at the rate required by the Programs of Instruction (POI). But less than 12% of the CTS hours were on-line (that is, involved direct use of a computer terminal by a student), and the remainder involved working in off-line activities. It would seem, then, that the CTS courses would not be greatly different from their self-paced counterparts. In one course CTS students completed 543 POI hours in a mean time of 462.9 actual hours, while self-paced students completed 599-657 POI hours in a mean of 645.6 hours. CTS students tended to spend 20-30 minutes on a terminal at one time, and the maximum recommended time is 45 minutes. Comparisons of CTS with conventional, or "lockstep," instruction were not attempted.
2. Instructional Personnel. In addition to instructors present during training and to whom the students have access, CTS requires the services of instructional programmers supported by specialists who enter materials into the computer. Apparently, instructional programmers are military technical experts working in conjunction with civilian specialists (Gaddis, 1973, p.2). Programmers need to be trained in a number of aspects of computer-based instructional programming, and nearly 200 hours of development time may be required for each on-line hour. Project ABACUS employed regular instructors as instructional programmers, and this practice seems to have had the effect of increasing the workload of other instructors.
3. Facilities. The computer that is the base of CTS is in one building at Fort Gordon while terminals are in a room of the building in which the computer is housed and in two rooms in other buildings. Separate rooms near the terminal rooms house audiovisual media used by CTS students for off-line studies. Terminal communication (appropriate channels for computer cables) has been a problem at Fort Gordon.
4. Management. The development of CTS posed a large number of difficult management problems -- after development work was

well under way the purpose of the system changed from CAI to CMI, the site was changed from Fort Monmouth to Fort Gordon, and personnel turbulence kept robbing the project of key personnel -- but the difficulty of developing such a system is an issue separate from the management of it once it is in place. The management of student learning appears to be a function shared between instructors and the computer. That is, some tests (pretests and post-tests on learning elements, the smallest units of instruction) are administered on-line while instructors administer the performance tests on larger units of instruction; the computer maintains some student records while instructors record others.

Figure 12 seems to illustrate the management of students within CTS as Seidel et al. (1978) have described it. The content is organized hierarchically with major subdivisions being labeled "annexes." Each "annex" consists of one or more tasks, each task is divided into task components, and each component into learning elements and a performance element. The student thus progresses through a number of elements which add up to a task component, through a number of task components which add up to an "annex," and finally through several "annexes" which add up to course completion. Because there seem to be no "annex" tests in the CTS courses that Seidel et al. (1978) have reported, the "annex" level of instruction is not shown in Figure 12; it would have no impact on the management of learning. There are nuances in the management of learning in CTS that are, of course, also not represented. Typical of these is the option the student has in regard to the pretests; he may take them or not, as he chooses. But if he does take one and scores above a certain level, he may skip the associated instruction and go on to the next learning element.

5. Learning Characteristics/Student Population. The students of CTS appear to be typical Army trainees, but, of a sample surveyed for attitudes toward the system, most did not prefer to be instructed through CTS. Though they tended to like using the computer terminal, they felt isolated and also expressed dissatisfaction about having to use a large number of media other than the terminal. They were most positive about the self-pacing feature and the clear and interesting presentation of materials; they were most negative about their inability to ask questions and the amount of information that they could have expected from an instructor but did not get from the system.
6. Course Content/Task Types. At the time of the evaluation of CTS by Seidel et al. (1978), the system had been used only for electronics training. According to Gaddis (1973) CTS was in fact a more or less direct result of the continuing effort (since 1966) of the United States Army Signal Center and School to develop CAI as a means of teaching basic electronics. The three courses implemented at the time of the Seidel study were Field Radio Repair, Teletypewriter Equipment Repair, and Avionics Communication Equipment Repair.

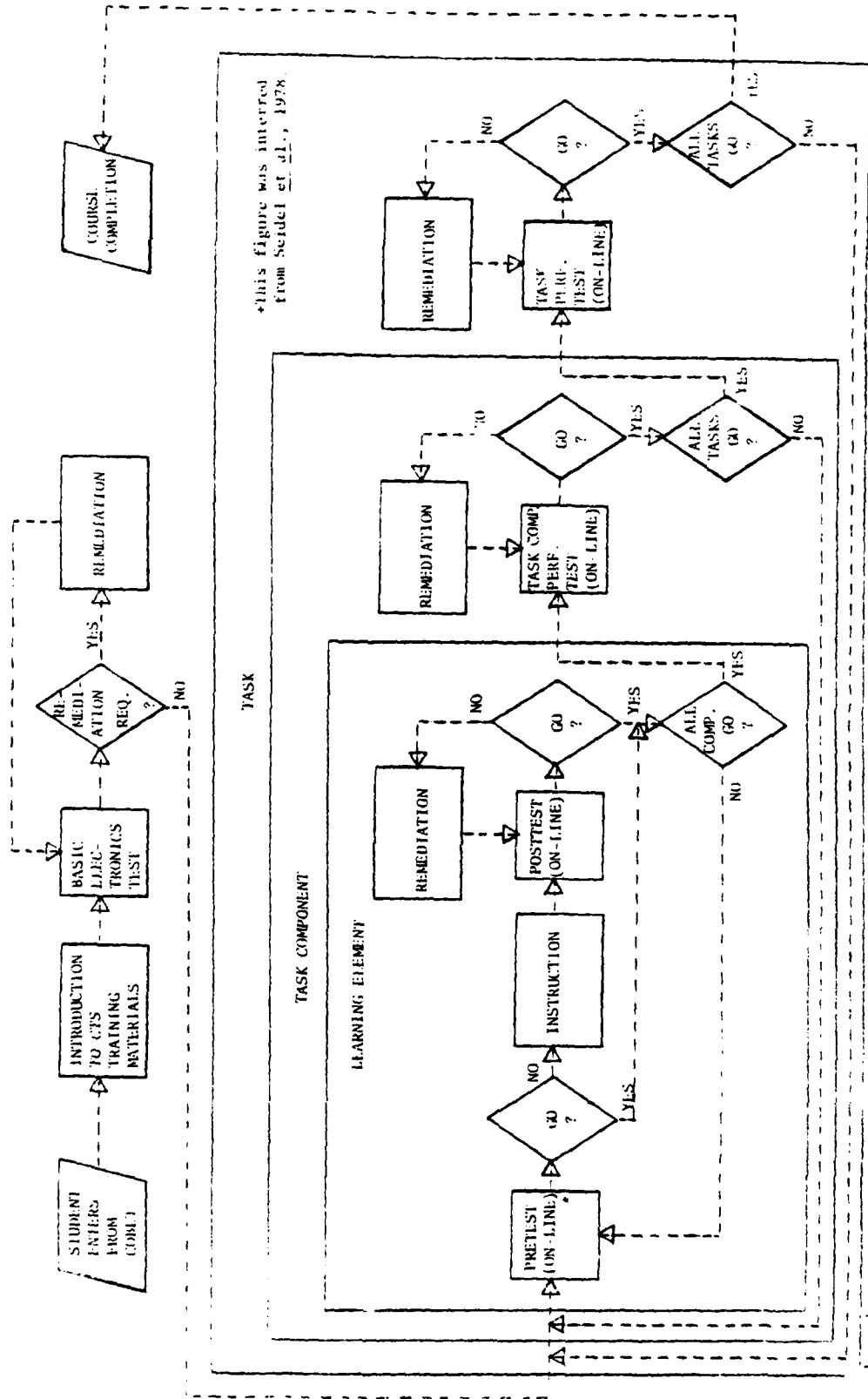


Figure 12.
Management of Learning, CIS*

Legend
 Solid line = Common Basic Electronics 1 on line, (a prerequisite course)
 Dashed line = Student Flow
 *Optional with student.

7. Instructional Methods. The most obvious instructional method employed in CTS is that of CAI/CMI, but other methodologies are inherent in computer-based approaches. It will be recalled that CAI is methodologically much like programmed instruction and that CMI is generally neutral with regard to approaches to the various off-line learning activities with which it is associated. Because of the prominence of the Lesson Study Guide as a controller of student activity, and because of the prescription of remediation (as a response to the failing of tests), Individually Prescribed Instruction (IPI) and learning packages also appear to at least be conceptually present. In that the amount and kind of instruction a student receives is varied in response to his performance (a student may be classified as "low," "medium," or "high" performer), adaptive learning of a fairly gross sort is also present. The design of CTS also provides for the selection of instructional modes (various combinations of print and audiovisual presentations) on the basis of the student's Progression Index, but this feature had apparently not been implemented at the time of the Seidel evaluation. An early paper by Seidel and Kopstein (1970) suggests that even more refined adaptive techniques must have been considered during the design of CTS.
8. Instructional Media, Materials, and Devices. CAI terminals are of the cathode ray tube (CRT)-keyboard type. Interdependently operating minicomputers control the terminals, and associated systems manage a data base and timesharing function. Some of the terminals are used by instructors for monitoring purposes. Audiovisual devices -- videotape players and apparently a considerable variety of other such devices -- are also employed and are usually housed in rooms separate from the terminal rooms. The Lesson Study Guide is a kind of learning packet, directing students to parts of technical manuals and to various other media presentations.

Personalized System of Instruction (PSI)

Personalized System of Instruction (PSI), or Keller Plan, so called after its developer, Fred S. Keller (1966), has been in common use at the college level for about fifteen years. Generally, it has enjoyed success and has been widely implemented and imitated.

Because PSI has been so widely implemented, it would be very difficult or impossible to summarize all the particular instances of it with all their variations. Thus, the following information is principally from Keller (1966), its developer, with other sources noted.

Because PSI is ordinarily implemented within existing fixed schedules, the time allotted for learning within this system should probably be regarded as fixed, even though the amount of time students actually spend varies widely and some students use more than the allotted time. Still, the time allotted for segments or units of instruction is not rigidly fixed, and this is probably the

more important consideration. Thus, PSI is most usefully viewed as an example of a variable-time model. Because of the instructional options the student has, treatments should also be considered variable. Objectives and proficiency levels, however, are presumably fixed in all or nearly all cases. The relevant model, then, is fixed objectives, variable time, fixed proficiency, and variable treatments (see Cell 11 in Figure 9). The system apparently does not involve selection, but the sequencing of material and the mastery requirement imply hierarchical content.

1. Time Available for Learning. The time constraints within which PSI operates obviously vary from situation to situation, but in colleges and universities it has typically been implemented within the confines of existing schedules. Thus, for typical college courses about fifteen weeks (plus or minus a week or so) would be available overall with an hour or more devoted to learning activities several times a week. Because much of the course time is spent in independent mode (which can be regarded as self-paced), the amount of time individuals spend on the course material varies widely while the overall time boundaries remain relatively fixed. A common practice within PSI is to establish deadlines for units of study (Bijou et al., 1976, p. 36), and according to Taveggia (1976), it is the nature of PSI to force students not to procrastinate but to pace themselves through a course so that they can finish on time (p. 1031). Still, students frequently do go beyond time limits and complete their PSI courses in subsequent semesters.
2. Instructional Personnel. The instructional personnel of a course implemented through PSI usually consist of the instructor or instructors who would be present in a traditional course and, in addition, one or more classroom assistants and a number of proctors (who work directly with students) to give a proctor-student ratio of about 1-8.
3. Facilities. Facilities (classrooms, laboratories, independent study areas) can be expected to vary with content, but PSI has been implemented within single (though perhaps large) classrooms.
4. Management. Figure 13 represents the management of student learning within PSI as it has been inferred from a number of sources. Students enter the system without assessment, presumably because the system is able to accommodate wide ranges of aptitude and achievement within the intended population. At an initial meeting of the class, the conduct of instruction is explained and beginning learning packages are distributed. From that point each student works on assigned packages. When he passes a "readiness" test on a "package," or unit, which indicates that he is ready for the next unit, he is then -- and only then -- assigned the next unit. Mastery performance is required, usually at a 100% level. Students who fail "readiness" tests recycle through units, first conferring with their proctors to determine what they need to learn. When the student has passed all units, he has completed the course; there is usually no final examination.

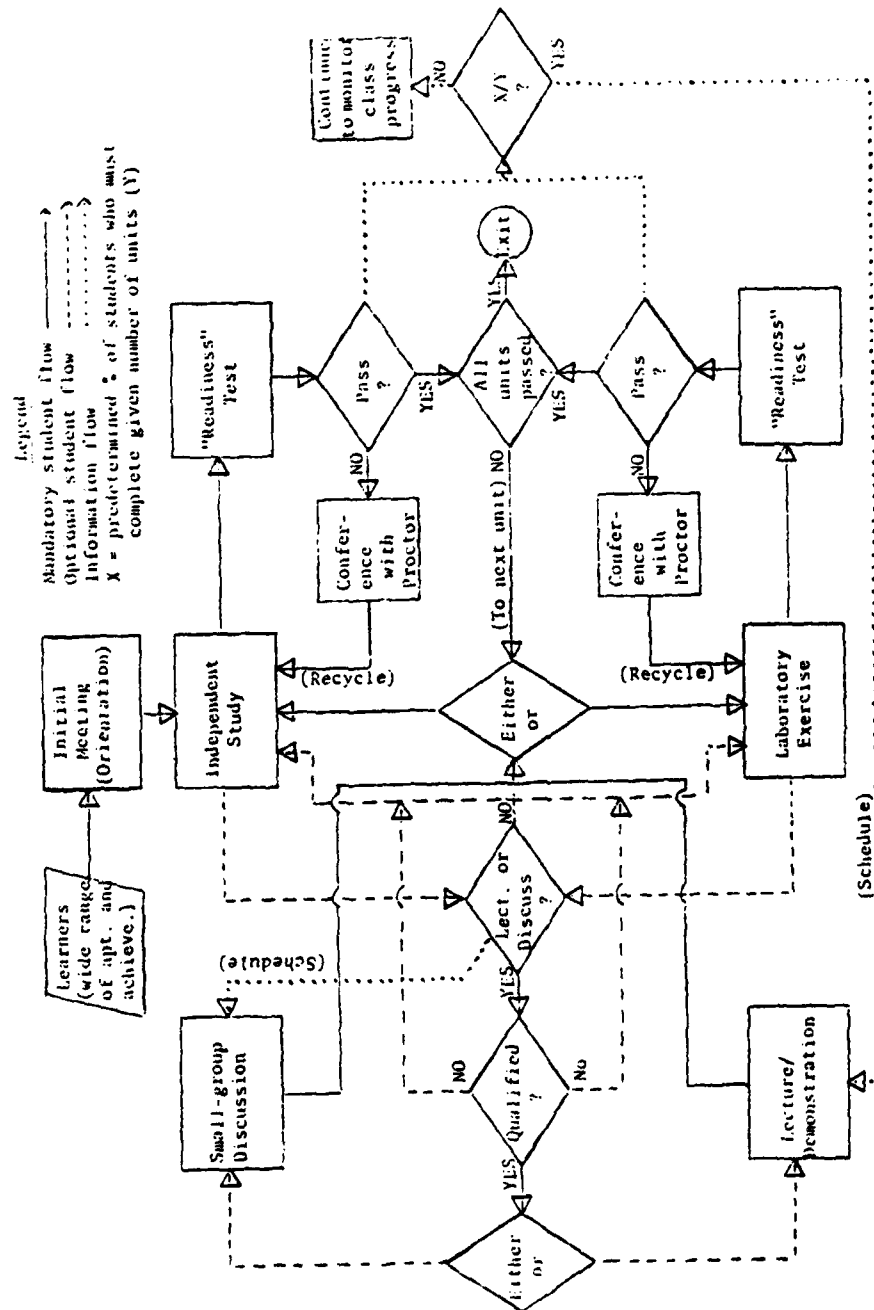


Figure 13
Management of Learning PSI (Keller Plan)

For students who demonstrate that they can benefit from them, lectures, demonstrations, and small-group discussions are scheduled. Lectures and demonstrations are scheduled when a certain proportion of the students (say 50%) has passed a certain number of units (say 10-15% of the units). These are optional but the right to attend must be earned. Students are not tested on these activities, which may be inspirational in purpose. Small-group discussions are offered in the same way when a sufficient number of students feel a need for them. To operate the system it is necessary to know how many students are in which units so that resources may be assigned. This function has been computerized.

5. Learner Characteristics/Student Population. The student population usually consists of college freshmen and sophomores. but the Navy, for example, has employed the method successfully for the training of enlisted personnel in propulsion engineering (McMichael et al., 1976). While it may be reasonable to assert that the typical student to be found in a PSI course is relatively high in aptitude, to name a relevant learner characteristic, it may not be safe to maintain that the method is especially appropriate for students with that characteristic. It was the Navy's experience that PSI was successful for a greater proportion of students in propulsion engineering training than was lockstep instruction. (McMichael et al., 1976, pp. 43, 44)
6. Course Content/Task Types. Again, because of the wide application of PSI, it is difficult to characterize the content or task types that have been successfully trained through the method. Content appears to have been largely cognitive both in college courses and in such programs as the Navy's propulsion engineering training for enlisted personnel, but part of the training described by McMichael et al. (1976) involved hands on training and thus tasks with psycho-motor elements.
7. Instructional Methods. Hess and Lehman (1976), it will be recalled, identified PSI as a "major method" of individualized instruction and pointed to the use of proctors as a significant feature of it. Robin (1976) noted such characteristic features of the system as self-pacing, unit mastery learning, lectures and demonstrations as motivators rather than sources of information, and the emphasis on written material to communicate content (pp. 314, 315).
8. Instructional Media, Materials, and Devices. Specific media, materials, and devices also vary from specific instance of PSI to specific instance, but a common feature of most instances would be the dependence on written materials to communicate content. According to McMichael et al. (1976, p. 42), "A common practice is to use an existing textbook and to prepare supportive materials designed to facilitate mastery of important points." The preparation of the course materials involves breaking the content down into small units and developing criterion tests for each such unit.

Individually Prescribed Instruction (IPI)

Another well-known and successful system of individualized instruction is termed Individually Prescribed Instruction (IPI). It is a product of the Learning Research and Development Center at the University of Pittsburgh and was developed by prominent scholars of educational technology (Scanlon, 1970). Precisely detailed and sequenced objectives, thorough diagnosis of learner characteristics, continuous monitoring of learner progress and reactions, and careful tailoring of instructional modes and materials to individual differences are all central features of the system. It too has been widely employed, and commercial packages for some content areas have been available.

The overall time allotted for learning within this system would appear to be fixed (see below), but because at least limited self-pacing is clearly a feature of the system, it should probably be regarded as an example of a variable-time model. Treatments are also variable in that students are placed in the hierarchical content on the basis of pre-tests and routed to alternative treatments on the basis of performance. Objectives and proficiency, however, appear to be fixed. IPI thus appears to be an example of the fixed-objectives, variable time, fixed-proficiency, variable-treatment model discussed in Chapter III (see Cell 11 in Figure 9). IPI is also clearly an example of the hierarchical diagnostic model presented by Walberg et al. (1972).

1. Time Available for Learning. The literature of IPI does appear to address the issue of time constraints, but because the system was developed specifically for the elementary school setting it seems reasonable to assume that IPI practitioners have been less concerned with time constraints than, say, college and military instructors and managers.
2. Instructional Personnel. IPI typically involves a principal instructor supported by a paraprofessional aide, but the aide does not seem to be a necessity. The complex nature of the instructional process, however, does seem to require the cooperative efforts of a number of institutional staff members (Lindvall and Bolvin, 1970).
3. Facilities. No more than a classroom appears to be required by typical IPI applications.
4. Management. Figure 14 represents the management of student learning within IPI as it has been inferred from a number of sources. Precise information about learner behavior is essential to successful management of IPI systems. Day-to-day operation requires such data as: (1) the level, unit, and skill of each learner; (2) the time a given learner has spent on acquiring a skill; and (3) the next skill each learner is to be assigned. Such information guides the planning for small- and large-group instruction, small-group discussions, and tutoring.

Because IPI emphasizes individual differences, testing is frequent and thorough. It employs four basic types of instruments: placement tests and evaluations, which yield data for

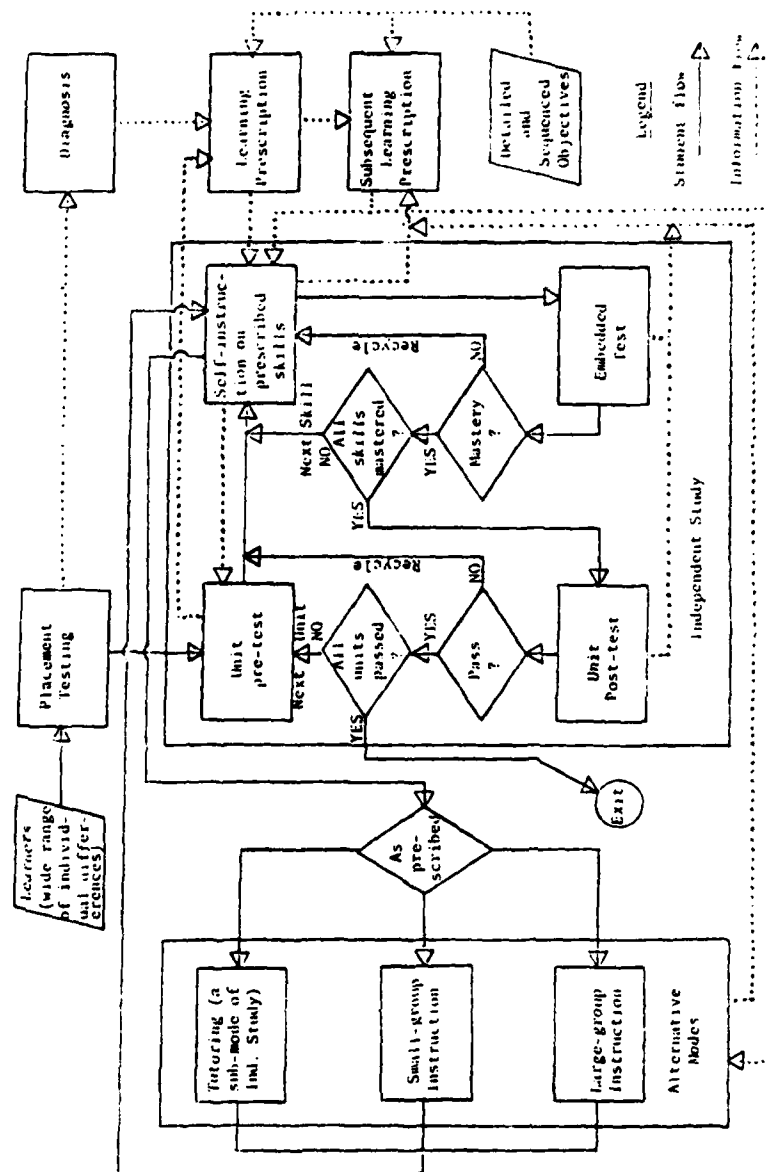


Figure 14
Management of Learning IPT

detailed diagnoses of each learner; pretests for each unit of instruction; post-tests for each unit; and "embedded" tests, which indicate to the learner his progress through a unit. The placement tests are keyed with considerable precision to the organization of content. "Units" of instruction are defined by the cells of a two-dimensional matrix with levels of difficulty along one axis and content areas along the other (see Figure 15). For a given content area, say D, a student tests first at an arbitrary level of difficulty, say 4. If his score indicates that he already knows the material, he tests again at D 5. He proceeds in this manner until his score falls within a predetermined range, and he is then assigned to the unit that corresponds to that last test. If, on the other hand, his score were to indicate that the material of D 4 is too difficult for him, he would test again at D 3 and proceed in this fashion until his score falls within the predetermined range.

Pretests and post-tests measure entering knowledge or skill and exit knowledge or skill in relation to instructional units; the self-check tests which the learner takes to assess his mastery of a skill are called "Curriculum Embedded Tests." Learner performance is fed back to the system to influence both subsequent prescriptions for learning and modifications of the system.

		Levels of Difficulty						
		1	2	3	4	5	6	7
Content Areas	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							

Figure 15. Two-Dimensional Matrix

5. Learner Characteristics/Student Population. The IPI student population appears to have consisted principally of elementary school students. A child-development point of view may be noted in the writings of prominent developers of IPI (see, for example, Bolvin and Glaser, 1968), and the earliest implementations of the system were apparently in elementary schools. But according to Hess and Lehman (1976, p. 18), the system has been implemented at secondary and post-secondary levels.
6. Course Content/Task Types. Typically, course content has included such elementary subjects as mathematics, science, and reading, but other content areas have apparently been addressed at the secondary and post-secondary levels.
7. Instructional Methods. Hess and Lehman (1976) have identified IPI also as a "major method" of individualized instruction. The identifying features of it have been mentioned above, but the central feature according to Hess and Lehman is the detailed assessment of learner characteristics and the use of the assessment to develop a prescription for learning that matches the learner's characteristics.
8. Instructional Media, Materials, and Devices. IPI employs a variety of instructional modes and materials, but the emphasis appears to be on a type of programmed text for independent study. The need for tutoring, small-group instruction, and large-group instruction is determined as a part of the process of individual prescription for learning, and each of these modes may require its own materials and media devices. The written individual prescription for learning is based on the ability of the learner, his general maturity, his learning style, and his reactions to various modes of instruction, and through such prescriptions the learner is assigned to particular modes and materials of instruction. The system therefore requires the development and use of a large number of tests.

Some Other Significant Individualized Instructional System Developments

While the systems of individualized instruction briefly discussed below do not meet the criteria for inclusion in this review, their obvious relevance for Armor training makes it important that they not be altogether ignored. Brennan and Taylor (1975) have reported a study to determine the feasibility of self-pacing a gross motor skills course, in this case the Crawler Tractor Operator Course at the U.S. Army Training Center, Engineer, Fort Leonard Wood, Missouri. Though the prototype system (there were actually two systems, Self-Paced I Program and Self-Paced II Program, which was a modification of I) was found to be feasible, allowing some students to learn to operate two pieces of equipment in addition to the crawler tractor, it apparently was not permanently implemented. According to one informal report, some sort of self-paced system for the Crawler Tractor Operator Course did exist at the time of the study reported by Brennan and Taylor (1975) but not, apparently, the one they described.

A self-paced heavy construction equipment operator course is now being developed at the U.S. Army Engineer School, Fort Belvoir, Virginia. Some materials have been developed and validated, but according to informal reports no part of the course had been implemented as of August, 1979. As the course has been designed, the student, guided by a list of "Self-Check Questions," first studies a task by means of videotape or some other audiovisual medium. When he is confident that he has learned the material presented, he reports to the "control center," where he is assigned to a piece of equipment for practice on the task under the supervision of an instructor. After a period of practice (and presumably after the student has acquired some confidence in his ability to perform the task), he is given a go/no-go test by the instructor. If he receives a no-go on any item in the performance checklist (the test), he is immediately corrected by the instructor and assigned review or additional practice.

CHAPTER V. CONCLUSIONS

The literature reviewed in the preceding chapters supports a number of general but significant conclusions. Some of these may be taken as criticism of individualized instruction as it now exists, as well as of the theoretical and empirical work associated with it, but most of them are forward looking, pointing both to unrealized opportunities and work to be done:

1. "Individualized instruction" is a generic term denoting a large class of instructional approaches rather than any particular approach. Generally, it is the intention of approaches called "individualized" to match learners with appropriate instructional strategies, but beyond this one seemingly universal trait there are many specific methodological differences among established approaches to individualization. As for saying what "individualized instruction" is, the definition cited in this review, it will be recalled, pointed to the frequency with which instructional decisions are made as the distinguishing guide to the true nature of a system of instruction. Thus, instructional decisions about which students should receive what treatment are made in all -- or nearly all -- instructional systems (that is, all instruction -- or nearly all -- is individualized to some extent), but a frequency below some value (not given in the definition or elsewhere) would mark a system which could be called "conventional," "traditional," or "lockstep," while a frequency above that value would mark a system which would be called "individualized." Since the discriminating value is not known, however, a definition of individualized instruction based on it is of little use. The solution to this essentially semantic problem, therefore, would seem to lie in simply avoiding the use of the term "individualized instruction" in any context where a comparison of competing systems is explicit or implied. Instead, a system of individualized instruction can be identified through a label that emphasizes some significant feature of it, such as self-pacing, mastery learning, or CMI. This seems to have been the strategy adopted in the description of a number of systems of individualized instruction.
2. There are few fundamental differences among current approaches to individualized instruction. Differences among existing approaches to individualization of instruction are much more apparent at the level of detail than at the level of fundamental structure: pre-assessment may or may not be employed, this medium of instruction or that may be emphasized, and contingencies may be more or less stringent; but in most systems objectives and proficiency levels -- from the student's point of view, at least -- are given, and while treatments and time for learning may be variable they are variable only within narrow limits.

In the final analysis, this state of affairs may be altogether desirable or necessary, but as the instructional developer or training manager looks about for a fundamental approach to individualization that may solve a unique problem, he may not find it profitable to compare only the fundamental structures (or, for that matter, the surface details) of established systems of individualization instruction. He may, however, find some profit in examining the empty cells of the matrix given in Figure 9, and this observation leads to the next conclusion.

3. There are many possible fundamental models of individualized instruction that have not yet been realized in a significant way (that is, there are many empty cells in the matrix given in Figure 9). Again, in the final analysis, this state of affairs may be altogether desirable or necessary. But because of the generally positive effects of variable time to learn and variable treatments (even though variable treatments usually do not give the learner a great many options), it is interesting to speculate on the possible effects of variable objectives and variable proficiency. It is known that, as a matter of course, not all students in conventional or traditional instruction learn the same things or, when they do learn the same things, learn them to the same levels of proficiency, and it is known that, as a matter of fact, this same situation exists in most systems of individualized instruction. What is not known in any reliable way is what effects could be expected from formalizing this situation within variable-objectives, variable-proficiency systems of individualized instruction. Because individually variable time to learn can save time (and therefore money) and individually variable treatments can save students in the sense that the probability of failing to learn can be diminished, it seems reasonable to think that individually variable objectives and levels of proficiency might have similarly desirable effects. Thus, for the instructional developer, training manager, or policy maker who needs conceptual guidance, there are possibilities for the individualization of instruction that are not expressed in generally established practice.
4. There are many ways to individualize, and the selection of an approach to individualization should be based on a careful examination of the needs, assets, and constraints of a particular instructional environment (context). There are some highly successful systems of individualized instruction that invite imitation (or replication), but the planner or designer should not become trapped within a narrow definition of his own making. The "many ways" are suggested both by Hess and Lehman's (1976) major methods and features of individualized instruction, listed in Chapter II of this review under Instructional Methods, and by the conceptual framework of individualized instruction discussed in Chapter III. But each major method, feature, and fundamental model that is considered for a particular context of instruction must be carefully considered in the light of the

realities of that context. On the basis of both accumulated experience with various approaches to individualization and available conceptual schemes for the classification of fundamental models of individualized instruction as well as instructional contexts, it should be possible to develop rational and systematic procedures for selecting ways to individualize within particular instructional contexts.

5. An indispensable aspect of individualized instruction is an adequate data base. Perhaps more than any other aspect of individualized instruction, it is the existence of a data base that permits individual needs and characteristics to be considered. If the learner and the teacher both know what the individual learner needs to learn, what he has learned, and what he should learn next, then individualization becomes possible -- even in the absence of many of the facilitative features commonly thought of as constituting individualized instruction. If the learner and the teacher both know how the learner learns best, then that best way can be employed -- if it is available. But in the absence of a readily accessible and systematically maintained data base, such knowledge will not exist when it is needed, during the necessarily brief moment when a decision about an individual learner is made. If it is the frequency of instructional decision making that makes the difference between individualized instruction and conventional or group instruction, then the data base is the keystone of individualized instruction. When individualized instruction is conducted on a large scale, computerization of the data base is common and may well be necessary.
6. In some areas the literature of individualized instruction is sparse or ill-defined. Information about the facilities required or used by various systems of individualized instruction is difficult to find, for example, and while there is somewhat more information about the impacts of individualized instruction on instructional personnel, and vice versa, there is less than the critical nature of the skills and attitudes of instructors leads one to expect. There is a wealth of literature on ATI research, but it can only be described as ill-defined.

Only a very few of the many studies or descriptions reviewed dealt in any detail with the design of facilities for individualized instruction, but the explicitness of these few leaves little doubt as to the importance of facilities for the design and conduct of individualized instruction. More commonly, facilities appear to be taken for granted, suggesting that for many developers and researchers the facilities were those that already existed and were thus a given part of the problem. Likewise, research reports and descriptive articles typically omit discussions of where instructional personnel came from, how they were prepared for their new roles, and what impacts their attitudes had on the success or failure of the system described. Again, the literature that does address these concerns leaves little doubt about the potency of the instructor as a factor controlling the efficacy of individualized instruction.

There is probably no area of learning research with greater potential significance for individualized instruction than that concerned with aptitude-treatment interactions, but after a dozen years or so of fairly intense effort the area still shows much more promise than achievement. But new directions appear to be getting established -- as in the Air Force AIS, for example -- and it still seems reasonable to expect that a prescriptive science of learning will someday evolve.

7. Finally, there are areas of future development that hold considerable significance for the design and conduct of individualized instruction. One of these areas, of course, is that of ATI, and it is intertwined with several others. Two of these -- those of the microprocessor (perhaps with bubble memory) and the videodisc -- appear to be undergoing rapid development, and if a third -- that of artificial intelligence -- should continue to develop in directions that appear to be possible, then an ultimate form of individualized instruction could well be achieved within the foreseeable future: a tireless and wholly positive automated tutor for each student that will respond to his/her characteristics and needs with a unique and well tailored program of instruction.

Two other areas may possibly get the attention they need at some time in the future. These neglected areas are those of instructor training and institutional change. Instructors involved in the implementation of systems of individualized instruction -- when they have been trained as instructors at all -- appear to have been trained in the practices of conventional or traditional instruction; that is, they have been trained as group rather than individual teachers, and this frequently means that they have learned little more than how to be effective lecturers. The conduct of individualized instruction, however, requires skills and behaviors that are very different from those exhibited by the effective lecturer. If individualized instruction is to be effective, instructors must change, and this observation is also true for the institutions in which individualized instruction is undertaken. Individualized instruction is, in essence, a new way of conducting the business of instruction, and it requires new skills, behaviors, and attitudes at all levels of the organizations or institutions in which it is implemented. If such basic institutional change does not occur, then individualized instruction will continue to be the intrusive newcomer with daily skirmishes to fight.

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APPENDIX

ABSTRACTS

INTRODUCTION

This annex contains abstracts of most, but by no means all, of the documents reviewed. In all, 222 documents were reviewed but only 157 abstracts are included here. In most cases, abstracts of general or well known works are not included nor are there any for most brief, descriptive, non-research articles, especially when the substance is given in the title or in the review itself. Thus, the criterion for including an abstract here can be said to be usefulness.

The abstracts are arranged alphabetically by title. Author(s) and date are also given for each document abstracted, but the list of references in the main volume must be consulted for all other bibliographic information. In all but a few cases, the abstracts are those provided by the authors of the documents reviewed; the few others were written by the documentation specialists of the project staff (see acknowledgments).

ANNEX: ABSTRACTS

1. Academic Improvement through an Experimental Classroom Management System, Matheny, K. B. and Edwards, C. R., 1974.

Employed an experimental classroom management system involving contingency management, individualized instruction, peer assistance, and teacher adoption of the role of a manager of learning activities in 25 Appalachian classrooms. The system appeared to be responsible for raising the number of students who made one month's achievement in reading for one month in the classroom from 27.5% to 57% over a seven-month period. Student success was related to the degree to which teachers implemented the various aspects of the management system. The system was ineffective in influencing student attendance. Students profiting most from the system tended to increase their sense of control over events happening to them. The study suggests that improvements in instruction may be accompanied by improvements in their academic achievement of students.

2. Achievement Treatment Interactions, Tobias, S., 1976.

Reviews and analyzes literature dealing with research on individualized instruction, often called the "aptitude-treatment interaction" (ATI), which deals with the relationships between individual differences and various treatments. Problems, pitfalls, and concerns of ATI research are extensively detailed; general conclusions concerning research in this area appear to be limited. Hypotheses concerning the ATI and suggestions for future research are presented.

3. Adaptive Training -- An Application to Flight Simulation, Caro, P. W., Jr., 1969.

Army pilot training requirements, particularly in the helicopter area, are growing rapidly. To meet the increased training load, an Army-wide system of aircraft simulators, known as the Synthetic Flight Training System (SFTS), has been designed and is under development. A feature of the SFTS is the automation of many instructor functions normally associated with training in flight simulators. A portion of the automation involves the application of adaptive training techniques. This paper describes the SFTS and the rationale for the incorporation in it of adaptive training. The selection of appropriate adaptive variables, techniques for error measurement and for providing feedback to trainees, and the adaptive logic employed are discussed.

4. Administrative Implications of Curriculum Reform, Abbott, M. G. and Eidell, T. L., 1970.

The Director of the Center for the Advanced Study of Educational Administration at the University of Oregon and one of his associates discuss the new role of administration in an individual-oriented educational system.

5. Adoption Guide for College and University Administrators, Wilson, Charles M.

Project CLASS (Coordinated Learning Activities for School Staff) provides a vehicle for local school systems, colleges, and universities to join together in the identification of teacher training and in-service needs and the development and execution of graduate studies and/or staff development programs designed to meet those needs. This document suggests the following guidelines for college and university administrators who are interested in the development of such a cooperative program: (1) establish a philosophic base of agreement within the faculty; (2) provide a structure for faculty planning and involvement that includes both college faculty and public school professionals; (3) provide a management structure that shares decision-making between the college or university and the public school system; (4) determine what system will be used for granting academic credit for the attainment of competence based on local school needs; (5) develop a staffing plan that provides for lower student/professor ratio than traditional graduate programs; (6) provide instructional resources appropriate for individualized study which are transportable to a field setting; (7) provide a system for the storage, retrieval, and management of individualized instructional materials; (8) prepare process manuals for each major element of the program; and (9) prepare to deal with the question of cost-effectiveness.

6. Advanced Development Work Resulting in Inventory Management (IM) Individualized Instruction Materials, Fallentine, B. C. and others, February, 1974.

A developmental project created prototype individualized instructional materials for the Inventory Management (IM) Course which could be incorporated into the Air Force Advanced Instructional System (AIS). Typical course segments and a final block of instruction were selected, and instructional materials were developed for these units. The materials were field-tested with individual students and revised; they were then used with a group of students, revised a second time, and used by several Air Force training classes. Results showed that all students attained all the learning objectives, and that a mean student time savings of 55% was achieved. Student attitudes were favorable and no problems were encountered. It was therefore concluded that the individualized materials should be used in the AIS since they resulted in increased efficiency with no loss of achievement.

7. The Air Force Advanced Instructional System (AIS): An Overview, Yasutake, J. Y. and Stobie, W. H.

The Air Force Advanced Instructional System (AIS) is a prototype computer-based multimedia system for the administration and management of individualized technical training on a large scale. The paper provides an overview of the AIS: (1) its purposes and goals, (2) the background and rationale for the development approach, (3) a basic description of the total system, and (4) the developmental status and overall schedule. Practical considerations influencing the design approach for the AIS prototype included features of: cost-effectiveness, systems approach, incremental payoff, and maximum modularity and flexibility. Presently, AIS development is directed to the technically-related development activities of instructional materials development,

instructional strategies, computer support, and system evaluation; future development will include system transition and institutional change.

8. The Analysis and Development of an Adaptive Instruction Model(s) for Individualized Technical Training; Phase I, Hansen, D. N. and others, August, 1973.

Shrinking training budgets pose a serious problem to those confronted with the present and future challenge of providing competent Air Force technicians for increasingly technical positions in a modern Air Force. One promising solution to this problem has been to harness the capabilities of the computer as an instructional training device. To be cost-effective, computer-based instruction must maximize individual student attainment of training objectives, while simultaneously minimizing training time and costs. Adaptive Instructional Models (AIM) constitute the means by which effective training can be accomplished with a minimum expenditure of student time and instructional resources. The report describes the purpose and function of AIM. Additionally, seven adaptive instructional models are analyzed, and recommendations as to model application in Air Force technical training courses are made.

9. Analysis of the Proctoring Variable in PSI Courses, Gaynor, J. F., March, 1975.

Presents an analysis of the proctoring variable in the F. S. Keller (see PA, Vol 43:4532) Personalized System of Instruction (PSI). The effective use of previously trained vs currently enrolled proctors as a vehicle through which individualized tutorial instruction can be achieved is compared and evaluated. Testing and feedback procedures are outlined and it is concluded that empirical support for an analysis of proctoring is of uneven quality and incomplete.

10. Application of Adaptive Decision Aiding Systems to Computer-Assisted Instruction, May, D. M., Crooks, W. H., Purcell, D. D., Lucaccini, L. F., Freedy, A., and Weltman, G., October, 1977.

A minicomputer-based Computerized Diagnostic and Decision Training (CDDT) system, combining principles of artificial intelligence, decision theory, and adaptive computer-assisted instruction, is described. Training focuses on decision-making in electronic troubleshooting. The CDDT System incorporates an adaptive computer program which learns the student's diagnostic and decision value structure using a trainable network technique of pattern classification, compares this structure to that of an expert, and adapts the instructional sequence to eliminate discrepancies through the use of heuristic algorithms. An expected value model of decision-making is the basis of the student and instructor models which, with the task simulator and adaptive instructions, form the core of the CDDT system. The instructor model also generates suggested actions in response to student requests for assistance. The student's task is to troubleshoot a complex circuit by making test measurements, replacing the malfunctioning part, and making verification measurements. The student values of interest are those for information gained through the measurements, and for the replacement of circuit modules.

11. Application of Adaptive Decision Aiding Systems to Computer-Assisted Instruction: Adaptive Computer Training System (ACTS), Crooks, W. H., Kuppin, M. A., and Freedy, A., June, 1978.

This report describes the Adaptive Computerized Training System (ACTS) which combines the techniques of circuit simulation, artificial intelligence, decision modeling, and adaptive computer-assisted instruction to provide training in decision making. The ACTS incorporates an adaptive computer program which learns a student's value structure and uses this structure to train the student in practical decision making.

This report describes the development and operation of the ACTS as it is applied to training electronics troubleshooting. Experimental evaluations have demonstrated that the adaptive decision model accurately models a student's performance, and that adaptively-selected instructions and decision feedback can improve troubleshooting performance.

12. Application of Adaptive Decision Aiding Systems to Computer-Assisted Instruction: Experimental Studies, May, D. M., Crooks, W. H., and Freedy, A., February, 1978.

This report describes a system for Computerized Decision Training (CDT) which focuses on improving and sharpening higher order cognitive skills in judgmental decision making. The CDT system incorporates an adaptive computer program which learns the student's value structure, and uses this structure to train the student in practical decision making. This report describes the application of decision models in training, and presents the features of the CDT system as it is applied in electronic troubleshooting. Experimental evaluations have demonstrated that the adaptive decision model accurately models the student's performance and that the adaptively-selected instructions sometimes improves troubleshooting performance.

13. Applications of Videodisc Technology to Individualized Instruction, Schneider, E. W., September, 1975.

Several general considerations and characteristics are described and illustrated for the application of videodisc technology to individualized instruction: (1) a prototype of a videodisc unit; (2) digital read-only memory; (3) cost economics; (4) educational uses; (5) development versus videodisc terminals. A bibliography of descriptive material on videodisc technology is included.

14. Augmented Feedback in Adaptive Motor Skill Training, Cote, D. O., Williges, B. H., and Williges, R. C., 1978.

Two training models in motor learning and the effects of visually presented augmented feedback on training and transfer were examined in two studies using a two-dimensional pursuit tracking task. Training in both studies consisted of three-minute trials and continued until criterion performance was attained. The transfer task used in both studies consisted of one seven-minute session in which tracking difficulty shifted each minute. In Study I, the combined effects of training type and augmented feedback on training time and transfer performance were examined. Twenty-four male college students were randomly

assigned to one of four training conditions. These were: (1) fixed-difficulty with no augmented feedback; (2) fixed-difficulty with augmented feedback; (3) automatic adaptive with no augmented feedback; and (4) automatic adaptive with augmented feedback. In transfer, no feedback was given in all groups. No differences in training time were observed. However, subjects trained using the automatic adaptive model exhibited significantly less tracking error in transfer. In Study II, four automatic adaptive training conditions were used to examine possible interactions between the automatic adaptive training model and feedback cues in training and transfer. Six male college students were randomly assigned to each condition. Feedback in the four conditions was: (1) training-no feedback, transfer-no feedback; (2) training-feedback; transfer-no feedback; (3) training-no feedback; transfer-feedback; and (4) training-feedback, transfer-feedback. No reliable differences due to feedback occurred in training or transfer. The lack of reliable differences due to feedback in both studies is believed to be a result of an overload of the visual channel.

15. Automated Apprenticeship Training (AAT): A Systematized Audio-Visual Approach to Self-Paced Job Training, Pieper, W. J., Catrow, E. J., Swezey, R. W., and Smith, E. A., April, 1973.

Two automated apprenticeship training (AAT) courses were developed, administered, and evaluated for Air Force security police law enforcement and security specialists. AAT is a systematized audio-visual approach to self-paced job training which employs an easily operated, portable and reliable teaching device. AAT courses were developed to be job specific and were based on a behavioral task analysis of the two security police specialty areas. AAT graduates were compared with graduates of comparable courses for the same jobs in a training regime by aptitude group design. Evaluation criteria included a job specific performance test, and apprentice knowledge test and supervisor's ratings.

16. Behavioral Instruction in the College Classroom, Robin, A. L., 1976.

Reviews and discusses the major theoretical assumptions underlying the major approaches of personalized systems of instruction (PSI): The Keller Plan; Ferster's (1968) Oral Interview; Johnston and Penny-packer's (1971) Performance Session; and the Group Remediation System. Outcome research concerning these methods is evaluated, and the influence on final outcome of various PSI components is considered; i.e., self-pacing, unit-perfection requirement, stress on the written word, proctors, study objectives, grading, lectures, and Component-Student interactions. It is suggested that research in the area suffers from three major problems: methodology, the nature of the attitudinal response and high withdrawal rates. Issues and directions for future research are suggested.

17. Chem Tips: Individualized Instruction in Undergraduate Chemistry Courses, Shakhshiri, B. Z., September, 1975.

Describes a functional management system which individualizes instruction in undergraduate chemistry courses. CHEM TIPS (Chemistry Teaching Information Processing System) is designed to monitor each student's

progress, identify specific weaknesses and strengths in his understanding of the course material, prescribe individual study assignments, and use student feedback in modifying teaching strategies.

18. Classroom Management of Learning Package Programs, Smith, L. W. and Kapfer, P. G., September, 1972.

The behaviors associated with learning packages are different from the traditional expectations and monitoring these behaviors requires a new awareness on the part of the teacher. New behavioral competencies are listed. Implementation moves and strategies dealing with facilitative, disruptive, and self-motivated learning behaviors are discussed for the teacher's use.

19. A Comparison of Adaptive and Nonadaptive Training Strategies in the Acquisition of a Physically Complex Psychomotor Skill, Riedel, J. A. and others, December, 1975.

Results of research to determine if an adaptive technique could be used to teach a physically complex psychomotor skill (specifically, performing on an arc welding simulator) more efficiently than the skill could be taught with a nonadaptive technique are presented. Sixty hull maintenance technician firemen and firemen apprentice trainees were selected randomly to perform on the simulator and were given pre- and post-training tests. Analysis of covariance was used on the data, and results indicate no significant difference between the effectiveness of adaptive and fixed schedules in training the skill studied. An introduction discusses the problem, purpose, and background of the study, as well as presenting a rationale for adoption and a history of adaptive applications. Research methodology is examined in terms of the subject, apparatus, experimental setting and design, and procedures. A discussion of the results, conclusions, and recommendations are presented. Six tables and eight figures supplement the text. It is recommended that since there may be a relationship between physical task complexity and the utility of adaptive/fixed training strategies, further research to understand the potential interaction between these two variables be undertaken.

20. Competency-Based Learning Packages: A Case Study, Murray, N. J., September, 1976.

Describes the instructional design, development, and delivery system of competency-based, criterion-referenced packages and syllabi used in the external-degree programs of the Institute for Personal and Career Development of Central Michigan University. Designed for mature adults, these materials emphasize learning by doing, learning by modeling, and learning from patterning and responding to reality situations. A self-instruction package is not a modified textbook or a subject presented in a linear-programmed format, but an effort to achieve the best of both worlds. Each module contains a self-assessment test. Some consist of preclass assignments plus group instruction materials. This assures some commonality of entry level or identification of students needing attention.

21. Comprehensive Staff Differentiation, Bishop, L. K.

A differentiated staffing of teachers would allow teachers to assume responsibilities or differentiated duties based on their level of experience, training, and professional competence. This paper outlines fundamental theoretical premises such as: (a) a climate for professional behavior; (b) differentiation of responsibility and career mobility in teaching; (c) diffusion of power and decentralization of decision-making; (d) flexibility of instructional time and space; and (e) development of self-regulatory functions and teacher accountability. An operational model is presented.

22. Computational Achievement of Group IV Trainees with a Self-Study Format: Effects of Introducing Audio, Withdrawing Assistance, and Increasing Training Time, Main, R. E., September, 1974.

A series of experiments was performed to determine levels of computational skills that could be achieved by personnel with marginally acceptable preinduction scores on the Armed Forces Qualifications Test after training which utilized the Practical Arithmetic Self-Study (PASS) course. The effects of providing supplementary audio materials, decreasing assistance from instructors, and increasing training time were investigated. In general, PASS course training appeared to be highly effective in the printed format.

23. The Computer as Adaptive Instructional Decision Maker, Kopstein, F. F. and Seidel, R. J., September, 1969.

This document is a brief overview of the concept of adaptive instructional systems. Covered in the discussion is: (1) an introduction to the concept of instruction or information exchange system; (2) a three-dimensional representation of the variables: data elements, students and course level; and (3) instructional decision models which assess decision factors, selects an initial option and optimizes the presentation. The instructional decision models use valid confidence testing to select stimulus support and further actions which is a technique for telling the computer what the student does not know as well as what the student does know. Future direction for instructional decision models is discussed.

24. Computer-Assisted Instruction for Dispersed Populations: System Cost Models, Ball, J. and Jamison, D., 15 September 1972.

Problems of cost stall substantial implementation of computer-assisted instruction (CAI), particularly for dispersed populations. This paper examines the problems inherent in providing CAI to scattered groups so that accurate estimates of the costs of different technologies (including satellites) which could deliver CAI to dispersed populations can be made and so that, on the basis of these costs, educators can make decisions about the allocation of their resources. The paper first outlines a CAI system capable of reaching dispersed populations without excessive costs (i.e., the system requires only 110 bits per second communications capability for each student terminal). This makes the service economically feasible. Next, models of several communications alternatives for the system are provided. The results of

this modeling constitute approximate minimum cost communication designs for many configurations of populations dispersal. Finally, some basic economic trade-offs and implementation alternatives are described which are relevant to educators who must decide whether or not to use CAI for certain populations.

25. Computer Based Education: An Approach Toward Adaptive Learning Procedures, Casmey, H. B., August, 1976.

Though recent decades have witnessed radical changes in the nature of the society, technology offers a way for schools to continue providing quality educational services. The combination of rapidly changing constituencies, an emphasis on cost-effectiveness, and the trend toward individualized learning presents educational needs that can be filled using computer-based instruction and administration. This report summarizes current trends in computer-based education, including descriptions of four programs: (1) Minnesota Educational Computing Consortium; (2) Control Data's feasibility study; (3) Special Learning Disabilities Project; and (4) Law Enforcement Assistance Agency Project.

26. Computer-Managed Instruction: An Annotated Bibliography, Finch, J. J., March, 1972.

Presents content summaries of 28 references on computer applications that assist teachers and students in individualizing instruction.

27. Computer Managed Instruction in Navy Training, Middleton, M. G. and others, March, 1974.

An investigation was made of the feasibility of computer-managed instruction (CMI) for the Navy. Possibilities were examined regarding a centralized computer system for all Navy training, minicomputers for remote classes, and shipboard computers for on-board training. The general state of the art and feasibility of CMI were reviewed, alternative computer languages and terminals studied, and criteria developed for selecting courses for CMI. Literature reviews, site visits, and a questionnaire survey were conducted. Results indicated that despite its high costs, CMI was necessary if a significant number of the more than 4,000 Navy training courses were to become individualized and self-paced. It was concluded that the cost of implementing a large-scale centralized computer system for all training courses was prohibitive, but that the use of minicomputers for particular courses and for small, remote classes was feasible. It was also concluded that the use of shipboard computers for training was both desirable and technically feasible, but that this would require the acquisition of additional minicomputers for educational purposes since the existing shipboard equipment was both expensive to convert and already heavily used for other purposes.

28. Computer Managed Study for Small Computer Systems, Daykin, P. N., Gilfillan, J. W., and Hicks, B. L., March, 1975.

Discusses a model of computer managed study (CMS) in secondary schools to provide minicomputer services for students, teachers, and administrators. Current CMS research is outlined and the CMS system at the University of Illinois is described in detail. Student computer terminal use is evaluated critically with a positive assessment for student learning and evaluation.

29. A Computer Program for Management of Student Performance Information, Steffenson, R. G. and Read, E. A., May, 1970.

Describes a computer program which manages student achievement (performance) and readiness information and relieves teachers of time-consuming tasks, i.e., test scoring, recording and arranging test results, analyzing testing instruments, and revising, updating, storing, and retrieving records. The program was designed to the specifications of teachers who individualize instruction. The individualization process involved two models, the initial and continuous process flow, whose steps are delineated. The program is further described in terms of system definition, direct loading transaction, test loading transaction, direct update transaction, test update transaction, system design, computer program design, curriculum definition, mastery definition, performance matrix, and testing features.

30. Computers and the Learning Process in Higher Education, Rockart, J. F. and Morton, M. S. S., 1975.

This book deals with the use of computers in the instructional process. A careful delineation of the uses and limitations of computers in higher education, comparing computer-based and non-technology-based methods. The authors see the use of computers in education as having a useful and valuable role but consider it doubtful that it will serve as a substitute for conventional instruction.

31. Computers in Military Training, Sherron, G. T., June, 1975.

Field visits were made to twenty military installations throughout the United States -- nine Army, two Air Force, one Marine Corps, four Navy, and four Department of Defense. Through computer and education and training conferences in Washington, D.C. and New York, personal contacts were made with personnel from four additional installations. Hearing of the research project, they asked to have their activity included in the research by on-the-spot-interviews. This extension of the design allowed all twenty-four of the military installations which have an active computer program to be represented in this paper.

32. A Conception of Individualized Instruction, Walberg, H. J. et al., October, 1972.

Argues for three basic principles in considering instructional materials and curricula that: (1) individualization is multidimensional -- a particular package or program can be individualized in some ways and not

in others; (2) the degree of individualism is found in the usage of materials as well as in their inherent qualities; and (3) all learning and instruction must be viewed as individualized to some degree.

33. The Concepts of Performance-Oriented Instruction Used in Developing the Experimental Volunteer Army Training Program, Taylor, J. E. and others, March, 1972.

This report describes the planning and implementing of the Experimental Volunteer Army Training Program (EVATP) at Fort Ord early in 1971. This was the Army's first effort to effect major training innovations in the conversion toward an all-volunteer Army. By the fall of 1971, this program was being used as a model for implementing the EVATP at other Army Training Centers. In developing the EVATP system, six established learning principles were applied to Basic Combat Training and Advanced Individual Training to modify the conventional training system. Course objectives and performance tests used were developed jointly by Fort Ord and HUMRRO. In a comparison with a conventionally trained group, independently conducted by the Infantry School at Fort Benning, EVATP graduates performed significantly better on five out of seven BCT subjects, and seven out of nine AIT subjects. In general, these gains were shown by men at all levels of aptitude.

34. Consequences of Training Teachers to Use a Mastery Learning Strategy, Okey, J. R., September-October, 1977.

Described is a project designed to produce materials fostering favorable teacher attitudes and acquisition of skills needed in using mastery learning in the classroom; in addition, effects on pupil attitudes and achievement are determined when teachers use mastery learning skills acquired during the training phase of the project.

35. Continuation of Development of an Individual Extension Training System for Managing and Conduction Training in the Army Unit, Bialek, H. M., Taylor, J. E., and Melching, W. H., January, 1978.

The work reported covers the development and field test of a comprehensive and integrated prototype training and evaluation system for combat units. The emphasis is on performance oriented training for individual skills. Five activities were pursued: (1) field testing of system components; (2) further refinement of system components; (3) continuation of three related research studies; (4) development of guidelines for transfer of technology; (5) preparation for a large scale field test and a study of retention of individual skills. Findings indicate that an individual extension training system (IETS) is feasible. Furthermore, it is consistent with the Enlisted Personnel Management System and Skill Qualification Tests.

36. Cost-Effectiveness of Computer-Based Instruction in Military Training, Orlansky, J. and String, J., April, 1979.

Compares and evaluates the cost and effectiveness of four methods of instruction including conventional, individualized, computer-assisted, and computer-managed.

37. Design and Implementation of an Individualized Instruction Program, Davis, J. J., December, 1977.

This article describes a procedure for determining an optimal individualized instructional program. The model incorporates certain critical features lacking in many contemporary schemes: it proceeds in a systematic manner; it addresses the interaction of cognitive processes and instructional task demands; it provides for continuous evaluation and modification; and it deals with measurable behaviors. The model is divided into three components (adapted from Tuckman and Edwards, 1973). The first component, analysis, contains the following three activities: (1) the determination of post-instructional behaviors; (2) the translation of these behaviors into behavioral objectives; and (3) a specification of a sequence for the presentation of the objectives. Following analysis is synthesis, which involves: (1) determination of learner competencies and processes; (2) description of materials; and (3) establishing the instructional setting. The outcomes of each of these steps are integrated into an instructional program. This program, along with evaluation and modification, comprise the final component of the model, operation.

The remainder of this article details each of these activities.

38. Designing Facilities for Learning: An Experiment at Burlington County College, Douglas, H. L., October, 1970.

Describes one college's efforts at systematically incorporating the new media into the instructional program.

39. Developmental Aspects of Individually Prescribed Instruction, Bolvin, J. O. and Glaser, R., October, 1968.

The authors present four aims of IPI in achieving the adaptation of instruction to individual characteristics and background: (1) assessment of individual differences; (2) mastery of a subject; (3) development of self-directed learners through instructional procedures; (4) provision of the opportunity for students to become involved in the learning process. The first two aims are discussed in further detail. Assessment must deal with different entering education, rates of learning and individual goals. Six aspects of mastery learning are identified and discussed.

40. Developing the Potential of Low Ability Personnel, Jealous, F. S., Bialek, H. M., Pitpit, F. G. P., June, 1975.

Examined the scope of the learning capacity of marginal US Army personnel, the longitudinal effects of long-term, self-managed learning strategies, and the proficiency levels reached as a result of the application of these strategies. Data were collected on the self-selected activities engaged in by the 24 participants and the proficiency levels reached. Considerable gains were reported in both areas for a majority of the participants. Recommendations for setting up a special individualized instruction program are listed in the event that utilization of large numbers of marginal personnel is necessary.

41. Development and Implementation of a Performance Based Training and Evaluation System for the Combat Arms, Bialek, H. M. and Brennan, M., November, 1978.

This report describes the results of attempts to implement the Individual Extension Training System (IETS) in two infantry battalions. This effort was accomplished during the third year of a three year development and implementation project. This report describes, in detail, the following: (1) the content, administration, and outcomes of a series of workshops given to trainers and training managers of the participating units; (2) the design, procedure, and outcome of an evaluation of the system in operation including results of first-hand observations of training and interviews; (3) an analysis and discussion of problems related to implementing the IETS.

42. Development and Implementation of the Computer-Assisted Instruction Study Management System (CAISMS), Alessi, S. M., Anderson, R. C., Anderson, T. H., Biddle, W. B., Dalgaard, B. R., Paden, D. W., Smock, H. R., Surber, J. R., and Wietecha, E. J., February, 1974.

This paper reports the work accomplished during the initial year of a contract between the University of Illinois and Navy Personnel Research and Development with Advanced Research Projects Agency support. The purpose of the project was to design, tryout, and evaluate a system for maintaining attentive study of instructional materials. A CAI system was used for this purpose but, in contrast to most CAI efforts, existing materials were used and students spent minimal time in on-line contact with the computer. The report includes a manual of procedures for preparing test items which maintain attentive study, evaluation of the system, cost projections for use of the system, and a suggested extension of the system.

43. Development, Field Test, and Refinement of Performance Training Programs in Armor Advanced Individual Training, Young, D. L. and Taylor, J. E., June, 1975.

Performance-oriented instruction was developed, field tested, and refined in two Advanced Individual Training (AIT) programs -- Armor Reconnaissance Specialist (MOS 11D) and Armor Crewman (MOS 11E). Tasks for both MOS (Military Occupational Specialty) were inventoried and the inventories were reduced by eliminating those tasks which are not required for entry-level duty performance. Performance objectives were written for tasks that could be feasibly and appropriately trained. These performance objectives were translated into performance measures and tests. Both programs were revised to include the performance objectives and measures. Field test, data collection, and refinement of the two training programs extended over 10 successive training cycles. The approximate number of trainees involved were 1,000 and 2,000 respectively. Programs were refined on the basis of observation of instruction, results of formal performance examinations, and attitude indicators. The final programs resulted in high trainee proficiency levels, and favorable trainee and instructor attitudes. Questionnaires used to sample trainee and instructor attitudes toward the performance-oriented programs are appended.

44. Development of a Behavior Taxonomy for Describing Human Tasks: A Correlational-Experimental Approach, Fleishman, E. A., February, 1967.

The need for identifying a set of unifying dimensions underlying skilled behavior is discussed. The issues bear on problems of generalizing principles from laboratory to operational tasks and from one task to another. Combinations of experimental and correlational approaches appear to be required. The conceptual framework and research strategy utilized by the author in his research on perceptual-motor abilities is described and its relevance to taxonomy questions discussed. The integrative nature of the framework developed is illustrated by a wide variety of studies, in laboratory and operational situations, ranging from those of skill learning and retention to the effects of environmental factors on human performance, and in the standardization of laboratory tasks for performance assessment.

45. Development of a Model Tank Gunnery Test, Wheaton, G. R., Fingerman, P. W., and Boycan, G. G., August, 1978.

Research was undertaken to develop a model live-fire test that can be used to evaluate tank crew proficiency in neutralizing targets. The model test takes into consideration different types of target engagements, the behaviors of the individual crew members that are required and the practical constraints associated with the use of main gun ammunition for testing purposes.

Existing descriptions of M60A1AOS gunnery objectives were reviewed and updated to reflect current US Army Armor School doctrine.

46. Development of an Individual Extension Training System for Managing and Conducting Training in the Army Unit, Taylor, J. E., Suchman, J. R., Melching, W. H., and Bialek, H. M., October, 1977.

The work reported here was accomplished during the first year of a contract to develop a performance-based system for the conduct of individual training and evaluation in Army combat units. The work was conducted in concurrently running development and research phases. The development phase: (1) determined the current approach to the conduct of individual skill training and evaluation by the subordinate units of an Army combat division; (2) determined the resources (time, material, personnel) available to a division for such training and evaluation; (3) developed a model for accomplishing the Army's training objectives under real-world resource constraints; (4) designed a prototype system for accomplishing training and evaluation for a representative sample of job tasks for the Light Weapons Infantryman (MOS 11B) and the Indirect Fire Infantryman (MOS 11C) at EPMS Skill Levels 1 and 2; and (5) developed and pilot tested instructional, evaluation, management, and record keeping techniques and materials to support the system in a subsequent field test. The research phase studied the effects of major variables impinging upon the system; i.e., (1) personnel turbulence within units; (2) the attractiveness of a variety of incentives for pursuing training; and (3) cost effective approaches to determining an individual's training needs. At this writing, findings and products of the development and research phases are being incorporated into a

field test of the system in an infantry battalion. Three rifle companies, under varying conditions of personnel turbulence, are employing the system to conduct individual training and evaluation. Data are to be gathered on: (1) the system's feasibility; (2) performance of participants; and (3) attitudes of participants, trainers, and training managers toward the system. The system will be refined on the basis of field test results.

47. The Effectiveness of Alternative Media in Conjunction with TEC for Improving Performance in MOS Related Tasks, Hoyt, W. G. and others, December, 1977.

This research report addresses two questions: Does CAI provide a suitable and acceptable medium for delivering Training Extension Course (TEC) materials to field units? Can Army lesson developers feasibly be trained to convert self-paced, audio-visual materials into CAI format and easily update such materials? The approach used was to convert six TEC lessons into CAI format. The job sequence for each task was followed and each new topic was introduced as needed. This provided a logically-structured, integrated, functional, product-oriented, learner-centered approach. The results of this project suggest that: CAI can be cost effective; development and evaluation lead time can be short; Army lesson developers can be trained in a relatively brief period. Results also suggest potential training effectiveness as a result of individualized self-paced instruction inherent in the use of CAI, and evaluation capabilities useful in the management of the instructional process. Appendices include the scope of the project, procedure guides for use with a UNIVAC computer system, workbook examples, data collection system, and the conversion workshop schedule.

48. The Effectiveness of Instructional Strategies Designed to Compensate for Individual Differences in Student Memory Abilities and Motivation, McCombs, B. L., March, 1978.

Effects of various instructional strategies designed to compensate for student differences in pre-course memory abilities (processing and retrieval skills) and motivation (anxiety, curiosity) were investigated for lessons differing in content and task requirements. Performance on each strategy was compared to performance on mainline instructional treatments, separately under no progress management conditions, for 34 to 181 students in the Air Force Advanced Instructional System's Inventory Management course. Interaction analyses on lesson times-to-criterion and criterion test scores generally supported expectations that compensating strategies would benefit low memory ability, low curious, or high anxious students. A particular strategy's success was found to be a function of task and content characteristics, and progress management conditions. Findings are discussed in the context of the methodology used to design and evaluate these strategies, and the methodology's feasibility and efficiency for application in computer-based instructional environments is addressed. The effectiveness of specific compensating strategies is also discussed within the frameworks of contemporary information processing and motivation theories.

49. The Effect of Incentives on Student-Paced Instruction, Johnson, K. A., Salop, P. A., and Harding, L. G., September, 1972.

A system of incentives was developed for use in a student-paced training sequence. Student aptitude was used to predict each student's rate of progress through the sequence. Students were told that if they fell too far behind their predicted rate of progress, they would be assigned to special remedial study sessions, and that if they exceeded their predicted rate of progress, they would be given preferential treatment in assignments to subsequent courses. This system was evaluated in two studies on slightly different versions of the training sequence. In the first study the incentive system led to a 17% reduction in training time; in the second study it led to an 11% reduction in training time.

50. The Effects of Internal Proctoring upon Examination Performance in a Personalized Instruction Course, Johnson, K. R., Sulzer-Azaroff, B., and Maass, C. A., September, 1976.

Investigated the effects of required internal proctoring on the examination performance of 60 students in an introductory psychology course. Course materials were divided into three segments of four units each. After mastery was demonstrated on each unit within a segment in proper succession, students took a generalization achievement test (GAT). Three groups were required to proctor the quizzes of 15 classmates in one of the three course segments. Group 1 proctored Segment 1 quizzes; Group 2, Segment 2; and Group 3, Segment 3. Group 4 did no proctoring. Each student in Groups 1-3 was required to proctor at least two quizzes on each unit in the segment. Results show that students who proctored in each segment scored higher on the corresponding GAT than students who did not. Differences ranged from 5 to 17% in each instance and were statistically significant. Each group also answered more final exam items correctly from the segment that they proctored, but the differences were not as large. Results are discussed in terms of multiple benefits of proctoring and the cost-efficiency of internal proctoring.

51. The Effects of Mastery, Adaptive Mastery, and Non-Mastery Models on the Learning of a Mathematical Task, Taylor, S. S., March, 1975.

Three learning models (adaptive mastery, typical mastery, and traditional non-mastery learning models) which employed different criteria for terminating computer-based practice in order to determine mastery or non-mastery of arithmetic skills were compared. The efficiency of two different sequencing arrangements (mixed and clustered) of practice items was also examined. All treatments involved the teaching of basic arithmetic skills to seventh-grade students. The adaptive mastery learning model produced the same high level of performance on both the post-test and a delayed retention test as the other two models, but requires less time, fewer practice items, and minimized overpractice. No significant differences were found between the clustered and mixed item arrangements.

52. An Empirical Investigation of Individual Differences in Time to Learn, Anderson, L. W., April, 1976.

Results show that student differences in time-on-task to learn to criterion are alterable and can be minimized over a sequence of learning units given appropriate adaptive learning strategies.

53. An Empirical Investigation of the Interrelationships among Six Elements of Individualized Instruction, Johnson, J. K., December, 1976.

This research studied the interrelationships of six traits of individualization: diagnosis, content options, flexible time frames, evaluation choice in location, and alternate forms of instruction. The work included development of instruments to inventory the traits, execution of the inventory at the high school level, and statistical analysis of the results. Findings revealed three factors: (1) learner selection factor; (2) learner requirement factor; and (3) the instruction design factor.

54. Evaluation of a Prototype Computerized Training System (CTS) in Support of Self-Pacing and Management of Instruction, Seidel, R. J., Rosenblatt, R., Wagner, H., Schulz, R., and Hunter, B., August, 1978.

This report contains an evaluation of the prototype Computerized Training System (CTS), sponsored by the Department of the Army and the U.S. Army Training and Doctrine Command (TRADOC) and implemented at the U.S. Army Signal Center and Fort Gordon (USASC&FG). The methodology involved a "lessons learned" approach and includes guidance for future implementation of computer-based training systems.

55. An Evaluation of Computer-Managed Instruction in Navy Technical Training, Carson, S. B., Graham, L. L., Harding, L. G., Johnson, K. A., Mayo, G. D., and Salop, P. A., May, 1975.

The purpose of this project was to develop and evaluate a Computer-Managed Instruction (CMI) system that would be less expensive than Computer-Assisted Instruction (CAI), would provide a frequency of interaction that falls somewhere between that provided by CAI and that normally provided by CMI, and would handle some of the clerical and administrative burdens that are normally imposed by student-paced instruction. More specifically, a system was developed that would make assignments, grade tests, provide feedback to the student, and provide some of the information needed for the effective control and management of a large-scale system of student-paced instruction. Both the instruction and testing took place off line.

The system was evaluated in two short courses taught at the Naval Air Technical Training Center, Memphis. It was compared to: (1) classroom instruction and (2) a system of student-paced instruction that was based on the training materials and tests developed for the CMI system, but which substituted "manual" operations for certain of the operations provided by the computer in the CMI system.

It was found that the use of either form of student-paced instruction led to a reduction in training time of approximately 50% and to slightly higher scores on criterion-referenced tests of student knowledge. There were no substantial differences between the two student-paced systems in terms of training effectiveness. There were several factors which precluded a precise comparison between the two student-paced systems in terms of either cost or cost avoidance, but both were substantially less expensive than current CAI systems.

56. An Evaluation Through Field Testing of Individualized Instruction Materials in Wisconsin Post-Secondary Institutes, Lambrecht, J. J. and others, August, 1972.

To determine the relative levels of achievement of students enrolled in courses designed to permit individualized instruction and to determine those courses or instructional aspects considered effective or ineffective in achieving objectives, achievement data on 1,204 students within the post-secondary institutes of the Wisconsin vocational education system were gathered from school records, and background data were obtained by questionnaire. Critical incidents were obtained through personal interviews with 224 students and 28 teachers. Analyses were performed contrasting student achievement and the critical incidents across subject areas, across technical school districts, within separate subject areas, and across five models of individualized instruction and four class scheduling patterns. Some principal findings were: (1) higher grades and fewer course incompletes or withdrawals were received by students who possessed these characteristics, previous experience in the subject, high school graduation, and enrollment in an associate degree program; and (2) course characteristics which were most effective included student-pacing of their own programs, use of pretesting to place students within a course, student selection of special study topics, and use of different types of testing procedures.

57. An Experimental CMI System on the PDP 11/20, Espeland, L. R. and Walker, G. S., December, 1973.

A computer-managed instructional (CMI) system is being developed for use in investigating a CMI environment for Air Force technical training using the PDP 11/20 minicomputer. Software and hardware interfaces are now available for 24" core memory with an additional 128k random access disc storage. Hardware interfaces are complete for the student key-readers, an interactive graphic terminal, a test form reader and a computer-controlled slide projector. The CMI system also uses the manufacturer's hardware such as the cathode ray tube terminal, card printer and line printer. Key reader devices, capable of reading data from a coded key, identify the user and his location to the system and monitor the use of instructional materials and media not controlled by the computer. Computer software to operate the hardware is ready, and a series of short lessons is available which demonstrate how an instructional course can be managed using a sample adaptive model with pre-tests, lesson options based on student characteristics, course tests and feedback for students and instructors.

58. An Exploration of Two Correction Procedures Used in Mastery Learning Approaches to Instruction, Block, J. H. and Tierney, M. L., December, 1974.

The impact of male and female college students' grades, achievement, and attitudes on the respective "correction" procedures used in Bloom and Keller type mastery learning strategies was investigated. Findings indicate periodic corrections, using Bloom's strategy, may improve students' ability to apply course material.

59. Factors Related to Individual Training, Taylor, J. E., April, 1970.

A resume of the findings of ongoing research on the design of strategies for conducting individual training is presented. Studies being conducted, both in laboratory and operational training settings, are assessing the impact of individual difference, task, and training method variables on the design of training strategies. The findings are seen to bear directly on the Army's requirements for designing efficient instruction for a training population that now includes large numbers of trainees in all mental categories of the AFQT.

60. Finding A Way to be a Human, Stonebarger, C. W., October, 1969.

Based on the premise that the school is an environment where systematic instruction, creative work and community interaction occurs, a program that provides for individualized instruction in science is described. Ten different learning environments are provided for the students. Instructional programs are individually chosen, self-administered, self-scheduled, self-tested and feedback revised. The role of the teacher is discussed.

61. Functional Context Training in an Operational System, Weingarten, K., Hungerland, J., Brennan, M., Allred, B., and Pollyea, M., March, 1970.

This paper describes the work plan for the development of a complete training model suitable for multi-aptitude training populations and stressing individualized, self-paced learning in an operational functional context. Progress through the curriculum is determined by proficiency in task performance. The training model generates novel management problems and provides for techniques for their solution.

62. Further Validation of a State Epistemic Curiosity Measure in Computer-Managed Instruction, Judd, W. A., McCombs, B. L., and O'Neil, H. F., 1973.

Evaluated the reliability and construct validity of the State Epistemic Curiosity Scale in the context of a computer-managed instruction task. Data were obtained for 441 undergraduates. The relationship of students' statements regarding their curiosity about the instructional materials was investigated with respect to their subsequent test performance and their statements regarding state anxiety during the test administration. Results indicate that the scale appears to be a particularly reliable instrument and also support the assumed inverse relationship between state anxiety and state curiosity. Limited support was found for the relationship between curiosity and performance.

63. The Future of the Computer in Army Training, Rich, J. J. and Van Pelt, K. B., May, 1975.

The invitation to submit comments was extended to a Panel of Consultants on a site visit and conference at Fort Gordon, Georgia, December 7-8, 1974. The primary objectives of the conference were to construct a report which will define medium- and long-range plans for improving the Army's Computer Training System. The ultimate objective centers on investigating means by which progress from the current state-of-the-art in training technology to improved Army instructional systems can be realized. Each individual consultant was required to contribute a paper to the final report. The purpose of this report is to compile the comments on Computerized Training Systems (CTS) in compliance with Task Order 75-129. This report contains biographical sketches, general impressions, answers to selected questions, and recommendations for future medium- and long-range development of computerized training systems in the U.S. Army Training System.

64. Handbook of Procedures for the Design of Instruction, Briggs, L. J., 1970.

This monograph presents a set of procedures or a "model" for the design of instruction. This model employs a systems approach treating various aspects of system design including: developing course objectives, constructing tests, structuring objectives, media selection and prescription, and preparing and evaluating "formative designs."

65. The Importance of Faculty Attitudes in the Planning for Instructional Development, Spitzer, D. R., 1976.

Explores the nature and context of instructional development, a recent innovation in higher education. It is noted that misconceptions and misapplications of the concept have been frequent, especially in its confusion with media service. It was hypothesized that lack of concern about faculty attitudes in the planning of methods to serve the faculty is a basic obstacle to success in any instructional development program. A survey was conducted to assess attitudes of faculty at one college toward instructional personnel.

66. Individualizing Instruction: Establishing and Operating a Center for Self-Paced Learning, Civil Service Commission, Washington, D.C., February, 1977.

Basic information and references to more detailed information are presented in this guide which is designed to help in establishing a learning environment in which training of individual employees can be carried out in the most economical manner. Aspects of individualized learning systems are discussed and include the following: history and definitions; essential elements of an individualized learning center; determining needs and establishing objectives for a center; designing instruction; selecting and developing materials; validation of courseware; establishing and operating the facility with consideration of site location, facilities, environment, and selecting equipment; staffing

the center, quantity of center staff, scheduling, records maintenance, and cost considerations; and evaluation of the center to determine if objectives are being achieved. Appendixes contain a sample set of specifications for planning considerations for determining needs, a manager-coordinator checklist for evaluating learning center operations, and a trainee checklist for evaluating individual progress in an individualized learning center. A bibliography is included.

67. Individualized Instruction in Mathematics: A Review of Research, Miller, R. L., May, 1976.

One hundred forty-five studies concerning individualized programs of mathematics instruction were reviewed. The summary of results presented tends to support the effectiveness of individualized programs, but notes possible difficulties in implementing them.

68. Individualized Instruction in the Laboratory, Combs, R. G., February, 1975.

Reports on some objective data and presents some subjective conclusions on the use of self-paced instruction in an experimental electrical engineering course. Outlines some of the problems involved in the development of self-paced materials and identifies several demotivating factors associated with their use.

69. Individualized Instruction in the Science Curriculum, Lunetta, V. N. and Dyrli, O. E., February, 1971.

Reviews the foundations for individualized instruction in science, analyzes some of the attempts which have been made to implement it in the elementary and secondary schools, and explores the implications of individualized instruction for the science teacher.

70. Individualized Training and the Training of Individuals, McClelland, W. A., December, 1971.

Two current instructional research efforts relating to the problem of an individual student's learning and personal needs are reported. Characteristics of individualized instruction (e.g., terminal course objectives, remedial materials, measurement procedures), administrative constraints, (e.g., fixed time, cost of equipment, lack of skilled instructors), training strategies and goals are discussed. The APSTRAT (Aptitude Strategies) research involves peer instruction and provides for self-pacing, rapid feedback, and practice. Project IMPACT is an effort to provide the U.S. Army with an effective, efficient, and economical computer-administered instructional system.

71. Individualizing Instruction: Nine Ways to Individualize MACBETH or Anything Else, Leffert, B. G., August, 1976.

This paper describes a model for individualized instruction, in which instruction is seen as a flexible series of interactions between three factors: the student, the content, and the strategy for teaching. The model is based on the student's active involvement in the content and on the teacher's facilitation of student learning. The paper shows how

consideration of the three factors -- student, content, and strategy -- may result in at least three different teaching modifications for each factor. Considerations of each student's degree of socialization and independence may be reflected in the ways in which students are grouped: they may work alone, in pairs or small groups, or in large groups. Content may be adapted according to the degree of abstraction possible for each student, according to students' perceptual strengths and weaknesses, and according to students' interests and experiences. Strategy may take the form of personal contracts between teacher and student, use of media, or use of lectures. The paper presents the background of the model, shows how to diagnose a student's knowledge before beginning a new subject, and indicates how the model may be applied to the teaching of "Macbeth." Five worksheets to facilitate the study of "Macbeth" are appended.

72. Individualizing Vocational and Technical Instruction, Pucel, D. J. and Knaak, W. C.

The book's focus is on classroom procedures that allow an instructor to meet the needs of individuals while managing the learning activities of a group. The individualized instruction model that seems most appropriate for use with vocational programs is the fixed-content, variable-time, mastery model in which individuals are assisted in developing the skills and knowledge required to succeed at entry-level jobs in an occupation. Following an introductory chapter, Chapter 2 discusses methods for establishing vocational/technical program content, while Chapter 3 is directed toward identifying student instructional prerequisites for courses and specific tasks. Chapter 4 deals with the development of vocational instructional objectives (terminal performance objectives and intermediate performance objectives), based on job descriptions and task analysis. Instructional strategies, instructional media, and educational computer technology are discussed in Chapter 5. Chapter 6 covers methods of evaluating student progress in an individualized learning system. The concluding chapter recognizes the demands for "open access" and "accountability" as bringing increased pressure for individualizing vocational instruction programs. Appendixes include: sample job descriptions, sample differentiated staffing job descriptions, the National College Verb List, and a learning guide.

73. The Influence of Unit Pacing and Mastery Learning Strategies on the Acquisition of Higher Order Intellectual Skills, Denton, J. J. and Seymour, J. G., May/June, 1978.

In a study of mastery learning involving student teachers, it was found that in intense, short-term instructional systems, less specific remediation is appropriate, while more detailed remediation is better when there are few time constraints.

74. Inservice Education for Individualized Instruction, Scanlon, R. G. and Brown, M. V., February, 1970.

Described are the efforts of Research for Better Schools, a regional laboratory, to prepare teachers and administrators to use an individualized system.

75. Instructional Management: A Meaningful Alternative, Gorman, D. A., June, 1975.

Compares traditional teacher-centered instructional techniques with learner-centered, individually paced instruction. Differences in the teacher's role associated with each technique are pointed out.

76. An Instructional Model for Computer Assisted Instruction, Mizenko, A. J. and Evans, A. A., May, 1971.

An instructional model suitable for the implementation of the tutorial mode of a computer-assisted instruction program is described in this report. The general guidelines for the design of the model are presented. Course organization, instructional strategies, and learning paths are discussed. The model provided for the accommodation of high, middle, and low aptitude students in an adaptive learning environment. Also included in the report are flow charts that graphically depict the learning contingencies and instructional strategies addressed in the design of the model.

77. An Instructional Systems Technology Model for Institutional Change, Dudgeon, P. J., April, 1976.

The Canadore College Continuing Education Division model for innovative individualized and personalized programs contains several subsystems: analysis of current continuing education, identification of criteria, evaluation of the old model, design of the new model, simulations, evaluation of the new model, and implementation of the new model. The framework for a systems approach to instructional innovation is provided through a process called anasynthesis which allows complex elements of learning processes to be integrated to provide solutions to educational problems. A graphic analog model using LOGOS computer programs was constructed to solve problems of individualized and personalized instruction through anasynthesis. Research findings using the model show that the value of lectures or seminars is dependent on the student. Cognitive styles of students help them adapt instructional strategies to meet their own needs and the most successful personalized education programs combine cognitive and affective strategies.

78. Instructional Technology and Administrative Decisions, Eye, G. G. and others, December, 1969.

Concerned with the spiraling problems of technology and its impact on instruction, the American Association of School Administrators (AASA) two years ago created the Committee on Technology and Instruction. Since that time the Committee has been active in investigating a number of areas relevant to the impact of technology on the public schools. This article reports on the issues raised in these areas.

79. Intelligent Instructional Systems in Military Training, Fletcher, J. D. and Zdybel, F., April, 1977.

Intelligent instructional systems can be distinguished from more conventional approaches by the automation of instructional interaction and choice of strategy. This approach promises to reduce the costs

of instructional materials preparation and to increase the adaptability and individualization of the instruction delivered. Tutorial simulation and tutorial dialogue capabilities require a computer to: (1) generate problem statements and solutions; (2) determine efficient sequences; and (3) simulate a variety of situations encountered on the job. These enable students to: (1) test their own hypotheses concerning the subject matter; (2) probe for information at different levels of difficulty and abstraction; (3) acquire wide experience in minimum time; (4) obtain instructional material generated for their unique abilities and needs; (5) receive instructional aids for partially completed solutions; and (6) receive reviews and critiques of complete problem solutions. Description of the Welfare Effectiveness Simulation (WES) in military training, directions for development of intelligent instructional systems, and references are included.

80. Intelligent Video Disc as a Major Component of Individualized Instruction, Ingalls, R. E., 1977.

Due to the importance of visual stimuli for learning, the videodisc is expected to have a major impact on education. When combined with the computer, it will greatly expand the capabilities of computer assisted instruction. There are two major types of videodisc equipment: the optical type with a laser beam to read the information from the disc, and the capacitance version which reads the information by means of a stylus riding in the grooves of the disc. Both types should shortly be available to educators at a reasonable cost.

81. Interaction of Individual Differences with Modes of Presenting Programmed Instruction, Davis, R. H., Marzocco, F. N., and Denny, M. R., 1970.

Two experiments were conducted to study the interaction of individual ability and attitude differences among college students with modes of presenting programmed instruction. A wide range of individual differences measures were collected. In the first experiment, 189 subjects completed an algebra program using different modes of presentation: overt versus covert responding and constructed response versus multiple-choice. Some subjects were allowed to choose the mode of program presentation. In the second experiment, 180 subjects completed two short programs in introductory psychology with and without feedback. Modes of presenting programmed instruction did not significantly affect learning outcomes. No significant interactions were obtained. With one exception (reading), ability measures were not significantly related to educational treatments and appear to be of questionable value for prescribing instruction. The subjects allowed to select their own treatment modes did not do significantly better than subjects whose treatments were prescribed by the experimenters.

82. Interactive Video Disc Systems for Education, Bennion, J. L. and Schneider, E. W., 30 October 1975.

The basic design of the videodisc technology, especially the three features of the freeze frame, electronic address, and fast random access, makes possible the creation of a new audiovisual delivery system that has revolutionary applications for education in individualized interactive instruction. In addition to the linear playback mode for home movie

and television rerun entertainment, the optical videodisc is capable of providing branching because of random access and electronic addressing capabilities. The system is also able to accommodate many psychological procedures for enhancing learning, such as the capability of inserting questions in still frames or aural modes at any point. Special features offered by the videodisc system which make it more flexible than TICIT are motion control, greater audio capabilities, and the lack of need for an external computer.

83. The Interquiz Interval: A Measure of Student Self-Pacing, Lazar, R., Soares, C., and Terman, M., March, 1977.

Personalized system of instruction (PSI) courses aim to allow students to progress at individually optimal paces. An analysis of self-pacing is outlined, based on measurement of an interquiz interval (IQI), which represents the number of days between mastery on one unit quiz and the first attempt at the next quiz. The analysis was used to specify the pattern of temporal control over students' pacing under a standard recommended pace schedule. These baseline data from 144 undergraduates indicate that the conditional probability of taking a quiz (IQIs/opportunity) increased as a function of days since mastery of the previous unit. In a second experiment, 47 students were given an accelerated set of recommended target dates and an additional quiz question on their level of progress to date. These students showed higher conditional probabilities of quiz-taking over the days following mastery of the preceding unit than did their 38 classmates with the standard schedule.

84. I-STEP: Completely Individualized Teacher Training, Young, J. I. and Baird, J. H., July, 1974.

Describes the individualized Secondary Teacher Education Program (I-STEP) that is in operation at Brigham Young University. Differences between this and other teacher training programs are delineated, the advantages of it are described, and recommendations for its implementation are made.

85. Job Objectives for M60A1A0S Tank Gunnery, Kraemer, R. E., Boldovici, J. A., and Boycan, G. G., April, 1976.

Recognizing a possible need for increased efficiency in tank gunnery training, and the dependence of increased training efficiency on the availability of a pool or data base of gunnery job objectives, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) initiated research to develop the data base and to examine proposed gunnery training. A contract for assistance in achieving these objectives was awarded by ARI to the Human Resources Research Organization (HumRRO).

86. Job-Relevant Navy Training and Keller's Personalized System of Instruction: Reduced Attrition, McMichael, J. S., Brock, J. F. and Delong, J., March, 1976.

A U.S. Navy procedure for designing job-relevant training was combined with the organizational features of F. S. Keller's personalized system

of instruction to design and implement a training program in the area of propulsion engineering. The two systems led to a 10-week program that had relevant behavioral objectives, unit mastery, self-pacing, and individualized instruction and that graduated approximately 200 students/week. Under the lockstep procedures previously in use, 12% of the students were dropped for academic reasons, and 84% graduated. Within three months of beginning the new program, academic attrition was reduced to less than 1%, and 93% of the students graduated.

87. Knowledge of Results and Other Possible Reinforcers in Self-Instructional Systems, Geis, G. L. and Chapman, R., April, 1971.

Knowledge of results is most frequently cited as the reinforcer in self-instructional systems. The printed answer in a programmed text, for example, is supposed to reinforce the response the student emits previous to observing that answer. Some other possible reinforcers are briefly discussed, and the literature on knowledge of results in self-instruction is selectively reviewed. The review was organized as a search for evidence that knowledge of results might appropriately be called a reinforcer. It is found that the printed answer (or its analog in other media) is not globally and automatically a reinforcer. The review provides the springboard from which one might jump into broader questions such as how, when, and why information on one's own performance in a learning situation becomes reinforcing and contributes to more effective learning.

88. Learner-Centered Instruction (LCI): Volume 7. Evaluation of the LCI Approach, Pieper, W. J. and others, February, 1970.

An evaluation of the learner-centered instruction (LCI) approach to training was conducted by comparing the LCI F-111A weapons control systems mechanic/technician course with the conventional Air Force course for the same Air Force specialty code (AFSC) on the following dimensions: job performance of course graduates, man-hour and dollar costs of the two courses, and student acceptability and instructor problems for the LCI course. Measures of job performance included a job performance test, an Air Force practical test, the supervisors' ratings, and a substitute job knowledge test. The graduates were measured both at end-of-course and again after five months in the field at field follow-up.

89. Major Assumptions of Mastery Learning, Anderson, L. W., March, 1975.

Mastery learning can be described as a set of group-based individualized, teaching and learning strategies based on the premise that virtually all students can and will, in time, learn what the school has to teach. Inherent in this description are assumptions concerning the nature of schools, classroom instruction, and learners. According to the author, in mastery learning, both the teacher and learner are responsible for the desired learning. Moreover, differences in learning among individuals are, in fact, differences in the amount of time it takes them to learn. This amount of time is based upon three factors: his or her previous learning, his or her interest or confidence in learning the skill, and the quality of the instruction. Schooling

is a purposeful activity, which should develop talent rather than select and categorize it. Instructional grouping practices often violate mastery learning's assumptions about individual students.

90. Management Systems for Individualized Instruction: An Analysis of Five Approaches, Bosco, J. and others, 1976.

Describes the consequences of the implementation of several commercially produced individualization systems on teacher beliefs, practices, and on pupil achievement and attitude.

91. Managing Motivation in Personalized Instruction, Wagner, G. R. and others, March, 1974.

Addresses the topic of managing motivation in Keller's Personalized System of Instruction (PSI). Outlines the reinforcing features that are at the foundation of PSI theory, and examines methods used to ensure that these reinforcing properties are fully utilized.

92. Maximized Individualized Learning Laboratory, Reedy, V., March, 1973.

Describes the educational programs at the MILL (Maximized Individualized Learning Laboratory), an educational facility designed to provide short-term remediation for students who lack the skills to be successful in a particular program.

93. Measurement in Learning and Instruction, Glaser, R. and Nitko, A., March, 1970.

The document considers three general classes of instruction models found in current educational practice. One particular model of instruction -- a general model for individualization and adapting instruction to individual differences -- is described, and its testing and measurement implications are discussed. Central to this approach is the specification of desired instructional goals in terms of organizable domains of human performance criteria as well as adaptation of instruction on an individual basis so that these desired goals are attained by a maximum number of students.

94. Media Adjunct Programming: An Individualized Media-Managed Approach to Academic Pilot Training, McCombs, B. L. and others, January, 1974.

Media adjunct programming (MAP) techniques for presenting individualized, self-paced instruction were compared to traditional instructor-classroom (TIC) techniques in an undergraduate pilot Weather course. The MAP group completed the course in significantly less time than did the TIC group, representing a 29 percent time savings. In addition, MAP students performed equally as well as TIC students on the post-test and retention test, had significantly lower state anxiety scores while learning the materials, and reported significantly higher attitude scores toward the instructional method they received. Predictions of an inverse relationship between state curiosity and state-anxiety were only partially supported, in that significant interactions were found between treatment conditions and flight groups.

95. Models for Individualizing Vocational-Technical Instruction, Pucel, D. J., December, 1974.

Eight major instructional models and the basic strategies which define each of them are presented in this paper along with contrasts of the individualized instruction models with the "traditional" model of instruction (characterized by fixed-content, fixed-time, variable proficiency). The author notes that the models could be useful to industrial educators and other educators in modifying their teaching activities so that they can communicate with each other about the differences in the strategies and instructional models they use. Prior to discussion of the models, the author briefly discusses: (1) the need for individualized instruction in vocational education; and (2) three dimensions for classifying models: content dimension, time dimension, and proficiency or competency level dimension. The description of the eight instructional models includes a discussion of the possibility of organizing an instructional program using any of the instructional models as cells of a matrix which would include all possible combinations of the content, time, and proficiency levels. A figure of the matrix is included.

96. MODIA: Volume 2, Options for Course Design, Carpenter-Huffman, P., April, 1977.

This volume provides a detailed description of the design options incorporated in MODIA (a Method Of Designing Instructional Alternatives), a system developed to help Air Training Command plan technical courses. MODIA is a unique approach to planning that relates the use of training resources to the details of course design and operation. This report follows MODIA's design process and presents at each decision point pros and cons for each choice of option as it affects training effectiveness and use of training resources. Although the report is directed to course planners in Air Training Command, the options described are applicable in a wide variety of education and training settings. An overview of MODIA is given in R-1700-AF.

97. A Modular Approach to Vocational Curriculum. Blueprint for Individualized Instruction, Dupuis, V. L. and Bell, P. E., April, 1974.

A modular approach to vocational curriculum development is in operation at Admin. Perry Vocational-Technical School in Ebensburg, Pennsylvania. Computer terminals located in each classroom direct students in individualized instruction. Several examples are cited of the implementation of the modular approach to curriculum development in vocational education.

98. The Non-Lock-Step Educational System, Giordano, M. J., 30 June 1975.

The purpose of this effort was to investigate individualized and self-paced instruction systems throughout the country and to develop a detailed document showing how to plan, implement, and operate a self-paced individualized instruction system as an option to a conventional system on the college level. Benefits of such a system are that it can be applied to meet the needs of a wide range of student abilities and, at the same time, it represents an increase in teaching effectiveness and a decrease in cost. First a survey of individualized

instruction systems was undertaken, and then the operators of a few systems were invited to aid in the formulation of this prototype system as consultants. Early sections deal with how this learning process is managed and the complete organization of an individualized learning center. Subsystems within the total system (admissions, registration, bursar) are discussed along with budgetary considerations. Evaluation recommendations include efficiency (cost), effectiveness (achieving instructional goals) and testing the validity of instructional packages. Finally, there are recommendations for planning, implementation, and operation of an individualized, self-paced system.

99. Personalized Instruction Applied to Food and Nutrition in Higher Education, Boren, A. and Foree, S., March, 1977.

A personalized competency-based instructional strategy was designed and evaluated as an alternative to the traditional teacher-directed method. There was no difference in mean gain scores between the two groups for cognitive objectives, but the experimental strategy was superior in teaching psychomotor competencies. Student responses to the PSI strategy were positive.

100. A Practitioner's Guide to Machete-Swinging in the Paperwork Jungle: Record Keeping and Individualized Instruction, Armstrong, D. G., January, 1977.

Describes a systematic approach for determining how much energy teachers will use in record keeping tasks associated with individualized instruction systems. Evaluates the information benefits that are important enough to warrant investment of teacher record keeping time.

101. On Mastery Learning: An Interview with James H. Block, Brandt, R., May, 1976.

In this interview, James Block explains the model of mastery learning, developed by himself and B. Bloom, according to which individual differences in academic ability are lessened by appropriate teaching methods.

102. Mastery-Learning Decision Variables, Besel, R., 18 August 1971.

The Mastery-Learning test model is extended. Methods for estimating prior probabilities are described. The use of an adjustment matrix to transform a probability of mastery measure and empirical methods for estimating adjustment matrix parameters are derived. Adjustment matrices are interpreted as indicators of instructional effectiveness and as evidence of the existence of learning hierarchies. Two decision variables are considered: probability of mastery for an individual and proportion in mastery for an instructional group. Discussion of the reliability, complexity, and interpretability of these decision variables and comparison with decision variables for other test models is also included.

103. Navy Computer Managed Instruction: Past, Present, and Future, Hansen, D. and others, 1 July 1975.

The Navy computer-managed instruction system (Navy CMI) is a large, multi-site operation. Research findings show that it is yielding benefits in terms of cost savings. During fiscal year 1975, savings of over ten million dollars were realized, mostly due to course reductions ranging from 24 to 80 percent and reductions in on-board students. It has been found that CMI training yields better end-of-course performance levels while maintaining more positive attitudes among students. Attrition rates are lower with CMI, and a continuation of this trend is predicted as the system is expanded. Savings are projected in the potential for expanded capability and competitive procurement using the current system and hardware. Research has shown positive personnel attitudes associated with the integration of personnel and operational procedures using CMI. It is suggested that performance and cost benefits qualify Navy CMI for expansion.

104. One-Year Status Report, Computerized Training System Project, Project ABACUS, Gaddis, J. T., 1973.

This report covers the actions which have transpired during the first year of Project ABACUS, the Army's program for the development of a Computerized Training System.

It includes a narrative summary, key documents, and amplifying annexes.

As a historical document, it will be utilized in preparation of the final project report. It is also meant to provide the current reader with an understanding of how the project has moved to its present position, and what actions are anticipated to be completed in the near future.

105. A Paradigmatic Example of an Artificially Intelligent Instructional System, Brown, J. S. and Burton, R. R., June, 1977.

This paper describes the philosophy of intelligent instructional systems and presents an example of one such system in the domain of manipulative mathematics -- BLOCKS. The notion of BLOCKS as a paradigmatic system is explicated from both the system development and educational viewpoints. From a developmental point of view, the modular design of BLOCKS provides a working framework within which to explore different monitoring functions and various tutoring strategies. From an educational viewpoint, BLOCKS provides a dramatic example of the potential of a computerized intelligent tutor in a laboratory environment. By monitoring the student's behavior, the system can notice interesting situations and direct the student's attention to them. In this way, the computer can provide conceptual structure and guidance to a student's otherwise undirected experiences.

106. Peer Tutoring to Individualize Instruction, Ehly, S. W. and Larsen, S. C., May, 1976.

Discusses the benefits of peer tutoring, in which pupils who learn quickly assist those who are slower. The benefits of the method

accrue to both the tutor and tutee, particularly in the emotional areas. It is considered that peer tutoring narrows the psychological gap between the instructor and the pupils.

107. Performance Motivation in Armor Training, Eaton, N. K., September, 1978.

Motivation generally affects performance. This research asked specifically what performance outcomes (rewards) would motivate tank crews to perform better during training. First, 52 Armor crewmen answered, on a list of potentially useful recognition and tangible reward outcomes, how much they valued each one and what they felt was the probability of their getting it. Later, answers from 112 other crewmen confirmed and refined the outcome values, as well as indicating that outcome values were constant across rank for grades E2-E5. Outcomes with the highest combined scores were then offered as rewards for high performance during training, to 108 Armor crewmen. Analysis of results showed that for tank commanders, drivers, and loaders, performance in general was positively related to recognition-based motivation and negatively related to tangible reward. For gunners, performance was negatively related to recognition-based motivation. Strategies for motivation management programs could probably be based on recognition.

108. Personalized Instruction: A Summary of Comparative Research, 1967-1974, Taveggia, T. C., November, 1976.

Presented is a summary of the research comparing the Personalized System of Instruction (PSI) to conventional teaching methods during the period 1967 to 1974. Of 14 studies found, all favored PSI over conventional instruction when the comparison criterion was student achievement on final exams.

109. A Plan to Combine Individualized Instruction with the Lecture Method, Schoen, H. L., November, 1974.

An attempt to combine the advantages of group instruction with the advantages of individualized instruction is described. The rationale, procedure, and method are discussed in turn. Test results indicated that students learn at least as well by this combined method. Student opinion was generally favorable.

110. Planning and Implementing Individualized Instruction, K-12, Sandberg, N., November, 1977.

This document describes a master of education program that teaches educators how to plan and implement individualized instruction following the Individually Guided Education (IGE) organizational model developed by the Wisconsin Research and Development Center and I/D/E/A/Kettering. Seven major components of IGE are incorporated into the ten-course master's program with the purposes of: (1) preparing K-12 educators to plan and implement individualized instructional programs in their present roles; and (2) helping educators develop concepts and skills for assuming leadership in individualization. Planning for the future of the educators is seen as an integral part of the program. A budget for the program's implementation and recommendations for planning similar programs are included.

111. Planning Instruction and Monitoring Classroom Processes with Computer Assistance, Wang, M. C. and Fitzhugh, R. J., April, 1977.

The Classroom Information System (CIS) is an effort to apply computer technology to the problem of managing information in the classroom to relieve teachers of clerical duties, and also to provide them with a daily account of each child's progress. There are two curricular components: a prescriptive learning program focusing on basic skills (reading, spelling, math); and an exploratory learning program consisting of art, play, conceptual games, and activities which develop social and self-management skills. Factors considered in designing the system were dialogue characteristics, response time of the computer, amount of teacher training necessary, and control of errors and system failure. The class of students in which this program was implemented is made up of 50 children from five to eight years in age, two teachers, and one instructional aide. All were given instruction in the use of the computer terminals (typewriter and television-display types) which are located in the classroom. A teacher assigns work from the prescriptive learning curriculum to each child on a weekly basis. Children may select their own activities from the exploratory component. At the end of each week, the teacher obtains the student history report from the computer and meets with the student to discuss his/her progress. Initially, more teacher time was required for CIS planning; however this decreased as they became familiar with the programs. Students learned the system quickly and have made continued progress because of immediate feedback on their work from the computer. A bibliography, flow charts and a sample student history report are included in the appendices.

112. Possible Applications of Optical Video Discs to Individualized Instruction Systems, Bennion, J. L., 14 February 1974.

The videodisc with random access and large capacity for storage of high quality audiovisual material has the potential of becoming a very effective new medium for individualized interactive instruction at low cost. This medium should be developed carefully, making use of the experience gained in the TICCIT project and the best available instructional psychology and learning theory so that the full potential of the videodisc can be realized. New techniques for lesson development utilizing interactive control of still frames and motion sequences need to be explored. Learner control of freeze frame, slow motion, or fast motion options during motion sequences by repeating or skipping revolutions is possible with the videodisc system, and needs to be evaluated.

113. The Present and the Future in Educational Technology, Koerner, J. D., May, 1977.

This paper provides a description of the present state of development in educational technology as it has been illuminated by the Sloan Foundation's Technology in Education program. Current developments are reviewed in relation to: (1) the computer, (2) television and video reproduction, (3) low technology, (4) self-paced instruction, and (5) the reduction of costs through technology. A discussion of the kinds of experimental work needed in the future is provided in

relation to training of the faculty and improving the quality and dissemination of materials. Appended is a list of Technology in Education grants awarded from 1971-76 in amounts over \$20,000.

114. Proctor Training: The Effects of a Manual Versus Direct Training, Robin, A. L. and Heselton, P., March, 1977.

Examined the increment produced by adding direct training to a written manual in a comparison of two interventions for training proctors in personalized systems of instruction. Eleven students of abnormal psychology were randomly assigned to either a manual or training group. Both groups received a manual consisting of precise definitions and numerous examples of four proctor responses: social behavior, feedback, praise, and prompting. The training group also listened to audiotapes of correct and incorrect proctor responses and role-played proctor-student interactions. Observations revealed that although both interventions produced comparable gains in social behavior and feedback, training produced greater gains in praise and prompting. Evidence for generalization to actual classroom setting was obtained, but the mode of training did not influence the academic achievement of students subsequently assigned to each proctor.

115. Programmed Instructional Effectiveness in Relation to Certain Student Characteristics, Doty, B. A. and Doty, L. A., 1964.

The effectiveness of programmed instruction was investigated in relation to five student characteristics: cumulative GPA, creativity, achievement need, social need, and attitude toward programmed instruction. Students were 100 college undergraduates, and the programmed material was a commercially prepared unit in physiological psychology. Significant correlations were obtained between scores on an achievement test over the programmed unit and GPA, creativity and social need. When effects of GPA were parceled out, significant correlations were observed between achievement on programmed instruction and social need, suggesting that the latter is an important variable in the programmed learning situation.

116. Project IMPACT: Description of Learning and Prescription for Instruction, Seidel, R. J., Compton, J. G., Kopstein, F. F., Rosenblatt, R. D., and See, S., June, 1969.

Project IMPACT, Instructional Model/Prototypes Attainable in Computerized Training, is a comprehensive advanced development project designed to produce an effective and economical computer-administered instruction system for the Army. In this paper, the rationale for conceptualizing the instructional process in a form implementable by computer is described. The Instructional Decision Model (IDM), the heart of the CAI system, is discussed. Major issues are summarized and expectations for future model development are projected. The HumRRO hardware configuration is divided into three major subsystems: Information Processing, Data Storage, and Communications. Short-range and long-range computer software development is discussed. Instructional decision making is described and illustrated.

117. PSI + Job-Task Analysis = Effective Navy Training, Brock, J. F., Delong, J., and McMichael, J. S., April, 1975.

Describes the application of a Personalized System of Instruction (PSI) to a Naval training program in propulsion engineering. Experts performed task analyses which were used to develop behavioral objectives. Implementation of the PSI system reduced learning time by 20% over the previous "lockstep" technique. Student motivation was improved.

118. PSI and the Generic Method of Programmed Instruction, Hess, J. H. and Lehman, G. R., February, 1976.

Distinctive contributions of each teaching method to the solution of instructional design problems are identified within the General Model of Individualized Instruction.

119. A PSI Course in Child Development with a Procedure for Reducing Student Procrastination, Bijou, S. W., Morris, E. K., and Parsons, J. A., March, 1976.

A recurring problem for personalized systems of instruction has been student procrastination. Self-pacing often results in incompleted coursework and puts a strain on course management. Instructor-paced systems can be aversive and often fail to consider individual students. In this investigation, procedures were designed to combine both student- and instructor-paced systems. To reduce procrastination, a weekly point system for each unit of coursework was instituted; it was flexible enough to allow students to move ahead or to catch up if they fell behind. Under this system, a total of 268 undergraduates paced themselves evenly through course material over two different semesters, whereas the 92 students in the self-paced version procrastinated. The imposition of pacing contingencies resulted in no deleterious effects on student achievement, withdrawals, or course evaluations. Discussion focuses on the need to properly analyze the conditions, both historical and current, that influence self-pacing behavior.

120. Reality Therapy and Personalized Instruction: A Success Story, Mink, O. G. and Watts, G. E., 1973.

The Advanced Studies Program (ASP) at Southeastern Community College (Wilmington, North Carolina) is a developmental studies program that offers freshman courses in English, biology, and psychology to approximately 75 students. Learning activities are individualized and self-paced, and each ASP course has behaviorally stated objectives. Instructional techniques include the use of self-instructional packages, programmed materials, and various audio-tutorial aids. Through these individually styled instructional components, and reality-based counseling strategies, ASP attempts to internalize the external orientations of non-traditional students, thus greatly enhancing their chances of academic success. Rotter's Locus of Control Scale was administered to 77 freshmen prior to ASP enrollment. These students were given the scale again at the end of the first and third quarters. Of the 77 students entering ASP, 60 completed the spring quarter (77.9 percent).

This persistence rate is higher than those reported by Monroe (1972) for community college students in general. Control orientation for ASP students generally shifted toward greater internality, and grade point averages improved with gains in internality. Recommendations are made for further research, and a bibliography is appended.

121. Reinforcement Management; An Approach to Motivating Army Trainees, Cassileth, B., November, 1969.

To study the effectiveness of reinforcement management (contingency management) as applied to a military program of instruction already in operation, 335 students in an Army clerk-typist course in which self-paced instruction is used were given points for successive approximations to desired learning behavior. The points were exchangeable later for varying lengths of time off. Only trainees of high initial typing skill were found to have been significantly affected by the experimental program. The selective impact of contingency management found in this population is examined in terms of present military conduct of self-paced instruction, and in terms of military management and training.

122. The Relationship Between Certain Personality Variables and Achievement through Programmed Instruction, Traweck, M. W., 1964.

The purpose of this study is to investigate the possible relationships between certain personality variables in learners and their achievement in fourth grade arithmetic under programmed instruction. Subjects included 186 white students from six fourth grade classes enrolled in city schools in Tuscaloosa, Alabama, during the spring of 1963. The subjects were divided into two groups, the successful (those who achieved beyond their predictive performance in arithmetic fractions) and the less successful students (those who did not do as well as predicted). The California Test of Personality was used to measure self-reliance, withdrawn tendencies and nervous symptoms. Sarason's Anxiety Test was also used. Two specially prepared tests measured gains in achievement resulting from programmed instruction. Successful learners indicated tendencies to be more withdrawn, less self-reliant, and showed more signs of test anxiety than did the unsuccessful learners. Students whose personality test scores indicated a poorer adjustment achieved beyond their expected performance through programmed instruction. Programmed instruction appears to be a promising method of teaching for slow learners as well as those who are average and above average.

123. Resource Allocations to Effect Operationally Useful CAI, Seidel, R. J. and Kopstein, F. F., April, 1970.

Resource allocations, in terms of funds, people, facilities, and the delegation of appropriate authority to formulate appropriate policy, for research and development and implementation of computer-assisted instruction are discussed in this paper. A description and justification of CAI as a technology is included. The need for incorporating a systems approach to educational innovation is stressed. A partnership among industry (profit and nonprofit), government, and education is suggested as a model, and a national network of multidisciplinary

center is advocated as the vehicle for accomplishing the goals of research, development, and implementation of effective and efficient CAI systems.

124. The Role of the Teacher in Individually Prescribed Instruction, Lindvall, C. M. and Bolvin, J. O., February, 1970.

The teacher's role in IPI is identified as three major functions: (1) operating the system; (2) supplementing the system to enhance adaptation to individual needs; and (3) providing for the achievement of goals possible only with teacher intervention. Each of these functions is discussed in further detail.

125. Selecting an Approach to Individualized Education, Hull, R., November, 1973.

Four "prepackaged" individualized instruction systems (IPI, IGE, PLAN, open education) are presented here for use with Edling's model for selecting the program which is best for an individual school's needs. A brief sketch of each system is presented. Four stages along Edling's continuum are identified). Selection of the program according to Edling's continuum model is left to the reader.

126. The Selection and Analysis of Training Measures of Effectiveness, Brown, D., October, 1977.

In January, 1976, CDEC was directed to expand its testing program to include the evaluation of training programs, devices and techniques. Consequently, we now incorporate training objective sin our Combat Developments Experiments and have begun to design discrete training tests. Since there have been few prior attempts to collect quantitative training data, the selection of training MOEs can be a difficult task. In addition, qualitative training information can provide valuable assistance in the evaluation of training programs, and should, therefore, also be collected and reported as part of the field test. This paper discusses how training has been incorporated into CDEC's mission; gives examples of training EEAs and MOEs which have been used at CDEC; and concludes with a presentation of training results from some recent CDEC experiments.

127. Self-Paced Advanced Individual Training (AIT) and Duty Assignment Procedures, Hunter, H. and Wagner, H., June, 1973.

A study was made to: (a) describe how self-paced Military Occupational Specialty (MOS) training affects the Army assignment system; (b) identify ways the existing assignment system can accommodate individualized instruction; and (c) suggest modifications to the assignment system to provide better integration of self-paced training with assignment procedures. Information on self-paced systems in the Army, Navy, and Air Force and on assignment policies and procedures at the Department of the Army and at local training bases was collected, through interviews, correspondence, and examination of relevant documents. Relationships between self-paced systems and the assignment system were analyzed to identify points of accommodation.

128. Self-Pacing a Gross Motor Skills Course: Crawler Tractor Operator, MOS 62E20, Brennan, M. F. and Taylor, J. E., June, 1975.

As part of the Army's emphasis on performance-oriented instruction in training centers, a study was conducted to determine the feasibility of using self-paced instruction in a gross motor skills course. The Crawler Tractor Operator Course, a seven-week heavy equipment course conducted at Fort Leonard Wood, Missouri, was selected for the study involving approximately 300 trainees. Findings indicate that in the self-pacing system, training managers can: (a) train on additional pieces of equipment if trainees are retained for the full seven weeks; or (b) achieve substantial savings in the time and training costs if the trainees are released for assignment upon their qualification in the crawler tractor operator skills. Other findings from the self-pacing study are: (a) the system permits trainees to proceed through the course at their own rate of learning; (b) the rate of learning correlates moderately with individual predictor scores; (c) the system is readily accepted by the trainees; (d) although instructor workload is heavier, motivation and morale are higher; (e) peer instruction can be used; and (f) the system is more economical and efficient. The self-paced performance tests and questionnaires used to sample trainee and instructor attitudes toward the program are appended.

129. The Self-Schedule System for Instructional-Learning Management in Adaptive School Learning Environments, Wang, M. C., 1976.

The studies in this monograph are designed to examine the implementation processes of an innovative instructional program and the relationship between the implementation process and the achievement of certain program goals in school settings. The monograph is a contribution to the technical aspects of designing and implementing innovative educational programs in general, and the implementation of individualized instructional programs in school settings in particular. The studies reported were conducted in two public elementary schools, one located in an inner city neighborhood in Pittsburgh, and the other in a working class neighborhood in a suburb of Pittsburgh. Specifically the monograph is a series of research studies carried out during the developmental stages of an instructional learning management system, the Self Schedule System. It includes: (a) a brief description of the conceptual design of the Self Schedule System, which was created to implement the individualized instructional programs developed at the Learning Research and Development Center (LRDC) of the University of Pittsburgh; (b) the documentation of the implementation processes adopted to field test the Self Schedule System in school settings; (c) research findings on the effects of the Self Schedule System on student and teacher classroom behaviors, as well as student learning outcomes; and (d) evaluation of the Self Schedule System from the teacher's perspective.

130. The Sergeant Cut His Training by Half, Oliver, H. L., May, 1977.

Discusses how one U. S. Army school has been successful in increasing student motivation and decreasing training time through the use of self-paced instruction. Important components of this type of instruction are outlined.

131. Simulators for Maintenance Training Some Issues, Problems, and Areas for Future Research, Fink, C. D. and Shriver, E. L., July, 1978.

This report reviews past and present applications of simulation to maintenance training. Emphasis is on describing issues, problems and areas for future research as identified by recent authors. A variety of issues and problems are discussed under five headings: Application of Simulation Technology to Technical Training, Determination of Simulation Requirements, Design and Specification of Simulation Requirements, User Acceptance of Maintenance Simulators, and Cost Effectiveness of Maintenance Simulators. Requirements for future research are discussed under the following topics: Evaluating the Cost Effectiveness of Simulators, Comparing Simulators One with Another, Determining Training Requirements, Determining Simulation Requirements, Developing Exemplary Simulators, Developing Exemplary Mixes of Maintenance Training Media, Obtaining User Acceptance, Developing Improved Regulations for Maintenance Simulators.

132. The State of Knowledge Pertaining to Selection of Cost-Effective Training Methods and Media, Spangenberg, R. W., Riback, Y., and Moon, H. L., June, 1973.

Review and analysis of pertinent literature was the first step in research to develop criteria and procedures for optimal selection of cost-effective methods and media for use in Army training. The empirical data found in the review are insufficient as a basis for reliable selection of methods and media for specific training tasks. Also, existing methods-media selection procedures, training cost-analysis procedures, and suggested approaches for developing such procedures are inadequate for Army needs, although portions of some of these may be useful in developing procedures for Army use. Possible approaches for removing those inadequacies are discussed.

133. Stretching those Vocational Educational Facilities, Collins, W. J., January, 1978.

Presents plans for extending the facilities of a Massachusetts area vocational-technical school to accommodate an estimated 33% increase in enrollment. The plans described include a 45-15 plan which divides the school year into four quarters and an individualized instructional program.

134. Study and Proposal for the Improvement of Military Technical Information Transfer Methods, Shriver, E. L. and Hart, F. I., December, 1975.

This study reviews the new concepts for Technical Manuals which have been developed and tested over the past twenty years. The study focuses on those new concepts which have shown that personnel can perform better or with less training when using these new concepts. The processes and techniques used by these new concepts to obtain better job performance or less training are identified, analyzed, and summarized in a specification incorporating the best features of each. The test results obtained with the new concept manuals are summarized and projected into the personnel costs of owning equipment. Projections of these figures

indicate a reduction in the cost of ownership of about \$1.7 billion per year from adopting the specification of the processes used in the new concepts. The specification, Draft MIL-M-632XX (TM) has two Parts, I and II. They represent an integration of Technical Manuals (Part I) and Training (Part II) into one package which can be used for self-paced, self-contained, on-the-job training while trainees produce useful job products. A sample manual was produced under the specification covering a turret subsystem of the M60A2 tank. A test plan for experimental and operational tests of JPMs was also developed. The draft specification, described above, and the sample manual are documented separately and provided under separate cover to this report.

135. A Study of Information Acquisition in Individualized Instruction, Kuhn, D. L., Oct-Dec 1972.

Describes effects of study time on acquisition retention processes in a general biology course designed for female freshmen and sophomores in high and low analytic-ability groups. Concluded the presence of positive reinforcement, especially at high analytic level.

136. A Study of Remote Industrial Training Via Computer-Assisted Instruction, Schwartz, H. A. and Long, H. S., 1967.

During the latter half of 1965, several field engineers received their required training in new computer technology through remote computer-assisted instruction (CAI). Students at terminals located in four major cities communicated through tele-processing facilities, with a computer system located centrally. Students' examination scores, course completion times, and attitudes were compared with those of other students who received the material through self-study texts in use at the time. CAI students scored lower on one part of the examination, but completed the course in considerably less time than the self-study students. Attitude scores were somewhat equivocal. Students who had been exposed to both CAI and self-study texts indicated a strong preference for the former. When compared to a "regular classroom" type of presentation, however, the self-study students rated their method slightly higher than did the CAI students. CAI students' attitudes appear to be related to the availability of assistance when course material problems are encountered. Additional findings from locally trained CAI students are presented in support of this interpretation.

137. The Study of Teacher Behaviors in an Adaptive Learning Environment, Colbert, C. D. and Wang, M. C., March, 1978.

A multi-aged primary classroom environment was observed to determine: (1) the degree to which teacher behaviors specified by developers of an adaptive learning environment (ALE) are actually exhibited by the teachers; (2) the nature of classroom processes and interactions between teachers and students in an ALE; and (3) the extent to which contextual variables alter teacher behavior. Forty-six five- to eight-year old students in an instructional program of prescriptive and exploratory components were observed, along with their two head teachers and one instructional aide. Two preplanned observation schedules were used to record frequencies of observed student and teacher behaviors in the

ALE, functions that may be divided into consultative and management facets. Analyses of teacher behavior patterns, instructional climate based on these behaviors, student behavior patterns and their relationship to classroom processes, and patterns of teacher interaction with students of different characteristics were undertaken. The analyses indicated that teachers do direct the ALE to help students become self-directed and self-evaluating. The data also suggested that contextual variables, such as size of instructional group and subject matter, do affect the teaching patterns and teacher-pupil interaction.

138. The Supervision of Individualized Instruction Programs: Four Guidelines, Bailey, M. A. and Gerl, G. J., 1976.

What is the role of the supervision process as it relates to initiating and sustaining individualization in the classroom? Though each is integral to the total instructional effort, four distinct areas of responsibility may be discerned. These areas are discussed.

139. Survey of Computer Applications in Army Training, Rich, J. J. and Van Pelt, K. B., August, 1974.

The survey provides information on computer applications in training throughout TRADOC and DA training organizations and activities. Textual and tabular data are also included when the organizations or activities responded to the items in the questionnaires comprising the survey. Results show that about fifty percent of the responding organizations and activities use computers in some form of training. Findings also indicate that most of the sampled organizations and activities are desirous of either present or future orientation and instruction in either top management, middle management, or instructional programming concepts and principles embodied in a computerizing training system (CTS).

140. A Survey of the Present State-of-the-Art in Learning Center Operations, Sullivan, D. J. and others, February, 1974.

A survey of 28 military industrial, government, and academic learning centers was conducted. The purposes were to document the state-of-the-art in the establishment and operation of these centers and to determine their potential usefulness in terms of being able to provide individualized, cost-effective instruction in Air Force training programs. The survey identified each center's goals, instructional techniques, and learning resources; attention was also paid to instructional development procedures, courseware production and maintenance philosophy. Student time savings, increased learning and cost-effectiveness were generally reported, although specific cost data were hard to retrieve. The learning centers deemed most effective were those which: (1) were designed to meet clearly defined, existing instructional needs; (2) specified student performance requirements; (3) were administered under a unified system which controlled the quality of courseware content and production; and (4) developed and produced their own courseware to meet specific needs.

141. A Taxonomy for Decision-Making in Individualized Instruction, Tosti, D. T. and Harmon, N. P., September, 1972.

Classroom decision making, known here as instructional management, is divided into seven categories covering the range of classroom decisions from establishing behavioral objectives to estimating support personnel requirements. These seven categories represent the instructional management taxonomy. Media employed in instructional management (assessment media, decision media, and initiation media) handle the processing, storing and transmitting of information within the system. The future will see a strategy which is based upon a mix of the taxonomy and the instructional management media.

142. The Teacher's Response to Technology and the Individualization of Instruction, Steward, J. R. and Love, W. A., February, 1970.

Studied the attitudes of 123 teachers in an innovative school dedicated to individualized instruction. Each student completed a 12-item Teacher Opinion Questionnaire and ranked five definitions of individualized instruction according to importance. Results reveal: (a) a high level of job satisfaction; (b) that loss of teacher status was not considered significant; and (c) that the extra effort required of the teacher was considered worthwhile and creative. Students also reported a considerable amount of role confusion and indicated the need for additional training in innovative techniques and guidance. Many students felt that the teacher should not be responsible for preparing his own curriculum material. Ranking of components of individualized instruction revealed strong agreement that many paths be available to the student to reach an objective at his own rate. A new emphasis is noted on the role of the teacher in assisting the student in his personal and academic development.

143. Teaching Machines and Programmed Learning, A Source Book, Lumsdaine, A. A. and Glaser, R., 1960.

Provides a comprehensive reference source on teaching machines and associated techniques of instruction. This book reflects a dual emphasis including both the nature of specific devices for presenting instructional material to the individual learner and the development of programs these devices are designed to present. Contributions include the early rationale of teaching by Skinner's machines and their use in education and military and industrial training.

144. A Theoretical Basis for Individualized Instruction, Kingsley, E. H. and Stelzer, J., July, 1974.

A theoretical basis was formulated for a model of individualized instruction. The theory is semi-axiomatic in nature so that the definitions and assumptions used are stated explicitly. Set theory and symbolic logic are the conceptual tools used. The model includes theories of subject-matter structure and student state description. These are related by an overall instructional model. A main result shows how subject-matter structure constrains student state transitions through a subject matter. An application of the subject-matter

theory is made to an existing Air Force course. A number of open problems are given whose further investigation would help make the model a more practical instructional tool.

145. Toward an Adaptive Learner-Controlled Model of Instruction: A Place for the New Cognitive Aptitudes, Boutwell, R. C. and Barton, G. E., May, 1974.

Reviews and evaluates research on the Aptitude Treatment Interaction (ATI) approach to individualized instruction in the classroom. The goals of this method include the discovery of human aptitudes with which the instructional designer can differentiate human performance, and the design and implementation of instructional treatments which will reliably predict maximum student performances regardless of aptitude. It is concluded that ATI research has not made any significant impact on these issues because nothing applicable to nonlaboratory situations has been developed. Possible reasons for this failure are discussed. Aptitudes are considered not to be a reliable predictor of task performance. Instead, it is suggested that the student's problem-solving style be monitored through the use of a computer. Feedback will help the student modify inappropriate ways of learning.

146. Training Manual for a Competency-Guided, Individualized Program for Special Education Supervisors 1972-1975, King, J. D. and Harris, B. M., 1976.

Presented is the training manual used to prepare special education supervisors in a competency based and individualized one-year program at the University of Texas. Noted in the overview are such program concepts as the role of the supervisor in instructional improvement and as an instructional change agent and the need for determining critical competencies. Discussed in the section on program goals, assumptions, and specifications; are the generic model, ways to individualize the programs, field experiences, and independent study activities. Competencies are considered in terms of definitions, evaluation of critical competency statements, the critical competency statements, distinguishing characteristics, critical competency domains, and validation of critical competencies. Examined in the chapter on the program model are basic program components, program expectations, time allocations, the formal course component, the field experience component and program relevance and use. Three instructional resources (the independent system learning laboratory, computer assisted instruction, and the management information system) are described. The assessment of trainee performance, assessment instruments, assessment sequence, and competence assessment and job expectations are discussed in the section on the competency assessment system. Appended are a list of the critical competencies (with a rationale and example of each), a report on the national study of critical competencies, and a list of documents and materials developed by the project.

147. Trial Implementations of the Tank Crewman Skills Training Program (TCST), O'Brien, R. E., Crum, W. J., Healy, R. D., Harris, J. H., and Osborn, W., September, 1978.

This report describes the adaptation of a modular, performance based, individually-paced tank crewman skills training program (TCST) for

trial implementation in five different tank crew train-up situations: (1) mobilization train-up of active and reserve crewmen in a training center environment; (2) mobilization train-up of training center crews; (3) individual readiness training of armor crewmen preparing for unit gunnery training; (4) accelerated training of tank crew replacements; and (5) accelerated refresher training of experienced crews deprived of regular gunnery training. The procedure typically involved: (a) adapting TCST to the training situation; (b) planning training implementation; (c) pretesting; (d) delivering training; (e) administering a crew gunnery criterion test; and (f) post-testing individual skills. The training was administered by unit trainers under supervision of the project staff. Data was collected on individual skill proficiency, crew gunnery performance, and trainee opinions of the program. Two of the five studies produced positive results. In one, the training center active and reserve mobilization train-up, TCST produced trainee skill levels and opinions superior to those resulting from two alternative programs. In the other, the accelerated tank crew replacement training, TCST was used successfully in rapidly preparing non-11E soldiers to fill in as gunners and loaders on a gunnery qualification test. A Table VIII test in which the crews with replacements performed as well as experienced intact crews. Results of the other three trial implementations were inconclusive. A need exists for some kind of TCST to be used in preparing combat ready crews. The TCST program has a number of promising features, but needs further development. Of particular importance is the need for detailed trainer guidance on how to plan, schedule and deliver training.

148. Updating the Little Red Schoolhouse: Toward Developing a Pilot Model of Capital-Intensive Education to Promote Individualized Instruction and Stabilize Educational Costs, Swanson, A. D. and Willett, E. J., January, 1977.

A plan for a demonstration school is outlined. The design calls for a reallocation of capital and labor resulting in the heavy use of instructional technology and differentiated staffing. Comparisons with traditional schooling show the model to be potentially more cost-effective.

149. The Use of Mastery Learning as a Classroom Management Model, Dolly, J. R. and Meredith, J. H., April, 1977.

Weaknesses in Bloom's (1968) model and misinterpretations are described.

150. Uses of Computer-Assisted Instruction in Developing Psychomotor Skills Related to Heavy Machine Operation, Phillips, J. R. and Berkhout, J., December, 1977.

A study was performed to determine the relative effectiveness of different formats of computer-assisted instruction (CAI) in teaching a psychomotor performance task. A control group combining male and female

subjects received instruction based on the study of written materials and unstructured practice sessions on a heavy transmission gear-shifting task. No significant differences were found between male and female performance patterns and learning abilities under control conditions. Two experimental groups, both restricted to males, were trained under similar practice conditions with the addition of computer monitoring of performance and feedback of supplemental information to the students. One group received terminal feedback of numerical performance quality scores following each trial. The other group received continuous feedback of an analytic display (a display of nominal road speed against elapsed time in the form of an x-y plot) concurrent with each trial. Both experimental groups were tested for retention of skills after transitioning to a non-feedback performance environment. Both forms of computer-assisted instruction proved to be significantly superior to the control teaching procedure.

151. Utilizing Self-Instruction or Learning Packages: Teacher and Student Implications, Farley, A. and Moore, D. M., August, 1975.

Discusses considerations involved in the utilization of learning packages as alternative vehicles for continuous progress education. The types of activities which may occur in a curriculum based on a learning package are illustrated to assist teachers in generating ideas for instruction which are compatible with their individual teaching styles. Utilization of a learning package essentially involves an alteration in the frequency with which common instructional activities are changed. The teacher, as a facilitator, must anticipate and plan daily to engage in a variety of typical behaviors rather than to pursue a single technique. The role of the student in a learning package instructional program is described, and the concerns of teachers regarding the effects of implementing such a program on certain classroom activities are evaluated.

152. Varied and Fixed Error Limits in Automated Adaptive Skill Training, Crooks, W. H., April, 1974.

Two strategies of manipulating error limits were compared with a fixed error limit in an adaptive training system. Forty-five (45) subjects were given training in a bidimensional, high-order compensatory tracking task. The velocity/acceleration ratio of the control dynamics was the adaptive variable. The training group with increasingly rigorous error limits required more time to reach the exit criterion than did the group with increasingly lax error limits. The changing response requirements of the adaptive task suggest that interference produced the inferior performance of the former group. No differences among groups were demonstrated in a retention test, and there was no transfer from the training task to a simulated flight control task.

153. Varying Instructional Methods to Fit Trainee Characteristics, Koran, M. L., 1972.

Past research on training large numbers of teachers with different abilities has emphasized the importance of patterns of adaptation

where educational objectives, pacing, and sequencing were varied. Varying instructional methods (the thrust of this research) such as video presentation treatment, written presentation treatment, or no treatment were grouped under aptitude by treatment interaction. Findings showed that video treatment produced significantly higher performance than written treatment or no treatment. ATI research may practically be used for selection of appropriate subjects for self-pacing or conventional instruction, different instructional materials for different types of subjects, or even the selection of teachers.

154. Various Combinations of Traditional Instruction and Personalized Instruction, Williamson, D. A. and others, 1976.

Attempts to evaluate the effect of various combinations of traditional instructional methods (TM) and personalized instruction (PSI) on final exam scores. It is hypothesized that groups which received PSI combined with enrichment provided by TM will score significantly higher on their cumulative final exam than students who receive instruction by PSI alone.

155. Where Less is More, July, 1975.

By using individualized self-paced instructional programs, a U.S. Army helicopter repair training school is spending less time in training and turning out more qualified graduates.

156. Wisconsin System for Instructional Management: Teachers' Manual for the Unified System, Practical Paper No. 18, Bozeman, W. C. and others, November, 1977.

Individualized instruction including continuous progress education and team teaching requires a complexity of organizational structure dissimilar to that of traditional schools. In such systems, teachers must maintain extensive and complex student record systems. This teachers' manual provides an example of a computerized record system developed to complement the Individually Guided Education (IGE) program with its varying instructional approaches and innovative practices. Functions discussed include grading, achievement profiling, instructional grouping, diagnostic reporting, and student data base maintenance. Appended are sample forms, a glossary of terms, and a bibliography of other Wisconsin System for Instructional Management documents.

157. Working with Individualized Instruction, Esbensen, T., 1968.

Discusses individualized instructional systems from the standpoint of the nature and degree of individualization. Written by the Assistant Superintendent in Charge of Instruction at Duluth public schools in Minnesota, this book recounts three elementary school projects with widely varying student populations.