DOCUMENT RESUME

ED 042 917 VT 011 721

AUTHOR	Smith, Brandon B., Ed.; Moss, Jerome, Jr., Ed.
TITLE	Report of a Seminar: Process and Techniques of Vocational Curriculum Development (Minneapolis, Minn., Feb. 28-Mar. 1, 1970).
INSTITUTION	Minnesota Research Coordinating Unit in Occupational Education, Minneapolis.
PUB DATE	Apr 70
NOTE	126p.
EDRS PRICE	EDRS Price MF-$0.50 HC-$6.40
DESCRIPTORS	*Conference Reports, *Cooperative Planning, *Curriculum Development, *Curriculum Research, Job Analysis, Occupational Surveys, *Systems Approach, Vocational Development, Vocational Education
IDENTIFIERS	Minnesota, Research Coordinating Unit (RCU)

ABSTRACT

A group of nine persons met in Minneapolis at the invitation of the Minnesota Research Coordinating Unit to discuss some of the innovative empirical techniques for implementing the "systems" approach to vocational curriculum development, including some military pioneering efforts. The seven presentations discussed at the seminar included: (1) "A Systems Application to Curriculum Improvement" by David S. Bushnell, (2) "A Manpower Delivery System: Implications for Curriculum Development" by Robert G. Smith, Jr., (3) "Implications of Air Force Occupational Research for Curriculum Design" by Raymond E. Christal, and (4) "An Empirical Procedure for Identifying the Structure of the Technical Concepts Possessed by Selected Workers" by Jerome Moss, Jr. and others. Throughout the seminar, discussion was directed to (1) the preparation of students for entry or reentry into the labor market in relation to specifying the worker's role and tasks, (2) the selection of tasks to be taught, analyzing the selected tasks and stating performance objectives, and (3) the specification of instructional sequence. A major outcome of the seminar was a framework for use in describing the nature of conceptual and operational problems facing curriculum builders. (JS)

Report of a Seminar:

Process and Techniques of VOCATIONAL CURRICULUM DEVELOPMENT

Edited by

Brandon B. Smith and Jerome Moss, Jr.

April 1970

Minnesota Research Coordinating Unit
for Vocational Education
University of Minnesota, Minneapolis, Minnesota 55455

Table of Contents

Introduction

On February 28 and March 1, 1970 a group of nine persons met in Minneapolis, Minnesota, at the invitation of the Minnesota Research Coordinating Unit for Vocational Education, to discuss the process and techniques of vocational curriculum development. The participants are listed on page vii. A tenth person who had been invited, Joe Silverman, Naval Personnel and Training Laboratory, was unable to attend but his paper is included in this Report.

There were two primary and closely related reasons for conducting the seminar. First, new models of the curriculum development process based upon the "systems" approach, and innovative empirical techniques for carrying out the process are now being developed and tested. The vocational education community should be made aware of them. Second, a high percentage of these pioneering efforts are being carried out in and for the Armed Services. A closer relationship between occupational education researchers working in the military and those giving attention to non-military programs is long overdue — undoubtedly to the detriment of both groups. The seminar was, therefore, perceived as a small beginning to what is hoped will be an expanding, continuing forum.

The seminar was kept small so that its members could benefit from the maximized opportunity for informal discussion. Papers were written and distributed before the seminar to prepare participants for the two-day meeting.

This Report is our means of communicating with that portion of the vocational education community who we feel are most directly concerned with the methodology of curriculum development. The papers are reproduced as prepared by their authors. The "Summary" has been prepared by the editors and is a severely abridged account of the actual discussion, which reflects the editors' biases and limited perceptions and perspectives.

The staff of the Minnesota Research Coordinating Unit is very appreciative of the time and effort expended by the seminar members and contributors to this Report. We extend special thanks to Rupert Evans who chaired the seminar.

Seminar Participants

Seminar Chairman

Rupert N. Evans
Bureau of Educational Research
University of Illinois
Urbana, Illinois 61801

Seminar Co-directors

Jerome Moss, Jr.
Minnesota Research Coordinating
Unit for Vocational Education
125 Peik Hall
University of Minnesota
Minneapolis, Minnesota 55455

Brandon B. Smith
Minnesota Research Coordinating
Unit for Vocational Education
125 Peik Hall
University of Minnesota
Minneapolis, Minnesota 55455

Seminar Presenters

James W. Altman, President
Datagraphics, Incorporated
4790 William Flynn Highway
Allison Park, Pennsylvania 15101

David S. Bushnell
Advance Study Fellow
Battelle Memorial Institute
1755 Massachusetts Ave. N.W.
Washington, D.C. 20036

Robert G. Smith, Director
Program Development
Human Resources Research
Organization
300 N. Washington Street
Alexandria, Virginia 22314

Harry L. Ammerman, Senior Scientist
Human Resources Research Organization
Division No. 5, P.O. Box 6021
Fort Bliss, Texas 79916

Raymond E. Christal, Chief
Occupational Research Branch
Laboratory (AFSC)
Air Force Human Resources
Lackland Air Force Base, Texas 78236

Frank C. Pratzner, Researcher
The Center for Research and Leadership
Development for Vocational and Technica
Education
The Ohio State University
Columbus, Ohio 43210

Summary of the Discussion

SUMMARY OF THE DISCUSSION

Jerome Moss, Jr. and Brandon B. Smith

The discussion spurred by each presentation was wide-ranging in its coverage of the curriculum development process. To present the summary in chronological fashion would be to attempt a linear description of a spiral-like treatment of the seminar topic. The editors have therefore elected to organize the summary around *their* perception of the curriculum development *process* as it began to evolve from the discussions. Special techniques, considerations and problems will be related to the particular step(s) in the process with which they were associated. In this manner, it is hoped that the summary will be of maximum value to readers.

The organization selected, however, necessitated using a considerable amount of editorial license. No attempt was made at the seminar to reach a consensus regarding the specific steps in the curriculum development process, nor even to discuss all of the steps. Thus, the framework employed here is not necessarily entirely acceptable to each of the seminar participants. Certainly, it is *not* considered a description of the *complete* process by either the participants or the editors.

Throughout the seminar, discussion of the curriculum development process was applied to programs designed to prepare students for immediate entry or reentry to the work force; application of the process to "prevocational" or "orientation to work" programs was not discussed.

I. Specify the Role

The first step in the curriculum development process needs to be the specification of the role for which training is to be provided.

For the military, which frequently has foreknowledge of new weapons and other systems and which has considerable control over both occupational demand and supply, this step is fairly straightforward. A systems analysis can be conducted to define the scope and function of each "job" that needs to be done within the system in order to accomplish the system's mission. Individuals, who most frequently do not make a career in the military, can then be trained for specific, well-defined jobs (work roles).

For public school vocational educators, however, social values and practical considerations make role definition much more difficult. Vocational educators have little control over the labor supply, and almost none over occupational demand. Their programs are not the sole suppliers of the nation's trained labor. And vocational educators cannot be concerned only with satisfying manpower requirements, but must try to optimize the entire social system through maximizing the potential of every student. Consequently, the public school vocational educator must consider many factors, in addition to the needs of available specific "jobs," when defining the work roles for which training is to be provided. For example, in order to help assure individual job satisfaction, as well as satisfactory job performance, job engineering — the restructuring of work roles — may be required to adapt jobs to available human abilities and psychological needs (e.g. creating paramedical occupations). Consider also the effects of imposed, unrealistic labor market barriers, such as discriminatory practices, inefficient placement systems, and control by unions or management over entry points to certain career fields. To what extent should these barriers to the use of skills affect the scope and nature of the work roles for which training is to be provided? Further, concern for the career development of the individual also forces public school vocational educators to focus attention on the long-term usefulness of work skills. Studies of the predicted impact of technological change, the identification of occupational "clusters," and the specification of career ladders are all indicative of a desire to enhance the efficiency of training by defining a work role for training purposes that is <u>different</u> from the entry level job currently available in the labor market.

Finally, many vocational educators in the public schools would specify the roles for which training is to be provided to include aspects of the <u>non-work</u> as well as the <u>work</u> roles. Concern for citizenship and culture-carrying activities and the self-fulfillment of the individual would dictate this broader perspective of vocational education's responsibility.

II. Identify the Tasks in the Specified Role

After specifying the role, that is, putting boundaries around the total domain of concern for a given curriculum, it is then possible to identify the specific tasks that comprise the role. Tasks are groups of activities that generally occur together and which have a common purpose which is valuable in and of itself. Some examples of work tasks are: perform blood count, establish work priorities, plan work flow, make local purchase of supplies, audit cash payments, maintain files of plans and programs, receive and distribute computer outputs.

There are at least three kinds of problems attendant to the step of task identification: (a) What tasks within the role are educationally relevant? (b) What task sampling frame should be used? (c) What techniques of task identification are most efficient? These questions are discussed briefly below.

Ideological questions, such as the purposes of occupational instruction in different institutions, at different educational levels, and for various occupational groups, might affect the kinds of role tasks that are relevant to the educator. For example, the technical tasks of the work role involving cognitive and psychomotor skill performance are typically considered relevant by all vocational educators. But what about the affective behaviors that are involved in occupational adjustment and human relations tasks on the job? Are these to be identified as work role tasks to be taught? [The military and non-military seminar participants tended to disagree on this question.] The same issue can be extended; what kinds of tasks inherent in the citizenship and culture-carrying roles are to be included among the tasks to be taught in vocational curriculums?

It was fully recognized by seminar participants that it might be extremely difficult to identify all of the relevant tasks in some roles and/or impractical to teach all the tasks after they had been identified. For instance, as work roles become more complex — as tasks involve greater degrees of judgment rather than knowledge of procedure, as cognitive performance increases in relation to psychomotor performance, and as task generalization becomes important to performance — the problem of relevant task identification is intensified. Similarly, as the number of relevant tasks grow, and as training time (and cost) is restricted, the feasibility of teaching all identified tasks decreases. For these reasons, it is imperative for the vocational curriculum developer to create and make explicit a task sampling frame which classifies the total domain of relevant tasks from which specific tasks may be sampled for subsequent treatment and incorporation into the curriculum. There is no doubt that almost all non-military curriculum development efforts in the past have, in fact, sampled the tasks to be taught, but thus far none of them have made the basis for their sampling explicit. They are, therefore, unable to defend their selection of particular tasks as representative of the total, relevant task domain.

It is quite likely that the appropriate sampling frames will need to be multi-dimensional. There could be, for example, dimensions dealing with (a) work vs. non-work tasks, (b) entry job vs. career development tasks, (c) specific vs. related job tasks, (d) predominately cognitive vs. psychomotor vs. affective tasks, (e) tasks organized according to the hierarchical psychological processes required to learn or to perform them (per Gagne), and so forth.

Considerable time in the seminar was devoted to discussion of some techniques for identifying work role tasks. One successful task inventory technique (see the Christal paper in this Report) is to develop a task check list which can then be submitted to workers in the appropriate role (job) for confirmation and for specification of the relative time spent on each task. The data yielded is apparently valid and reliable. By applying certain statistical clustering techniques to the data, job clusters based upon task similarity can be formulated. Experience with the technique has shown that it is far superior to asking supervisors and former students about the value of prior training; asking about previous training tends to identify missing training elements, but fails to identify instructional "deadwood," that is, tasks taught but which are not being used on the job. Presently, the task inventory technique lacks adequate means for measuring the proper performance conditions and level of each task, which is important to the subsequent specification of educational objectives. The technique also becomes more difficult to apply as work roles increase in complexity and as fewer tasks are exactly replicable over time on the job. One application of the task inventory technique that might facilitate its use with more complex jobs is to first devise a classification of tasks, e.g. decisions to be made, information needed for the decisions, etc., which then permits cross-checking across the task categories in an interview situation to help insure complete task identification (see the Ammerman paper in this Report).

A second technique discussed by the seminar provided means for identifying the concepts and the relationships among concepts possessed by persons performing the work role at the desirable level of competence (see the Moss and Pucel, et. al. paper in this Report). The technique seems particularly suited to complex jobs in which instruction is less directly replicable on-the-job, but in which an interpretive and associative base for making judgements and applying concepts to a wide variety of tasks and situations is required. The technique, however, needs to be combined with some form of task identification method in order to be able to specify the instructional vehicles (tasks) needed to develop the designated conceptual structure.

Although most of the discussion dealt with techniques for identifying either cognitive or psychomotor tasks, the participants recognized the importance of being able to specify relevant affective tasks. It was proposed that these behaviors are simply another type of "task," and may, therefore, be treated after identification in the same way as other tasks. The immediate difficulty seems to be that we currently lack adequate methods, instruments and/or observation skills to reliably identify affective tasks and to specify the level of performance required for each.

III. Select the Tasks to be Taught

Since it is typically not practical to teach all of the relevant tasks comprising the specified role, criteria for selecting the tasks to be taught are required. The following are some of the potential criteria identified by the seminar: (a) The practical limit on the number of tasks to be taught is a function of the total time available and the time it takes to teach each selected task to a reasonable level of "functional utility"; it was agreed by the participants that teaching "about" tasks is not conducive to adequate task performance nor to task generalization, and is therefore an inefficient instructional approach. (b) Tasks must be selected from the task sampling frame so as to be representative of the total task domain. (c) Tasks should be selected that permit the greatest generalizability. These may be those tasks that most efficiently develop the desired conceptual structure (per Moss and Pucel, et al.); they are also the tasks that optimize the stimulus repertory, response repertory, response association, task repertory and self-directed tendency (per Altman paper in this Report); they may be selected on the basis of a taxonomy (per the Silverman paper). (d) Tasks which have the greatest frequency of use in the role (or time spent on them) might be selected. (e) Tasks which have emergency value or grave consequences for poor performance should be selected. (f) Tasks with the lowest "perishability" rate might be selected. (g) Tasks that are more "economical" to learn in the formal training program than on-the-job should be selected. (h) Tasks whose performance might reasonably be considered a prerequisite to the training program should not be selected.

When information bearing on the above kinds of criteria becomes available, some means for weighting each piece of data for making a final judgement about each task will be needed. In that event, a "policy capturing model" (per the Christal paper in this Report) might prove to be very useful until an empirical weighting based upon actual student performance in the specified role can be developed.

IV. Analyse Each of the Selected Tasks

Very little time was spent in the seminar on this step since Gagne' has already suggested a suitable task analysis technique. It was noted, however, that if a conceptual map were available it could provide a basis for checking the comprehensiveness of the results of the subjective task analyses.

V. State Performance Objectives

Using Mager's technique for stating performance objectives and applying it to the tasks selected to be taught, terminal objectives may be prepared as the next step in the curriculum development process. The accomplishment of each task can be stated as an objective. [Of course, terminal objectives may also be stated in terms of acquiring an appropriate cognitive structure.]

The results of analysing each selected task will yield the specific competencies necessary for stating intermediate or enabling performance objectives as they relate to each terminal objective. At the same time, results of the task analysis permit the specification of required competencies for entrance to the training program.

The seminar was generally critical of many curriculum development efforts which appeared to begin with the preparation of written performance objectives; while the achievement of those objectives may be measured, they may have no real validity or usefulness in terms of actual role performance. The seminar was also quick to note that the model described herein has as yet incorporated no reliable technique for determining the desired level of task performance at exit from the training program. The statement of performance objectives may therefore lack realistic performance standards.

VI. Specify the Instructional Sequence

Sequencing instruction as to achieve the required level of performance of all selected tasks in the most efficient manner is a difficult problem that has not received the attention it warrants.

At the micro level of sequencing activities, principles for generalization, such as those proposed by Altman in this Report, serve to suggest efficient reinforcement schedules. The task analysis process itself will yield sequences of sub-tasks which indicate instructional order. But the curriculum process must provide means to order and organize these otherwise disconnected individual task sequences. The seminar briefly discussed several possible techniques.

First, if the work role is relatively simple and "proceduralized," the tasks selected to be taught can logically be presented for instruction in the order that they will ordinarily be performed on the job. Concepts (information) to be taught can then be associated with a pertinent task and taught in the order determined by the sequence of tasks. Second, when the work role is comprised of specific but relatively unordered, interdependent tasks, the tasks can be sequenced in accordance with the presumed or proven demands of prerequisite competencies; that is, the results of all the task analyses can somehow be combined such that all the contingency relationships are taken into account. Third, in even more complex work roles perhaps the criteria for task sequencing should be the development of a pre-specified conceptual structure. In this event, a model of the appropriate conceptual structure could be identified, selected tasks might then be related to the conceptual structure, and the tasks (as vehicles for instruction) sequenced to permit an inductive or deductive approach to the development of the desired conceptual structure. Thus, unlike the first procedure suggested in which tasks are ordered in accord with the principle of job performance, the third procedure would order tasks so as to develop a predetermined conceptual structure. Conceptual structure development would be the sequencing principle applied.

Finally, the instructional program might not necessarily have to utilize only one of the suggested sequencing procedures. Cooperative programs in engineering, for example, typically apply at least two procedures: on-the-job experience and directly-related instruction are sequenced according to the dictates of the job, while the more "theoretical" in-school instruction is sequenced according to some "other" principle.

VII. Miscellaneous

Subsequent steps in the curriculum development process, such as identifying conditions of learning, designing an instructional strategy, developing instructional events, and creating student and curriculum evaluative procedures and devices were not discussed during the seminar. Instead, attention was given briefly to the mechanics of bringing about educational change.

Large-scale, "wholistic" attempts at change seem to be called for. Whenever possible, the scope of curriculum innovation should be as broad and as coordinated as possible in order to maximize its impact upon the student and thereby improve the likelihood of making significant educational improvements. Where dollars are limited, the scope of the curriculum to be changed may have to be restricted, but each such attempt, regardless of its scope, must provide for concurrent change in related support systems, such as pupil-personnel, teacher education, and administrative services. Failure to provide for change in relevant back-up systems has often been the apparent reason why otherwise promising innovations have failed to become regular parts of the school's program.

Some of the curriculum changes seen as desirable by the seminar members include (a) increasing the attention to be paid to the "products" of instruction, (b) making education more task oriented, with the tasks having face validity for students and actual relevance to out-of-school behavior, and (c) permitting more non-verbal behavior in the learning process, especially at the earlier stages of schooling, in order to provide the "concrete" experiences necessary for later abstract conceptual development.

VIII. Conclusions

The seminar was successful in highlighting some of the complexities in the process of developing manpower training curriculums, but it also served to illustrate that through cooperative research efforts the problems may not be insurmountable. Both military and non-military personnel are working towards the creation of objective, empirical procedures and techniques which will facilitate curriculum development efforts.

While it would be presumptuous to assume that the seminar produced any lasting solutions to curriculum development problems, it was able to begin to formulate a series of rather discrete steps in the development process and to suggest some of the problems related to each step. For example, it seems quite clear that one of the major problems facing vocational educators is to specify precisely the role which students are expected to play after completion of training. Further, it seems equally clear that while significant progress has been made in identifying and clustering technical tasks, considerably more research is needed to (a) develop task sampling frames from which it will be possible to select the tasks to be included in the training program, (b) precisely define the conditions and performance requirements for each task, and (c) propose new schemes for organizing the tasks in the most efficient instructional sequence.

In conclusion then, the ideas presented by the discussants and summarized here may not be a revelation to the profession, but they are at least enlightening in that a framework is provided to systematically describe the nature of the conceptual and operational problems facing curriculum developers. Through continued cooperation between military and non-military researchers, it may be possible to study and solve some of these problems.

Presentations

A SYSTEMS APPROACH TO CURRICULUM IMPROVEMENT

David S. Bushnell[1]
Battelle Memorial Institute

Introduction

Education in the United States is now a $65 billion enterprise. According to President Nixon, we now spend as much money on education in this country as does the entire rest of the world. Viewed from the perspective of the return on the dollars invested in education, economists have recognized that such expenditures may account for a large share of the economic growth achieved in this country in recent years. Education's role in maintaining and enhancing the skill and adaptability of a nation's labour force and in providing the wherewithal for continued economic growth through research has made it possible for us to continue our rate of economic advancement and growth. Paradoxically, our public educational system which has served us so well in the past now suffers from the infirmities of institutional rigidity. The rapid strides of a computer based technology, the rising cost of education, the growing impatience of the younger generation with outmoded, non-relevant curriculum, and the skepticism of the disadvantaged with the prescriptions of the professional educator provide evidence for the fact that educational institutions have not kept pace with these demands. This year's rash of riots and protests have put educators on notice that schools must begin to adapt to the needs of its students in ways which are appropriate to their short-term and long-term expectations.

We know how to improve the effectiveness of education but we're not quite sure how to go about it. The problems and shortcomings indicate that there is a need for clearer definition of goals as well as a means of dealing in a coordinated way with the multitude of variables which relate

---

[1] This paper was prepared during a one year appointment as an Advanced Study Fellow with the Battelle Memorial Institute.

10/11

directly to the achievement of those goals. Past efforts at school improvement have tended to deal with only fragmented pieces of the total learning structure. Each of the subsystems making up that structure must be viewed as part of a total system. Matt Miles observes that many experimental programs within the larger system fail to be exploited because the particular innovation is perceived as creating too many ripples, too much pressure on the other outmoded practices, with the result that those having vested interest in the conventional procedures resist the improvement.

For this reason, small scale curriculum improvement efforts such as many of those currently under development in vocational education, are likely to have little impact because they deal only with a small part of the total learning process. What is needed is a more massive (both in funds and effort) approach where attempts at piecemeal improvements are linked together across a spectrum of subject matter areas and grade levels. Few attempts until recently have been designed to go beyond the boundaries of a specific subject matter area when concerned with curriculum reform. Even fewer adventuresome souls have been willing to consider the need for modifying curriculum content, instructional procedures, teacher roles, and administrative procedures, all at the same time! Yet that is probably what is required if significant improvements in student performance and satisfaction are to be brought about.

Dr. Lloyd Humphreys, Chairman of the Department of Psychology at the University of Illinois in a presentation before the 1969 American Psychological Association Convention listed four priority items which he felt should be given our full attention in any attempt to improve the effectiveness of schools. His first principle was that curriculum improvement offers more payoff potential than any other form of educational change. Secondly, he argues that appropriate use of contingency reinforcement schedules will dramatically aid in the internalization of the child's desire to learn. Third, he stresses the importance of accurately measuring academic ability and adapting learning materials and requirements to that ability. Intelligence, he recognized, is a function of intellectual skills, knowledge, learning sets, and generalization tendencies. Each ingredient is interdependent with the others and resistant to chance in the short run. And fourth, Humphreys contends that the time the student has to learn or is willing to invest in learning may be as important a determinant of his ultimate proficiency as any other part of the teaching strategy employed. I mention these four principles only to keep in perspective where we as conferees might spend our own time most productively during these next two days. Which issues to examine, what variables to explore, and where to move next, these questions deserve at least preliminary attention. We should strive for the wisdom to understand and the courage to accept that which we cannot change (to paraphrase an old adage).

Fortunately, there is a relatively new analytical approach which offers us a way of manipulating the important learning variables and linking their results to the ultimate criteria of improved student performance. Systems analysis of course is not a new or magical formula for guaranteeing success. Most of us are well aware of the benefits of applying this technique to the design and implementation of training programs in military and industrial settings. Task analysis and job clustering have contributed (or will contribute) greatly to the preparation of students and adults for viable careers, provided we are successful in keeping in focus the necessary interplay between the adaptive, functional, and specific content skills which comprise all job requirements. How to translate these into vocational curriculum content is the central concern of my paper.

Is A Systems Approach in Education Possible?

Before attempting to argue that systems analysis techniques have a legitimate place in vocational curriculum design, let me observe that there are significant differences between an educational system and other systems. Introduction of the new math into a classroom generates a whole host of problems which are unlikely to be found in other institutional settings like the military. Students can't grasp the new terms and parents are frustrated because they can't help. Teachers are frustrated because they haven't been taught how to cope with wide-ranging student needs and abilities. Principals are frustrated because their students fail to measure up on standard achievement tests which haven't been overhauled to reflect the new approach. Regional accrediting groups require time and empirical evidence in order to decide whether or not the new curriculum meets their sometimes outmoded criteria of excellence.

There are still other problems. School boards in their worry over increasing demands on the tax dollar are often compelled to make hard choices between new course offerings and getting by with existing ones. This is particularly true of vocational education because the establishment of a new vocational training course can be much more expensive than the cost of a new physics or math program. The advantages of a new curriculum may be hard to determine empirically. Objective evidence supporting the choice of one set of materials compared to another may be non-existent (given the publisher's reluctance to adopt or reveal performance criteria).

The military training command, on the other hand, is training for a specific level of competence in a specific job which is not likely to change in the near future. Until recently at least, dollar and other necessary resources have not been a primary concern. Most trainees are high school graduates, well motivated, and already certain of their occupational pursuit during their period of service. Shifts in task requirements are usually anticipated well in advance of demand. Proficiency of the job incumbent following training is easily monitored with feedback to the training command a certainty.

This brief discussion is meant to establish how the level of complexity differs between the centrally-controlled and run military or industrial establishment and the decentralized and locally-managed school establishment. To realize this difference may be to realize the problems peculiar to applying a systems analytic approach to curriculum improvement in public education.

It is difficult to imagine anything or anyone not functioning in some kind of system. You have only to think of the human body as a series of interrelated systems and subsystems to gain a feeling for the comprehensiveness of this approach. The person or planner who applies a systems approach will usually view the institution or organism as a functioning entity. The basic elements are to set forth one's goals in quantifiable terms, plan and present the various alternatives to achieving these goals, operationalize the plan to be carried out, evaluate the results and feedback the evaluation into the system so that the operations can be appropriately modified or revised. Morgan and Morgan, in their article on "Systems Analysis for Educational Change,"[2] state that "the first step in applying a systems approach to education involves the specific definition of what outcomes or results are desired. It is against these specifications that the system, whether spaceship or educational program, is to be built. The next step is to analyze the many variables that will contribute to the performance of the system. What are the means and strategies that can be employed to produce the desired outcomes? This analysis of means can be complicated or relatively simple. It involves the study of relative cost of means, feasibility of their use, and the predictability of the results."

Modifying an ongoing educational program has oftentimes been stymied by our inability to cope with the multiplicity of variables involved. It is analogous to trying to convert a locomotive from coal to diesel fuel without stopping the train. Few educators, until recently, were capable of even verifying which educational procedures were the most valid. The availability of computers to education and the more sophisticated application of systems analysis have recently made it possible to deal in a systematic way with these highly complex problems that require simultaneous juggling of multiple variables. As an example, let's focus on the problems of identifying performance objectives in vocational education as a means of building and integrating curriculum materials so that they might more easily be adapted to individual student requirements.

One of the first and most important tasks to be undertaken in systematically building an individually oriented vocational curriculum with the necessary variety of materials and pathways needed to accommodate students of varying abilities, interests, and learning styles would be to convert where possible specific work tasks into observable behavioral specifications, i.e., a catalog of appropriately classified performance objectives that would describe with precision the minimal levels of performance that each trainee should be able to achieve. This does not ignore the fact that some trainees could go well beyond the minimally sufficient level. However, it would describe the adaptive, functional, and specific content skills needed to qualify for a given occupation.

---

[2] Morgan, Robert and Morgan, Jack, "Systems Analysis for Educational Change," TREND, Spring 1968, pp. 28-32.

Why Performance Objectives?

Apart from a growing discontent with the traditional ways in which performance objectives have been stated, what compelling reasons are there for going to the very great trouble of developing a full inventory of appropriate skills?

First, in using the systems approach to curriculum design, the goals or objectives for the program must be stated in terms of output specifications. In education, these specifications can oftentimes be stated in terms of behaviors. Without them there is little basis for deciding which learning intervention or teaching strategy would be most effective. When decisions on the selection of teaching strategies have been made without performance objectives, there are no empirical means of determining the degree of their effectiveness. It is doubtless true that most decisions about changes in instructional practice are made without verification in terms of what someone thinks is the effect of the practice on what is hoped to be the result. Consequently, systematic program revisions are virtually precluded in the absence of measurable performance objectives.

A second reason relates to the need for longitudinal validation of the effectiveness of public education in preparing young people to cope with their social and economic environment after they leave school. Unless we know with what behavioral attainments a youngster enters the adult world, there is little basis for relating his success or lack of it back to his school experience. The selection of given sets of performance objectives is purely judgmental. People of wisdom must decide that one objective is important and reasonable and that other objectives are not. At least one important criterion for the selection of objectives is that they appear to relate to preparing a student for his adult roles--as a worker, parent, or as a citizen. Such objectives tend to be selected in terms of their face value. That is, they look as if they ought to relate. Face validity is often misleading, and the appearance of relevance may not be supported by correlational analysis. Revisions in educational goals as a result of follow-up studies of high school students ought to be, but are rarely, done.

A third reason for requiring performance objectives is the need to assess the cost-effectiveness of educational programs. The American taxpayer will inevitably grow weary of continuing to vote for increased taxation for education with no tangible evidence of the effect that these expenditures have on the education of his children. With more precisely stated educational goals, it should be possible to associate behavior change with program costs. Student learning should certainly be the main, if not the only, basis upon which cost-effectiveness analyses should be made in education.

The most important reason, however, is the need for a detailed, carefully sequenced set of performance objectives and related achievement measures to help insure the adaptability of the curriculum to individual requirements. If the schools are ever to provide learning experiences tailored to an individual student's measured progress and tied to what a student last learned, his step by step progress in mastering an instructional sequence must be measurable.

Problems of Measurement

If it follows that developing performance objectives is a worthwhile and necessary step in the design of a sequenced series of learned units, then the problems of doing the job should be considered. Preparing educational goals in behavioral terms is not altogether new, but scholarly dialogue on the subject is remarkably thin. One of the most definitive works on the subject is probably Robert Mager's Preparing Instructional Objectives.[3] Without taking anything away from Mager's substantial contribution, the paucity of discourse on the problem of stating performance objectives in all spheres of learning has failed to provide ready answers. People who have written behavioral objectives (and there have been a fair number) have generally followed the procedures set forth by Mager. Yet, it appears that a large number of the most important educational goals do not lend themselves to objectification in the Mager manner. Consider citizenship, social skills, and aesthetics, for example.

In a recent educational meeting, David McClelland raised the objection that much of the work done on educational objectives was limited to "respondent" behaviors. He defined respondent behaviors as those elicited in a contrived stimulus situation which were appropriate for some parts of education, but not for all. He described the need for means of objectifying and measuring "operant" behaviors. Operants are defined as responses emitted by the learner in the absence of any clearly defined stimulus situation. For example, if an educational goal is to have the student learn to appreciate and enjoy good literature, the best test of whether or not this aim had been accomplished would best be assessed by the way in which the student actually invests his leisure time outside of school hours. The present technology of behavioral objectification and measurement doesn't really accommodate these kinds of "real world" criteria.

Another significant problem in behavioral objectification is the horizontal and vertical articulation needed among the conventional subject matter areas. A number of past efforts have not met with great success.[4]

---

[3] Mager, Robert F., Preparing Instructional Objectives. Palo Alto, Calif.: Fearon Publishers, Inc., 1962, 60 pp.

[4] See, for example, Stanford Research Institute's careful evaluation of the well publicized Richmond project, (BR5-1337) Kincaid, Harry, A Preliminary Evaluation of Richmond Plan (Pre-Technical Plan) Programs in Secondary Education, S.R.I., Menlo Park, California, 1968. ERIC Documentation No. 025654.

One of the principle reasons for this lack of success is that the integration has been attempted at the level of the teaching process without sufficient attention to the integration at the level of the educational objectives. An effective curriculum requires an appropriate fusion or integration of the objectives across subject matter lines--a task for which there is little precedence and one which calls for the careful phasing of a series of developmental activities.

In seeking to develop integrated performance objectives, the groups and individuals qualified to do this work inevitably move to a subject matter orientation as they plan their projects. The way the learning process has been organized, by discipline, with relatively little exchange across disciplines, may not be the most efficient way of arranging the learning experiences. It is predicted that a careful analysis and evaluation of the performance objectives of our present day secondary school curriculum would lead to a substantial reorganization of the objectives. It is possible, even likely, that there are wasteful redundancies in teaching the same or similar objectives in several fields.

More important than redundancies, however, are the gaps. That is, there are important educational objectives which are assumed to be taught somewhere in the curriculum but, in fact, may not be taught anywhere. There may be essential educational goals and objectives which have fallen through the cracks one finds between disciplines. In the interest of efficient learning, it may be more sensible to reclassify certain of the objectives into new groupings that are independent of the disciplines from which they were originally derived. For example, the basic principles of science may be better taught to some students in an industrial arts or a home economics setting than in the science class.

Classification of Performance Objectives

Considerable attention has been given by educators to classification strategies and educational objectives.[5] These taxonomies have sometimes been developed independent of a careful and complete analysis of the objectives. A more logical and scientific approach to building a taxonomy would be to first define all or as many as possible of the performance objectives in our present-day curriculum, then carefully evaluate and classify these objectives. The taxonomy would then be derived from this analysis, grouping objectives in terms of learning process or problem-solving skills.

Not all learning "outcomes" can be defined in terms of specific observable behaviors. A large part, however, can and should be objectified.

---

[5] Much of the remainder of this paper draws heavily upon the writings and thinking of Dr. Bruce Tuckman, Rutgers University, who is presently directing Project SCOPE.

The following steps are suggested as a procedure for systematically reordering the traditional subject matter into a more "organic" curriculum:

Step I - Development of Objectives by Subject Matter Groupings

It is essential that discipline scholars, classroom teachers, curriculum supervisors, and behavioral technologists be trained to work together in this initial phase of specifying performance objectives. Writing performance objectives is a demanding technology and a skill in short supply. A team effort requires a number of specialists who, nevertheless, have a common understanding of the procedures involved and commitment to the operationalizing of instructional objectives by subject matter groupings.

Step II - Analysis and Integration of Objectives

The second phase requires the analysis and integration of objectives independent of the originating disciplines. Two centers[6] have recently been set up with USOE funds to inventory, classify, synthesize, and refurbish performance objectives for operating schools. It is hoped that both will independently achieve an empirically sound classification scheme to be employed in the subsequent redesign of curriculum materials.

The types of services to be performed in the coordination and synthesis of performance objectives should be as follows:

1. Receive sets of performance objectives in various subject matter areas and alter the language employed, when necessary, to guarantee that each is truly "behavioral." In accomplishing this, a glossary of behavioral words such as the following could be used:

   a. identifying
   b. distinguishing
   c. constructing
   d. naming
   e. ordering
   f. describing
   g. stating a rule
   h. applying a rule
   i. demonstrating
   j. interpreting

---

[6] The first Center is under the direction of Dr. Bruce Tuckman at Rutgers University. The second Center is located at UCLA under the direction of Dr. James Popham. For a more complete discussion of the role of the second Center, see Popham, W. James, "Focus on Outcomes-- A Guiding Theme of ES '70 Schools," Phi Delta Kappan, Dec., 1969.

By using a constant vocabulary to describe the "behavior" called for in an objective, one achieves not only greater standardization, but one builds in an automatic basis for coding and classifying.

Thus, the first task will be to "clean up" the objectives and apply a constant "behavior language." This will entail not only the reproduction of a multitude of objectives on cards and storing them, but also <u>coding</u>. The first task will also include the refinement and complete description of the action word glossary.

2. Code all behavioral objectives. Two reasons support this procedure: (a) a cataloging device is needed which will provide for easy retrieval; (b) a way of reexamining and reorganizing the objectives along different lines of commonality is needed to serve as a basis for curriculum building or revision.

   Two coding systems need to be built into the objectives. The first is the level of generality of the objective as seen by the writer of the objective (e.g., 1.11 Science, Physics, Ohm's Law). A subject-matter classification scheme — using three or four levels of description — needs to be developed and used by the subject-matter specialists. Second, a glossary of behavioral terms, described above, need to be developed and refined and used to classify each objective.

3. Classify each objective in terms of the process or activity described and the object of the process. This scheme has some similarity to the Bloom Taxonomy,[7] but will differ in being two-dimensional rather than unidimensional. The classification of performance objectives by subject matter areas while only an intermediate step should have immediate value for teachers and curriculum planners throughout the country. An example of such a classification scheme might appear as follows:

	OBJECT				
PROCESS	1 Symbols	2 Ideas	3 Things	4 People	5 Self
1. Perception					
2. Conceptualization					
3. Application					
4. Evaluation					
5. Manipulation					

---

[7] Bloom, Benjamin S., <u>Taxonomy of Education Objectives</u>, New York; David McKay Co., 1956.

A MANPOWER DELIVERY SYSTEM: IMPLICATIONS FOR CURRICULUM DEVELOPMENT

Robert G. Smith, Jr.
Human Resources Research Organization (HumRRO)

Introduction

Once you have become infected, as I have, with system thinking, you develop some special habits. You begin thinking about purposes, about functions to carry out those purposes, and about interrelationships among the functions. But especially you tend to believe that the overall context of a matter is important.

Following this belief, I plan to present a simplified and abstract model of a manpower delivery system. I hope that this model will enlighten our later discussion by providing a suitable context for the translation from the military problem to the civilian problem.

The features of this model have been suggested by a study of the report of planning for the State of Pennsylvania by Arnold (1969).

Occupational Demands

In Figure 1 is shown one of the major components of the manpower delivery system. These are a set of occupations. The reader should think of the block of occupations as representing a time line and changes in occupations in accordance with various trends. For instance, at the top we see an occupation represented which has a relatively small requirement, but a requirement which is expected to be stable over the next several years. Moving down the block we see an occupation that has a larger requirement right now, but one which is declining in demand. Next, we see an occupation which has a fairly small demand at the present time, but whose demand is expanding. At the bottom of the occupation block we see a representation of an occupation with a large and stable demand.

From this Figure it is clear that when we consider the implications of both stable and changing demands, we must develop information concerning the overall economic predictions for the industries in which these jobs occur, and we must also be very much concerned with changing demands for various kinds of occupations.

Educational and/or Training Institutions

Figure 2 adds the next major group of components to the system. Here we have a set of educational or training institutions whose purpose it is to provide manpower to the various occupations. Again, it seems reasonably obvious that the educational and training facilities should have a quantitative relationship with the demand for occupations. Thus, if the occupations are decreasing, the education or training institutions should decrease their output. If the occupational demand is increasing, then the education or training institutions should increase their flow. Of course, it is probably easier to start new courses than it is to stop or reduce existing ones.

In addition to these quantitative considerations, analyses should be made of the occupational demands in a qualitative sense to determine what kinds of performances they will demand of the people who enter them. This is what will determine the objectives.

Guidance

In Figure 3 we add some additional features to our model. The first of these is guidance. By guidance I refer to the activities of attempting to provide some reasonable match between the characteristics of the individual student, the demands of various occupations, and the educational barriers which must be crossed before the individual can enter into his preferred occupation.

If the term guidance is too directive for some readers, they might wish to substitute the term counselling for it.

The guidance activities represent a relatively long-range method by which quantitative adjustments could be made to adjust the flow of personnel entering various occupations to the long-range trends for that occupation. At the same time, it would attempt to insure a reasonable degree of success for the individual during the training or education for the occupation, as well as success and satisfaction in the occupation itself.

Among the activities which I would lump under the function of guidance would include: the measurement of student aptitude and interest; both general introductions to the world of work, and specific introductions to the particular occupations the student is interested in, and the charting of an educational path which will help the student to enter his preferred vocation or profession.

Placement

If guidance represents the long-term adjustment of the system to the changing demands of various occupations, placement represents a relatively short-term adjustment. It refers to those methods by which a match is obtained between the vocational or professional graduate and the occupation. Placement would include such activities as those of the state or federal employment services, the activities of educational institutions themselves, and the activities of the individual himself.

A number of studies have shown that most people find their own jobs, perhaps with help from friends or family, rather than using governmental or educational placement activities. This suggests that instruction in job seeking could be very useful.

I remember when I was a budding new Ph.D. no one told me about the placement activities by which psychologists obtained jobs, such as the hiring halls at the professional meetings. I obtained a job through one of my professors. It was an excellent position, and a very interesting one. I don't regret having taken the job, but I have sometimes wondered whether I would have taken it if I had had a broader range of choices from which to look.

Barriers

There are a great many occupational barriers which lie between the educational or training institutions and entry into the occupation. Examples of barriers would be various kinds of licensing requirements (often with little relevancy to job success) and union membership, especially if the union has a policy of restricting membership.

Some of these barriers may be very relevant ways of assuring that only qualified people enter the occupation. Other barriers may be highly irrelevant. For instance, city government jobs may have the requirement that the person have lived in the city for a given length of time. This would restrict the possibilities for employment of someone who was a resident of another place.

It seems reasonably obvious that whatever barriers exist should be identified, and the appropriate action taken to be sure that the student will not encounter a barrier in his progress through the system.

The existence of barriers also has implications for the evaluation of vocational education programs. These programs frequently are evaluated in terms of the number of students placed. If we have a very effective educational institution from the standpoint of imparting the necessary job skills but yet the student cannot get past a barrier, this is not a suitable way of evaluating the excellence of the instruction. At the same time, it does suggest that the system needs to be looked at from the standpoint of making sure that the barrier is actually necessary, or that only those students who could get by the barrier are being guided into the appropriate educational programs.

Information Flow

Figure 4 now completes the model by adding arrows which represent the needs for information flow between the various parts. For instance, information from the various occupations is needed by the planners of educational and training programs so that the size of various programs can be adjusted to changing demands of the world of work, and so that qualitative trends in occupations can be reflected in the educational objectives. Information from the occupations is also needed by the guidance activities. The information needed by the guidance activities is clearly of a reasonably long-term nature. It should include some consideration of the aptitude requirements of the occupation or its educational counterparts, as well as the early special characteristics of the occupation that would be of interest to students and the long-range quantitative trends in the occupations.

There is also a requirement for the placement activities to obtain information concerning job vacancies and related information of a short-range nature in order to carry out the placement activities in an efficient manner.

There clearly is a requirement for the guidance activities to provide feedback to the education and training institutions on the characteristics of prospective students.

This model has been an abstract and rather generalized model but it does serve the function of pointing out to educational and training planners the principal things to look at when conducting a system analysis for vocational or professional education. Obviously, the specifics may vary from one state to another, or from one employment area to another. Yet, the general points should be similar.

REFERENCE

ARNOLD, Walter M. Vocational and Continuing Education in Pennsylvania: A Systems Approach to State-Local Program Planning. Pennsylvania Department of Public Instruction, 1969.

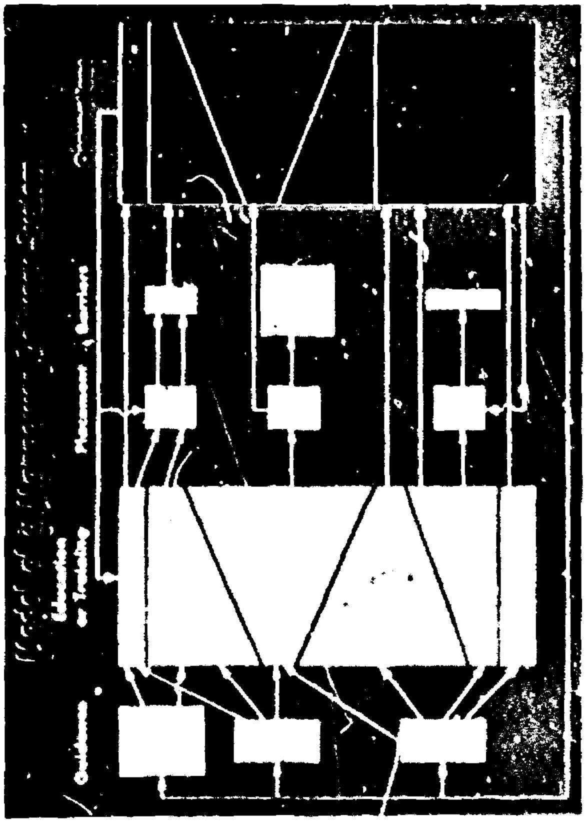


Figure 1

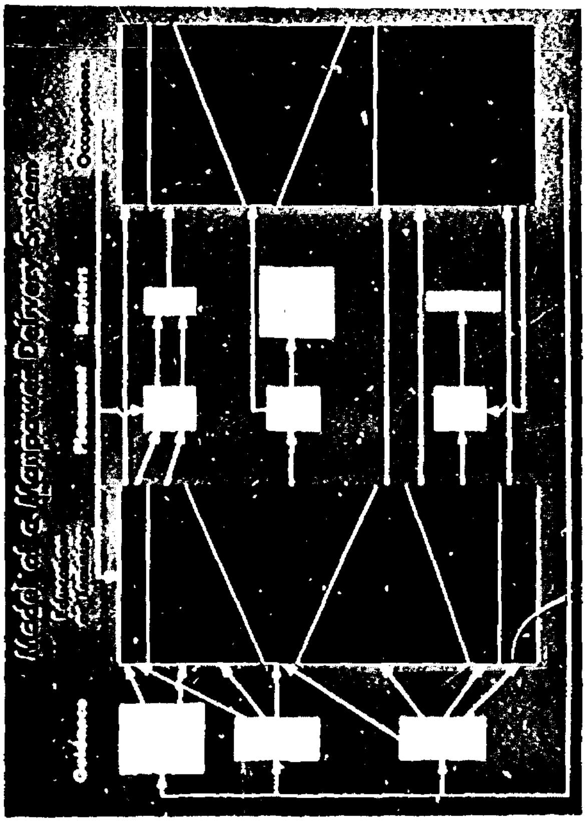


Figure 2

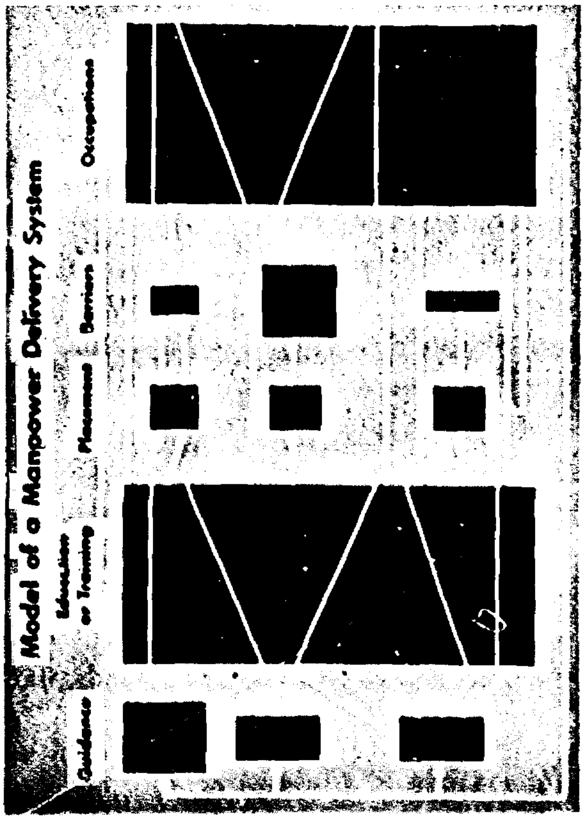


Figure 3

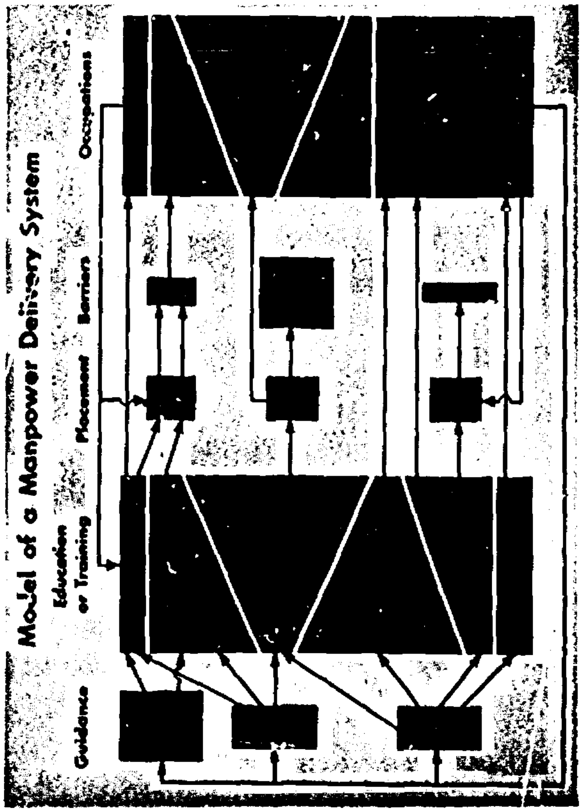


Figure 4

IMPLICATIONS OF AIR FORCE OCCUPATIONAL RESEARCH FOR CURRICULUM DESIGN

Raymond E. Christal, Chief
Occupational and Career Development Branch
Personnel Research Division (AFHRL)
Lackland Air Force Base, Texas

Introduction

For the past twelve years, the Occupational and Career Development Branch, of the Personnel Research Division (AFHRL), at Lackland Air Force Base, Texas, has been developing methods in such areas as job analysis, job evaluation, work organization, career planning, reassignment systems, performance evaluation, and job requirements. We are concerned with the study of individuals after they leave technical training schools, and we give particular attention to the occupational framework within which these individuals function. Our research has already had a significant impact on technical school curricula, and we are currently undertaking the development of methods for translating occupational information into a form specifically designed to help individuals who are responsible for curriculum definition. I will discuss this work in some detail. I will also describe two mathematical models which we have found to be very useful in our research, with the hope that they may be of some value to you.

Factors Affecting Curriculum Definition in the Military Services

Before getting into the main discussion, let me pinpoint some factors that make curriculum definition in the military services a little different than it is in the civilian sector.

First, a majority of individuals entering the services have already graduated from secondary school.

Second, most of the technical training courses given by the military services are of short duration — usually covering a period of between eight and fifty-two weeks.

Third, when a man in the service is sent to a technical training school, the decision has already been made that he is being trained to perform work in a particular occupation. Except under unusual circumstances, this decision is not subject to change. I am led to believe that occupational choice for those entering vocational and technical training in the civilian sector is not nearly so stable or specific.

Fourth, in the military services we do not have to protect individuals against their skills becoming obsolete. If a type of job disappears from the inventory, the military service foots the retraining bill, and the individuals involved suffer no loss of pay.

Fifth, the services often have years of advanced warning before jobs are established requiring new occupational skills. For example, curriculum experts begin planning courses to support a new weapon system while the new system is still on the drawing board.

Finally, technical training for service personnel does not end when they leave the school setting. They receive formalized on-the-job training, and they return to school for advanced training when such training seems warranted.

I would judge that all of these factors tend to make curriculum definition a little easier for those in the services than it is for those who work with vocational and technical high schools. But I would not want to leave you with the impression that the military services have the curriculum problem licked. Far from it. Data collected during the last several years make it apparent that problems associated with "what to teach" are as critical as problems associated with "how to teach," even in the military services.

Military Needs for Job Information

Let me describe the situation a little more precisely. I'll use the Air Force for purposes of illustration.

In the Air Force, there are about 800,000 enlisted personnel performing thousands of different types of jobs at hundreds of locations throughout the world. Each of these jobs has been established by some local commander who can, within limits, assign work to men any way he sees fit in order to accomplish his mission. It is the function of the Air Force training establishment to provide individuals with the knowledges and skills they will need for performing the jobs they will encounter. This means that the local commander needs some way to communicate the nature of the jobs he has established to trainers. Until recently, his only means for communication was through the assignment of a five-digit specialty number to each job, classifying it into one of approximately 250 career ladders, at the apprentice, journeyman, first-line supervisor, or superintendent level. This system is grossly inadequate, because it does not provide information at a sufficient level of detail for curriculum designers. In the first place, there are many more types of jobs than there are specialty numbers. New jobs are constantly being created in the field, but they nevertheless must be classified into the existing classification structure. Individuals who are responsible for the classification structure would like to maintain an appropriate classification code for each job, but they have no more information than the trainers about the nature of jobs being assigned to personnel. Individuals maintaining the classification structures and those maintaining course curricula each have to depend upon complaints from the field for indications that the system needs modification. The training command has course evaluation teams which visit a few organizations to talk with supervisors about the problems being encountered by course graduates; but this type of inquiry is both expensive and extremely limited in terms of the kind and amount of information yielded.

Because of this serious lack of information, the first goal we established for our occupational research program was to develop techniques by which the Air Force could collect more detailed and specific information about the jobs being assigned to personnel. We finally settled on a technique involving the administration of job inventories to workers in the field.

Description of Job Inventory

Now let me describe a job inventory to you. It contains two sections. The first section consists of background questions to be answered by a worker about his job and himself - - - questions relating to previous education, time-on-the-job, tools utilized, equipment worked on, interest in job, pay grade and so on. For an inventory being administered to civilian employees, one might wish to collect information about union membership, working hours, size of organization, products manufactured, and job location. Any questions can be included in the background information section of an inventory which will help answer questions about the occupational area.

The second section of a job inventory is simply a list of all of the significant tasks performed by workers in the vocational area being surveyed. That is, it includes tasks being performed by apprentices, journeymen, first-line supervisors, and superintendents in a single occupational area, such as automotive repair, firefighting, or metal working. If this task list is properly constructed (and this point is important to understand), then every worker in the occupational area should be able to adequately define his job in terms of a subset of tasks in the inventory.

In the Air Force we normally administer an inventory to several thousand workers in the heavily populated career ladders, and we attempt to obtain 100% samples in the less populated areas. A worker fills out the background questions, checks the tasks he performs, writes in any significant tasks he does that are not on the list, and indicates how his worktime is distributed across the tasks in his job. These data are sent to a central agency for computer analysis.

Advantages of the Job Survey Approach

Before I describe how we make use of this information, let me mention some of the reasons why we like the job inventory survey approach. First, the technique is economical. Data can be collected from thousands of cases throughout the Air Force for less than it would cost to collect data from a few cases using professional job analysts. Second, the information is quantifiable. That is you can actually count the number of people performing any given task, and describe their characteristics. Note that data collected by job analysts are not quantifiable. No two analysts will describe a job in exactly the same terms. The fact that information collected with task inventories is quantifiable means that it can be stored, manipulated, analyzed, and reported by computer. The fact that it is quantifiable also means that it can be subjected to research — that is, it can be validated and checked for stability using conventional statistical techniques.

This is all well and good, but the $64 question is whether individual workers are honest and conscientious when they fill out job inventories. Is the information they provide of good quality?

We feel satisfied that the answer to this question is "yes" — at least as far as Air Force enlisted personnel are concerned. We know that when a worker fills out an inventory on two occasions, he gives essentially the same information both times. Split-half correlations for information such as the percentage of employees performing each task run in the neighborhood of .95 to .99. Supervisors agree with the information provided by their subordinates. Information collected with daily work records is consistent with information collected with inventories. Workers do not inflate their job descriptions in terms of the number or difficulty levels of tasks reported. There is a high probability that significant tasks missing from the inventory will be written in by workers who perform them. In short, we feel that the technique yields information of good quality.

Analysis of Job Survey Data

Once we have collected occupational information from a large sample of individuals, the resulting data are fed into a computer. A record is generated for each individual case which contains his identification information, his answers to the background questions, and the amount of time he spends on every task in the inventory. Thus, we generate a bank of information describing the individuals and jobs in one occupational area.

In the time we have I cannot begin to describe the ways in which we analyze this occupational information to serve the needs of Air Force managers. We have developed a comprehensive set of computer programs, called CODAP, which is in essence an occupation information retrieval system. It contains dozens of programs, each designed to analyze occupational data to provide a manager with the information he needs for making a particular type of decision. What I propose to do is to describe a few of the outputs which are normally obtained by individuals responsible for training courses in the Air Force, and to indicate how these outputs have influenced curriculum design.

Consolidated Job Descriptions

The first program, which is simple but extremely useful, enables the investigator to produce a consolidated description of the jobs being performed by any group of workers of interest. For example, one might wish to see a description of the jobs performed by individuals in a given geographical area who repair a particular type of equipment, and who have been on the job less than one year. A consolidated job description can be obtained for any group of workers which can be defined in terms of information in the background section of an inventory.

Appendices I and II present typical duty and task descriptions, which I often use as examples, since they cover an occupation existing in all services as well as in the civilian sector. They describe jobs of journeyman medical laboratory technicians, working in hospitals and clinics throughout the Air Force.

Let's spend a little time studying the data in Appendix II. Every task performed by journeymen laboratory technicians is listed. The first task reads "collect blood specimens directly from patients." In the first of the four columns of numbers you will observe that 93.4 percent of these workers perform this task as part of their normal job. The second column indicates that the individuals who perform this task spend about 1.7 percent of their worktime on it. In the third column, we find that about 1.58 percent of the total worktime available to journeymen technicians is spent on this activity. If you were to sum the values in this third column across all tasks on this job description, the total would be 100 percent, since every task performed by any journeyman is listed. Cumulative times are shown in the fourth column, so you can see that the tasks on this first page account for about 38.56 percent of the total worktime available to the group. Finally, you will notice that the tasks are listed in order of the time spent values in the third column.

Use of Consolidated Job Desciiptions in Curriculum Design

Now let's look at this job description with a view toward curriculum design.

The first column of values is of special concern. It reports the probability that a journeyman in this occupation will be required to perform each of the tasks listed. You will observe that the tasks appearing on this first page are encountered by 70 to 90 percent of journeyman medical laboratory technicians. In the Air Force, an entry level course would include training on these tasks. Now look at the last page of the job description. Here you will observe tasks which are encountered by very few journeymen. Consider for a moment task M 35, which is concerned with conducting vitamin assays. Only about one percent of the journeymen are asked to perform this task, and even these cases spend only about one-half of one percent of their worktime on it. The question is whether one can afford to train everyone going into this field to perform a task which is so rarely encountered. In this instance, as far as the Air Force is concerned, the answer is "no."

Now look at the last task in the job description. First, let me point out that this is a poor task statement. Unless one is concerned with a work area where operating equipment is the primary mission, information regarding equipment utilized should be collected in the background section of the inventory. The task list should be made up of statements describing the functions performed. Thus, this last statement should have been worded "make radiation counts," rather than "Use Geiger-Mueller Equipment." Be that as it may, here is a task which probably should be included in the entry-level course —— even though the probability that a journeyman will encounter the task under normal conditions is extremely low. If we were ever subjected to an atomic war, someone had better be around who knows how to make and interpret radiation counts.

Example Job Description for a Heterogeneous Occupation

Now look at Appendix III, which presents the top few tasks in a job description for Disbursement Specialists in the Accounting and Finance area. In particular, I would like for you to run your eye down the first column of values, which reports the percentage of journeymen who are assigned to perform each task listed. You will notice that there are only three or four tasks that are being performed by as many as one-third of the workers in this occupation. If you were to see the rest of the description, you would find that most of the tasks existing in this occupation are being performed by fewer than two or three percent of workers at the journeyman level. This makes it very difficult to design a cost-effective training course for individuals entering this field. If you were to teach individuals all of the tasks which they might encounter, they could be expected to utilize less than ten percent of what they were taught.

I suspect that this is a problem often faced by those responsible for designing the curricula for vocational and technical training courses in the civilian sector. Obviously one could not teach students who want to become electronic technicians every task which they might encounter on-the-job. Nor could one establish separate courses for every type of job in the electronic technician area to which subsets of students might aspire. Some compromises must be made. This problem will be addressed later.

Identification and Description of Job Types

By looking at the Disbursement Specialist description, I can tell that the average individual only performs a small number of tasks out of the large number of tasks in the occupation. However, I can't tell by studying the description whether there might be some sizeable clusters of individuals who perform similar jobs. Since the occupational data bank contains a description of each individual job, there should be some way of computing the similarity of every job with every other job, clustering similar jobs, and printing out a description of each job cluster. We have developed mathematical models and written computer programs to do just this. These programs are highly sophisticated, and I will not have time today to describe them in detail. We often begin with a matrix of 4,000,000 overlap values, reflecting the similarities among a sample of 2,000 individual jobs. The clustering program groups jobs into four and a third billion configurations and evaluates each of these configurations in the process of arriving at the best definition of job clusters. When we applied the clustering program to jobs in the Accounting and Finance area (which includes Disbursement Specialists), we found that most of these jobs fell into one of 55 job types. These job types, in turn, could be grouped into a limited number of job clusters. For purposes of illustration, I have included the top few tasks from a sample of these cluster descriptions in Appendices IV through VIII. Now keep in mind that all of these clusters are currently considered to be in the same occupation, as far as the Air Force is concerned. This means that all individuals going into these job clusters take the same training course.

It is obvious that individuals working in the first cluster of jobs (Appendix IV) are processing military pay records in a computer shop. They receive records in batches, punch information or prepare tapes which are processed by computer. Eighty-seven percent of the individuals actually operate computers.

Individuals in the second major cluster (Appendix V) are spending full-time performing paying and collecting functions. There is essentially no overlap between the tasks performed by those working in the military pay computer shop and those performing the paying and collecting function.

The next cluster (Appendix VI) brings together individuals who work full-time processing travel pay claims. Again, the jobs performed by these individuals have little, if any, overlap with the jobs performed by individuals in the previous two clusters. By studying the first column of this job description, we can see that the jobs within the travel pay cluster are not very homogeneous. This is because there are several types of travel pay jobs reflected in this single cluster description.

The next cluster (Appendix VII) describes military pay clerks. Not the ones who work in the computer shop, but those that work in the main office. Again, this very large cluster contains a number of job types.

Finally, Appendix VIII presents an isolated job-type which includes a number of individuals who spend most of their time handling civilian pay functions.

Now notice the number of cases in each of the clusters. There are 401 cases in the military pay cluster and 102 cases in the computerized military pay cluster. However, there are only 14 cases in the civilian pay cluster. This means that the ratio of jobs associated with military pay to those associated with civilian pay is roughly 36 to 1; yet, at the time we conducted the survey, civilian and military pay functions were receiving about equal emphasis in the Air Force Career Development Training Course for Disbursement Specialists.

Identification of Training which can be Reduced or Eliminated

This brings us to a major point. When we first began comparing inventory results against training courses we felt that the most important contribution would be the identification of critical tasks which were not being sufficiently emphasized in the curriculum. Such was not the case. The hardest information to come by is the identification of tasks being trained for which incumbents are unlikely to encounter on the job. Trainers can ordinarily determine where additional training should be given, through the use of training evaluation teams and user surveys. However, it is extremely difficult for them to identify training that can be safely eliminated or reduced. An individual incumbent will recognize that he was trained on many tasks that he is not performing; but he doesn't know how many other men in his occupation in other jobs at other locations might be performing these tasks. There is no reason for him or his supervisor to raise a question about the tasks being trained for, which are not being encountered at a given location. Fortunately, this is one place where job inventory results pay off. They report the exact probability that incumbents will encounter each task in the work world.

Generalizing to the civilian sector, one could raise a question as to whether as much energy is spent identifying training which should be reduced or eliminated as is spent uncovering new subject matter to be introduced. Has every course been scrubbed to eliminate deadwood and obsolete subject matter? I cannot answer this question. But I can state that the Air Force is currently saving millions of dollars each year as the result of eliminating course content which job survey results have shown to be obsolete.

Other Job Survey Data Analysis Programs

I have described how occupational data collected with job inventories can be analyzed to produce a consolidated description of work being performed by any specified group of workers, and also how they can be analyzed to identify and describe the types of jobs existing in an occupational area. Another program is available which will compute and present a detailed description of the background information available for any particular group. Provided such questions are included in the survey questionnaire, the report will summarize salary data, union membership, job satisfaction, educational background, tools utilized, equipment worked on, travel required, number of individuals supervised, or any other data collected.

Another program will produce a description of the differences in work being performed by any two specified groups of workers. For example, one might wish to know the differences in the types of jobs being performed by graduates from vocational high schools and graduates from academic high schools, who are working in a given occupational area, and who have been on the job less than two years. The CODAP system contains a program which will compute separate descriptions for the two groups under consideration, compare their jobs, and present a consolidated description of the differences in work being performed by the two groups. The top and bottom part of an example difference description is shown in Appendix IX.

Perhaps curriculum designers would like to study career progression in a particular occupational area. A program is available which computes the percentage of individuals at each experience level performing each task and presents this information in an easy-to-read format. In the Air Force, we have found that training should be timely, if cost effectiveness is a consideration. A vocational or technical school in a civilian setting may wish to center its curricula on those tasks which individuals are likely to encounter during their first few years on the job. This same retrieval program can be used to display the percentage of individuals in each of several industrial settings who perform each task, or the percentages of individuals in each of several geographical areas performing each task.

The CODAP system also can compute and display individual job descriptions or a series of individual job descriptions meeting the requestor's specifications (See Appendix X). It will compute and report the total time spent by any specified group of individuals on any specified group of tasks. Provided the appropriate task difficulty indexes are available, the CODAP system will compute the difficulty level of each job surveyed. This is accomplished using a "policy" equation to be described later. Numerous other programs are available within the CODAP system, each of which is designed to organize and report occupational information desired by the user.

Adoption of the Job Inventory Survey Approach by Other Agencies

In the Air Force, we have already collected and analyzed occupational information from nearly 150,000 incumbents using the job inventory survey approach. Similar systems have been implemented by the Army and Marine Corps, and the Navy and Coast Guard are finalizing plans to go in the same direction. The Canadian Forces have surveyed about half of their occupational trades, and the Australian Forces are sending a representative to spend two years with the US Air Force studying the system for possible application in that country. It seems fairly obvious that there is a rapidly growing movement in the direction of establishing occupational data banks using job inventories, and I predict that this movement will soon take hold in the civilian sector.

Unfortunately, I know of no plans currently being made by the Department of Labor for setting up computerized occupational information data banks at the task level. However, a number of agencies are conducting surveys of specific occupations as part of research projects sponsored by the Federal Government. In some instances, curriculum development for technical training is an explicit goal for such projects. Provided one could obtain the necessary cooperation from employers, it would be feasible for one or more states to survey individuals in certain occupations in the geographical region serviced by their vocational and technical schools. The resulting data could be used for many purposes, including curriculum design.

Problem of Task Sampling in Curriculum Definition

Of course curriculum design is an art that involves consideration of more than a description of jobs being encountered by graduates of training programs. But such information cannot be neglected. In the Air Force, we have discovered that courses built in the absence of good occupational information sometimes have done a poor job of preparing individuals for the work they are later assigned to accomplish. We are convinced that occupational surveys conducted with job inventories provide the most useful data for curriculum design for the least money expended.

The complexities of curriculum design are not to be underestimated. Even when good information about job content is available, the translation of such information into curriculum statements is a very complex matter. Even in the Air Force, we cannot teach an individual to perform every work task he may encounter in a specific occupation. In the civilian setting, one is often faced with preparing individuals for a family of trades. Since only a small subset of tasks can be included in the curricula, the problem of selecting the best sample of tasks becomes critical. Some of the factors which might be considered are the following:

(1) The probability that the task will be encountered by the student at various time periods after graduation. Assuming occupational stability, this factor can be obtained directly through administration of job inventories to present incumbents.

(2) The perishability of the skill. It is particularly important not to waste time teaching skills which are highly perishable, unless students are likely to make use of such skills soon after graduation.

(3) The cost effectiveness of teaching the task in the formal school setting vs. teaching it in the job setting. Some tasks can be easily taught on the job. When school time is limited, these tasks are best left to be learned on the job.

(4) Frequency of inadequate performance.

(5) Consequences of inadequate performance.

(6) Probability that the task will have to be performed in an emergency situation. (This is a critical factor in occupations such as firefighters and medical personnel who service disaster situations).

(7) Transferability of the skill (this is a difficult factor to measure).

(8) Trainability of the skill. (Some skills are better obtained through selection than training).

The above list of factors for consideration is intended to be suggestive rather than exhaustive. Assuming that all tasks in an occupational domain were measured on such factors, the problem of task selection is still formidable. For example, in maintenance areas, such as electronic and automotive repair, students must be taught how to use test equipment and the tools of the trade. One must make sure that tasks are selected which serve as good vehicles for training students in the use of such equipment. Some tasks provide a better framework than others for teaching theory. If theory is to be taught (some would argue that it should be given little emphasis) then this factor must be considered in task selection. It also might be desirable to establish some type of stratified sampling strategy so that the tasks which are selected cut across the job types which are determined to exist in the occupational domain.[1]

It soon becomes obvious that the problem of task selection is so complicated that there is no hope of an optimal solution unless the factors to be considered are specified and the data to be weighed are quantified. To give the appropriate weight to all factors would probably require computer manipulation of data using sophisticated mathematical models. Vocational teachers could play a large role in defining factors and weights, but the final selection of tasks could probably best be accomplished by professional curriculum designers who are quantitatively oriented.

It should be observed that quantification of data does not eliminate judgment from the process. It simply makes the application of judgment more systematic.

Description of the Policy Capturing Model

This brings us to one of the mathematical models I promised to discuss. It is called JAN (Christal, 1968) which stands for Judgment Analysis. JAN has been used by the Air Force to quantify policy in many programs. For example, it has been used to establish: (1) job evaluation equations; (2) job difficulty equations; (3) the new Weighted-Factor Airman Promotion System; and (4) the Automated Airman Assignment System. In each instance we were able to express policy judgments in the form of mathematical equations.

The concept of capturing policy with an equation is described in a paper entitled "Selecting a Harem — And Other Applications of the Policy-Capturing Model (Christal, 1968). This paper included a short fable which

---

[1] The problem of organizing tasks into a logical sequence for instructional purposes is not considered in this paper, although it is recognized as a major requirement in the curriculum design process.

seems to do a reasonable job of communicating the nature of the basic model. It is therefore quoted in full, below:

> Once upon a time, there was an Oriental king who was concerned as to how he might make a name for himself in history. "I know," he said, "I'll select a harem larger than King Solomon's."
>
> So the word went out, and soon thousands of young girls were arriving from the various provinces to seek the king's approval.
>
> Early one morning the king began his selection process. As each girl filed by, he looked her over carefully and then expressed his judgment.
>
> "Excellent!" he would say. "This one is very pleasing to my eye." Or perhaps he would hum and haw with indecision. Many times he would show his disapproval in no uncertain terms. "Never!" he would say. "Pass on! Pass on!"
>
> In each instance, the Court Recorder attempted to quantify the king's degree of approval by checking the appropriate level on a 9-point scale which had been devised especially for the occasion by the Chief of the Royal Psychometricians.
>
> By suppertime the king had considered some 300 girls. His eyes and his imagination were beginning to tire.
>
> "Most High First Counselor," he said, "you've been watching me all day, and by now you should know my likes and my dislikes. I've decided to leave the selection of my harem in your hands. But take care! If your choices do not please me, it will be your head!"
>
> After the king retired, the Most High First Counselor summoned the Chief of the Royal Psychometricians. "I'm passing the job on to you," he said. "If you fail to please the king, your head will roll along with mine."
>
> The Chief of the Royal Psychometricians called his staff together and explained the situation.
>
> "We must not fail," he said, "or it will be all of our heads."
>
> "How shall we proceed?" asked one of the young staff members who was fresh out of the Royal Academy.
>
> "Well," responsded the Chief, "we know how the king rated the first 300 girls. Right?"
>
> "Right!"
>
> "And we can see everything the king saw when he looked at the girls. Right?"
>
> "Right!"
>
> "Then all we have to do is to uncover the girly characteristics considered by the king and determine how he weighted them in his judgment. This is a natural for the Multiple Linear Regression Model." (See Bottenberg and Ward, 1963)
>
> "But how do we know which characteristics he considered?" asked the neophyte.
>
> "We don't, you fool! Didn't they teach you anything in that school? That's what the regression model is for. If a girly characteristic adds to our ability to predict the king's ratings, we may assume he gave it consideration. Now let's get on with the business."
>
> "How about height?" asked one of the staff members. "Does the king like short girls or tall girls?"
>
> "Neither," replied another. "I would guess that the relationship between height and the king's preference is curvilinear. Some girls are too tall, while others are too short."
>
> "Well," responded the neophyte, "if the relationship is curvilinear, then we cannot use the linear regression model. If we were to plot the curve between height and acceptability, I think we would find it to be parabolic."
>
> "They really didn't teach you very much in that school, did they?" commented the Chief. "What is the general equation for a parabola?"
>
> "$aX^2 + bX + c$," responded the neophyte.
>
> "Bravo!" declared the Chief. "Now let X be a vector of heights. If we square each value in the height vector, we generate a new vector X^2. Now if we introduce these two predictors in the regression model, what will be the form of the resulting equation?"

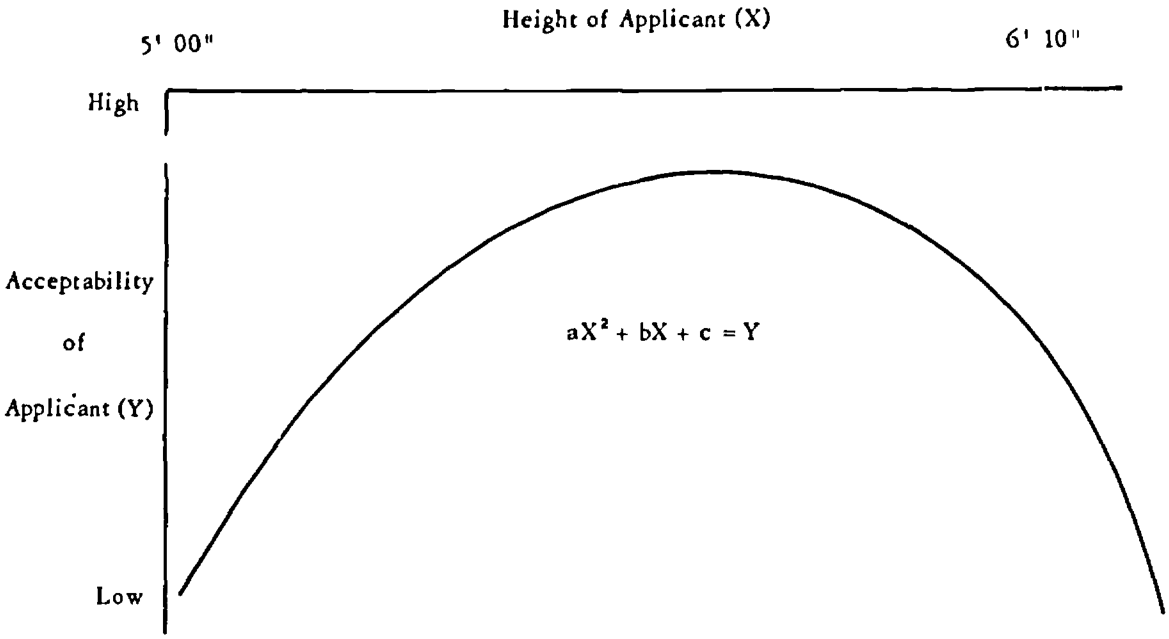


Fig. 1. Relationship between applicant height and judged acceptability.

"aX^2 + bX plus the regression constant c," replied the young man.

"Simple, isn't it?" responded the Chief. "You see, there's no problem in fitting curvilinear relationships with the linear regression model as long as the proper power terms are introduced as predictors. The linear restriction is on the weighting system, not on the form of the predictors." (See Figure 1.)

"How about eye color?" asked one of the other staff members who was eager to move on. "I'm sure the king looked at the color of each girl's eyes."

"Fine," said the Chief, "we will consider eye color in our equations. Since eye color is not an ordered variable, we must introduce a separate categorically coded predictor for each color."

"What the Chief means," whispered one of the staff members to the neophyte, "is that for a variable associated with a particular eye color, each girl will be assigned a value of 1 if her eyes are that color and a value of 0 if her eyes are not that color."

"It's been my observation," said one of the group, addressing the Chief, "that the king likes blue eyes on blondes, but not on brunettes."

"That's easily handled," responded the Chief. "First we will introduce categorical predictors for each hair color, then we can cross-multiply eye-color and hair-color variables in order to generate the approximate interaction predictors." (See Table 1.)

"I thought," said one of the group, "that the regression model assumes the predictors to be normally distributed, and also that their joint-distribution is normal. We certainly can't meet these assumptions using powered terms, interaction terms, and categorically coded predictors."

"You're right," said the Chief, "if you're thinking about the multi-normal model. But we're going to use the fixed-X model, which does not involve those assumptions. We would be stupid to restrict ourselves to normally distributed predictors. It would force us to omit most of the variables which we know the king considered."

"But," objected the staff member, "if we use the fixed-X model, we cannot generalize beyond the computing sample."

"Who can't?" responded the Chief. "Let's not assume our equation will fail to hold up just because our predictors are not normally distributed."

"Well, I'm from Outer Missourivich," said the staff member.

"Very well," replied the Chief, "if it will make you feel better, we will develop our equation on the first 150 girls rated by the king, and then check how well the equation predicts his judgments of the remaining 150 girls."

And so went the conference into the wee small hours of the morning. Over 100 predictors were eventually defined, each representing a girly characteristic which might have influenced the king's judgments. The time had now come for the acid test. Could they produce an equation which would simulate the king?

Table 1. Examples of Categorically Coded and Interaction Predictors

	Predictor Vectors						
Applicant Number	X_1 Blue Eyes	X_2 Brown Eyes	X_3 Brown Hair	X_4 Blonde Hair	X_5 $(X_1 X_3)$	X_6 $(X_1 X_4)$	X_7 $(X_2 X_3)$
1	1	0	1	0	1	0	0
2	0	1	1	0	0	0	1
3	0	1	1	0	0	0	1
4	1	0	0	1	0	1	0
5	0	1	0	1	0	0	0
6	1	0	0	1	0	1	0
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
N	1	0	1	0	1	0	0

Some of the royal guards had to be called in to help measure and evaluate each girl on the predictor variables. It was a madhouse with 20 guards checking eye colors, weighting, and measuring the 300 girls.

By late afternoon, the raw data had been accumulated. All that night and throughout the next day and night, one could hear the constant clicking of the abaci beads coming from the royal computing shop. Then came the answer:

"We got an R^2 of .87, and it held up in the cross-application sample," reported a messenger to the Chief of the Royal Psychometricians, who was with his staff in the coffee room anxiously awaiting the results.

"Hmm," said the Chief, "that's pretty good. But it's not good enough for me to risk my head on it. There must be some variable we failed to consider."

"Maybe the king likes girls who look like his mother," offered the neophyte. "Men often do."

"You're a genius," said the Chief. "It's certainly worth a try."

"How can we quantify that?" asked a staff member. 'You can't measure it with a yard-stick."

"We'll establish a rating board," responded the Chief. "Each board member will judge how much each girl looks like the king's mother. We will use an average of their ratings for each girl as our new predictor."

When the new variable was introduced into the king's policy equation, the R^2 jumped to .94. Everyone now felt confident that they had an equation which would truly simulate the king. The rest was routine. By the end of the week all of the 8,000 girls in the applicant pool had been evaluated by the final policy equation, and those with the highest composite scores were selected.

The king was very pleased with the results, and as a reward, he gave the Most High First Counselor and the Chief of the Royal Psychometricians their choice of the leftovers.

> The preceding fable describes capturing the policy of a single judge. However, if there is high interrater agreement among members of a policy board, then mean values can be used as the criterion vector to represent the entire board. If interrater agreement is low, it may be that the raters can be divided into two or more groups within each of which there is high agreement. This can be accomplished through application of a hierarchical grouping technique which clusters judges in terms of the homogeneity of the prediction equations (Christal, 1963; Bottenberg and Christal, 1961). Thus, if more than one policy exists among board members, each such policy can be identified and described. Differences in policies are thereby pinpointed for arbitration.

It is entirely possible that the JAN technique could play a role in curriculum design. For example, boards of judges could be given task ratings on factors such as those mentioned earlier (probability of tasks being encountered on job; perishability of skill; ease of teaching in school vs. on-the-job; etc.). The judges would be asked to study the factor information and evaluate a sample of tasks in terms of the desirability of their being included in curricula. The JAN technique could be used to express the boards' policies in the form of regression equations. These equations could then be applied to tasks in each curriculum area for which factor information is available. The same equations could be applied to new tasks which later come under consideration.

Description of the MAXOF Clustering Model

The second mathematical model which might be of some use to curriculum designers is called the MAXOF Clustering Model (Christal and Ward, 1966). MAXOF is a highly flexible technique for grouping people or things into categories. It takes its name from the concept of MAXimizing an Objective Function, which is its most unique and useful characteristic. In using the model, the investigator must make three major decisions. First, he must define a way of expressing the similarity among the things or people to be clustered. The model makes no demands on the form of this overlap function. It can be correlation coefficients, co-variances, cross-training times, distance functions, or measures of the homogeneity of regression equations. Any function is legitimate which can be quantified, and which serves the investigator's purpose. Second, the investigator must define an objective function which is to be maximized during the clustering process. For example, the investigator may wish to maximize the average intercorrelations among items within clusters —— or to minimize the average distances (D^2) between items within clusters. Again, there is no restriction on the form of the objective function, except that it be feasible to compute. Third, the investigator must decide on the appropriate number of clusters to report.

The model begins with each of N objects in a separate group. The number of groups is reduced by one at each stage, until all objects are in a single group. Choice of the two groups to be collapsed at a given stage is determined by considering all possibilities and selecting that one which best satisfies the objective function previously established by the investigator. Thus, the model groups objects into every possible number of exclusive clusters, from N to 1. The investigator decides on the appropriate number of clusters to report by considering relevant factors.

Applications of the MAXOF Clustering Model

The MAXOF clustering model has been applied to a variety of practical problems, including: (1) grouping jobs in a manner which minimizes average cross-training time among jobs within clusters; (2) defining a large number of jobs with a fewer number of consolidated job descriptions in a manner which maintains maximum descriptive accuracy; (3) clustering technical schools into families and producing associated prediction equations so as to maintain maximum predictive efficiency; (4) clustering judges in terms of the homogeneity of their policy equations, and producing composite equations for each group accepted; (5) establishing a taxonomy of Latin American tapioca plants; (6) grouping tropical fish in terms of the similarity of their eating habits; (7) grouping reading areas; (8) grouping scientists in terms of the similarity of their reading interests; (9) grouping documents; (10) clustering tasks; and (11) analyzing profiles.

Possible Applications of the MAXOF Clustering Model in Curriculum Design

From the above illustrations one can see that the MAXOF Clustering Model is extremely general purpose. I am not in a good position to recommend specific applications for curriculum designers, but I will venture two suggestions for consideration. First the Model could be used to cluster judges in terms of the homogeneity of their policy equations (as described above). Second, it might be used to group subject matter content into courses. Let me expand on this latter application. In the mathematics area, for example, one could develop a matrix of information in which potential course elements are the rows and occupations are the columns. The body of the table would contain numerical indicators of the value of each content element for individuals entering one of the occupational areas. From these data, two overlap matrices could be computed. One would reflect the overlap among occupations in terms of the similarities of their requirements for mathematical content. The MAXOF model could be applied so as to maximize the similarity of course element requirements among occupations within clusters. For each cluster, one could compute the average level of need for each content element.

The second matrix would reflect the overlap between mathematical content elements. For any pair of elements, the overlap value would reflect the extent to which they are required in the same occupations. The content elements would then be grouped so as to maximize the overlap values among content elements within clusters. One could compute the average need of individuals in each occupation for content in each cluster.

There are several ways that the raw data for the original matrix could be generated for the clustering problems described above. For example, one could have teachers, curriculum experts, or supervisors in the occupational areas make judgments about the relevance of content elements. An alternative approach would be to include questions in job surveys asking job incumbents to indicate how often they use specific mathematical skills, e.g., "How often does your job require you to determine the square root of a number." It might be interesting to compare incumbent responses with supervisory statements and judgments made by teachers and curriculum experts.

Summary

Curriculum definition is in many ways a simpler matter in the military services than it is in the civilian sector. Nevertheless, the question of "what to teach," is as critical in the military services as the question of "how to teach." This is because there has not been available detailed information about the jobs encountered by technical school graduates. The Air Force has developed and tested an occupational survey methodology which involves the administration of job inventories to incumbents in each occupational area. The method produces reliable data which define job characteristics at the work-task level. Computer programs are available which can be used to organize and report this information in a form convenient for use by curriculum designers. Several applications of the data to curriculum design problems have been given.

It is suggested that more time should be devoted to identifying curriculum elements which can be safely eliminated or given reduced emphasis in training programs. Occupational survey data provide a way to quickly identify skills being taught which are unlikely to be utilized by school graduates.

The problem of sampling tasks around which training programs can be organized is critical and has been treated in some detail.

Finally, two mathematical models have been described which may be of benefit to curriculum designers. One is a "policy-capturing model," which might be used to make more explicit the judgmental steps in curriculum definition. The other is a clustering technique which might be used for organizing content into courses in a more cost effective manner.

REFERENCES

1. Bottenberg, R. A., and Christal, R. E., An Iterative Technique for Clustering Criteria Which Retains Optimum Predictive Efficiency. WADD-TN-61-30, AD-261 615. Lackland AFB, Texas: Personnel Laboratory, Wright Air Development Division, March 1961. Also, The Journal of Experimental Education, XXXVI, Number 4, Summer 1968, pp. 28-34.

2. Bottenberg, R. A., and Ward, J. H., Jr., Applied Multiple Linear Regression. PRL-TDR-63-6, AD-413 128. Lackland AFB, Texas: Personnel Research Laboratory, Aerospace Medical Division, March 1963.

3. Christal, R. E., JAN: A Technique for Analyzing Group Judgment. PRL-TDR-63-3, AD-402 813. Lackland AFB, Texas: Personnel Research Laboratory, Aerospace Medical Division, February 1963. Also, The Journal of Experimental Education, XXXVI, Number 4, Summer 1968, pp. 24-27.

4. Christal, R. E., Selecting a Harem - And Other Applications of the Policy-Capturing Model. PRL-TR-67-1, AD-658 025. Lackland AFB, Texas: Personnel Research Laboratory, Aerospace Medical Division, March 1967. Also, The Journal of Experimental Education, XXXVI, Number 4, Summer 1968, pp. 35-41.

5. Christal, R. E., and Ward, J. H., Jr., The MAXOF Clustering Model. (In Press). Lackland AFB, Texas: Personnel Research Division, Air Force Human Resources Laboratory.

Note: A bibliography of reports relating to occupational and career development research conducted by the Personnel Research Division is available from the author upon request.

APPENDIX I

DUTY DESCRIPTION FOR JOURNEYMEN MEDICAL LABORATORY SPECIALISTS (N=394)

D-TSK	DUTY TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
J	Performing Hematology Procedures	92.64	20.48	18.97	18.97
M	Performing Biochemistry Procedures	87.82	16.42	14.42	33.39
N	Performing Urinalyses	90.36	13.07	11.81	45.20
F	Performing General Medical Laboratory Tasks	99.49	11.07	11.01	56.21
L	Performing Blood Banking Procedures	87.56	10.72	9.39	65.60
G	Performing Bacteriological Procedures	90.36	6.39	5.77	71.37
A	Organizing and Planning	74.62	6.56	4.89	76.26
K	Performing Serology Procedures	82.23	5.41	4.45	80.71
E	Maintaining Supplies and Records	87.31	5.04	4.40	85.11
I	Performing Parasitology Procedures	83.50	4.85	4.05	89.16
C	Inspecting and Evaluating	67.01	4.62	3.10	92.26
H	Performing Mycology Procedures	77.66	3.07	2.38	94.64
D	Training	59.14	3.56	2.11	96.75
O	Performing Histology Procedures	60.15	2.84	1.71	98.45
B	Directing and Implementing	47.21	2.90	1.37	99.82
P	Preparing Medical Illustration Materials	8.63	1.05	0.09	99.91
Q	Performing Radioactivity Detection Procedures	1.78	2.10	0.04	99.95

APPENDIX II

TASK JOB DESCRIPTION FOR JOURNEYMEN MEDICAL LABORATORY SPECIALISTS (N=394)

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
F	18	Collect Blood Specimens Directly from Patients	93.40	1.70	1.58	1.58
J	3	Perform Blood Count	89.09	1.56	1.39	2.98
J	17	Perform Hematology Procedures for Differential Cell Counts	88.83	1.49	1.33	4.30
J	24	Perform Hematology Procedures for Hematocrit Tests	89.09	1.45	1.30	5.60
N	2	Examine Urine Specimens Microscopically	88.07	1.43	1.26	6.85
J	5	Prepare Blood Smears	89.85	1.39	1.25	8.10
F	10	Prepare and Process Specimens	87.56	1.39	1.22	9.32
N	9	Perform Urinalyses for Glucose Tests	87.82	1.38	1.21	10.53
N	15	Perform Urinalyses for Specific Gravity Tests	87.06	1.38	1.20	11.73
N	6	Perform Urinalyses for Albumin Tests	87.06	1.36	1.19	12.92
F	3	Clean Area and Equipment Aseptically	80.96	1.46	1.18	14.10
N	1	Examine Urine Specimens Macroscopically	87.82	1.32	1.16	15.26
J	6	Separate Serum from Blood	87.31	1.30	1.14	16.40
F	11	Prepare Reagents	93.40	1.19	1.11	17.51
J	2	Identify Morphological Variations of Blood Cells	88.07	1.21	1.06	18.57
M	4	Operate Spectro-Photometer	77.66	1.34	1.04	19.62
J	21	Perform Hematology Procedures for Erythrocyte Sedimentation Rate	87.56	1.19	1.04	20.65
K	7	Perform Serological Procedures for Cardiolipin Microflocculation	78.93	1.30	1.03	21.68
G	1	Examine Specimens Microscopically	86.04	1.18	1.01	22.69
G	2	Identify and Classify Pathogenic Bacteria	78.68	1.27	1.00	23.69
G	10	Prepare Culture Media	78.68	1.26	0.99	24.68
F	12	Prepare Solutions and Standards	86.55	1.09	0.94	25.62
M	25	Perform Biochemical Procedures for Liver Function Tests	78.93	1.18	0.93	26.55
M	27	Perform Biochemical Procedures for NPN and BUN Tests	79.95	1.16	0.93	27.48
G	11	Stain Bacteriological Smears	85.28	1.08	0.92	28.41
L	3	Crossmatch Blood	72.59	1.24	0.90	29.30
L	16	Test Blood for ABO Grouping and ABO Subgrouping	80.20	1.12	0.90	30.20
J	1	Identify Immature Blood Cells	86.29	1.04	0.89	31.09
I	2	Examine Specimens Microscopically	81.47	1.08	0.88	31.97
G	6	Perform Antibiotic Sensitivity Test	75.38	1.17	0.88	32.85
F	14	Prepare Specimens for Shipment	84.26	1.03	0.87	33.72
E	3	Log Incoming or Outgoing Specimens	71.83	1.16	0.83	34.55
L	18	Type Blood of Donors and Recipients	74.87	1.10	0.83	35.38
L	2	Centrifuge and Separate Serum from Clot	73.10	1.11	0.81	36.19
M	33	Perform Biochemical Procedures for Total Protein and A/G Ratio	75.13	1.06	0.79	36.99
L	17	Test Blood for RHO or DU Factors	76.14	1.04	0.79	37.78
L	8	Perform Direct and Indirect Coombs Tests	75.38	1.04	0.78	38.56

Appendix II *(Continued)*

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
M	5	Prepare Reagents and Standards	75.38	1.01	0.76	39.32
J	27	Perform Hematology Procedures for Prothrombin Time	79.19	0.95	0.76	40.08
J	4	Perform Spinal Fluid Cell Counts	84.52	0.88	0.74	40.82
I	1	Examine Specimens Macroscopically	79.95	0.92	0.73	41.55
I	6	Identify Protozoans, Cestodes, Nematodes, or Trematodes	74.62	0.95	0.71	42.26
F	19	Collect Fecal or Urine Specimens Directly from Patients	52.79	1.33	0.70	42.96
J	28	Perform Hematology Procedures for Reticulocyte Count	84.26	0.82	0.69	43.65
N	8	Perform Urinalyses for Bile Tests	85.28	0.80	0.68	44.34
I	3	Perform Concentration and Flotation Techniques	72.84	0.93	0.68	45.02
J	13	Perform Hematology Procedures for Coagulation Times by Capillary Method	79.70	0.85	0.68	45.70
M	34	Perform Biochemical Procedures for Uric Acid Tests	70.81	0.96	0.68	46.37
N	3	Perform Kidney Function Tests	76.14	0.89	0.68	47.05
J	30	Perform Hematology Procedures for Thrombocyte Count	80.46	0.83	0.67	47.72
J	14	Perform Hematology Procedures for Coagulation Times by Lee-White Method	82.23	0.81	0.66	48.38
M	37	Utilize Methods for Colormetric Procedure	52.03	1.25	0.65	49.03
J	11	Perform Hematology Procedures for Cerebrospinal Fluid Count	80.96	0.80	0.65	49.68
M	32	Perform Biochemical Procedures for Total Cholesterol and Esters Tests	68.27	0.93	0.63	50.32
M	17	Perform Biochemical Procedures for Chlorides Tests	71.07	0.89	0.63	50.95
N	12	Perform Urinalyses for Occult Blood Tests	82.49	0.76	0.63	51.58
E	5	Maintain Files of Clinical Laboratory Requests	54.82	1.14	0.63	52.20
J	8	Perform Hematology Procedures for Bleeding Time, Duke Method	71.83	0.86	0.62	52.82
M	38	Utilize Methods for Electrolyte Determinations	61.68	1.00	0.61	53.43
J	20	Perform Hematology Procedures for Erythrocyte Indices	79.44	0.75	0.59	54.03
M	11	Perform Biochemical Procedures for Calcium and Phosphorus Tests	64.72	0.92	0.59	54.62
E	7	Maintain Files of Laboratory Records or Reports	51.27	1.14	0.59	55.20
J	25	Perform Hematology Procedures for L. E. Test	75.38	0.77	0.58	55.79
L	5	Draw Blood for Transfusions	64.47	0.90	0.58	56.36
K	13	Perform Serological Procedures for Heterophile Presumptive and Differential Antibody Test	63.45	0.90	0.57	56.94
J	18	Perform Hematology Procedures for Eosinophile Count	80.46	0.71	0.57	57.51
M	2	Operate Flame Photometer	64.97	0.88	0.57	58.08
G	8	Perform Sperm Counts	79.44	0.71	0.57	58.65
J	29	Perform Hematology Procedures for Sickle Cell Preparations	82.74	0.68	0.56	59.21
M	14	Perform Biochemical Procedures for Carbon Dioxide Determinations	67.26	0.83	0.56	59.77
E	11	Receive Incoming Supplies	55.58	0.96	0.53	60.31
L	15	Store Blood According to Grouping and Factor	59.90	0.89	0.53	60.84
F	20	Collect Pus Specimens Directly from Patients	65.99	0.80	0.53	61.37
N	20	Perform Urinalyses for Urobilinogin Tests	75.89	0.66	0.50	61.87
K	14	Perform Serological Procedures for Latex Fixation Test	59.64	0.84	0.50	62.37
K	6	Perform Serological Procedures for "C" Reactive Protein Tests	61.42	0.80	0.49	62.86
H	4	Perform KOH Preparation for Dermatophyte	68.02	0.72	0.49	63.35

Appendix II *(Continued)*

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
A	10	Develop and Improve Work Methods and Procedures	53.55	0.91	0.49	63.84
L	4	Dispose of Blood After Time Limit	62.18	0.77	0.48	64.32
M	8	Perform Biochemical Procedures for Blood Alcohol Tests	66.75	0.71	0.48	64.79
M	20	Perform Biochemical Procedures for Creatinine Tests	61.42	0.76	0.47	65.26
L	6	Maintain Donor Files	58.63	0.79	0.47	65.73
N	10	Perform Urinalyses for KETONE Studies	55.33	0.84	0.46	66.19
H	2	Examine Specimens Microscopically	60.15	0.77	0.46	66.65
J	12	Perform Hematology Procedures for Clot Retraction Test	73.35	0.63	0.46	67.11
A	5	Assure the Availability of Equipment and Supplies	42.64	1.06	0.45	67.57
A	26	Requisition Supplies and Equipment	44.67	1.01	0.45	68.02
E	12	Requisition Supplies	44.42	1.00	0.45	68.46
N	16	Perform Urinalyses for Total Protein	63.45	0.70	0.44	68.90
M	21	Perform Biochemical Procedures for Enzyme Analyses	46.70	0.95	0.44	69.35
M	42	Utilize Methods for Titrimetric Procedure	55.33	0.80	0.44	69.79
M	13	Perform Biochemical Procedures for Carbohydrates Tolerance Tests	44.67	0.98	0.44	70.23
H	5	Prepare Culture Media	57.87	0.76	0.44	70.67
H	1	Cultivate Mycology Specimens for Primary Isolation	56.09	0.77	0.43	71.10
D	6	Give On-The-Job Instruction in Medical Laboratory Activities	40.10	1.04	0.42	71.51
N	7	Perform Urinalyses for Bence-Jones Protein Tests	68.78	0.60	0.41	71.93
I	5	Stain Parasitological Smears	53.81	0.77	0.41	72.34
F	22	Collect Skin Specimens Directly from Patients	58.12	0.71	0.41	72.75
K	8	Perform Serological Procedures for Cold Agglutinations	57.11	0.72	0.41	73.16
N	4	Perform Pregnancy Tests	48.48	0.84	0.41	73.57
C	6	Evaluate the Accuracy of Routine Reports	39.09	1.04	0.41	73.98
K	5	Perform Serological Procedures for Antistreptolysin "O" Titers	48.48	0.82	0.40	74.37
L	13	Record Information on Blood Record Card	53.05	0.74	0.39	74.77
L	7	Maintain Files of Blood Banking Forms	53.30	0.74	0.39	75.16
F	9	Perform Preventive Maintenance on Laboratory Equipment	47.72	0.82	0.39	75.55
F	24	Collect Sputum Specimens Directly from Patients	52.28	0.72	0.38	75.93
L	1	Attach Serial Numbers to Units	48.22	0.78	0.38	76.30
M	1	Calibrate Instruments	52.03	0.72	0.37	76.68
L	14	Screen and Schedule Donors	50.51	0.72	0.36	77.04
N	5	Perform Urinalyses for Addis Counts	63.96	0.56	0.36	77.40
C	1	Determine Equipment Repairs or Replacements Needed	47.21	0.76	0.36	77.76
O	9	Prepare Specimens for Shipment	39.85	0.89	0.36	78.12
L	11	Prepare Blood for Shipment	46.70	0.72	0.34	78.46
M	40	Utilize Methods for Gasometric Procedure	41.37	0.81	0.34	78.79
K	11	Perform Serological Procedures for Febrile Agglutinations	45.69	0.72	0.33	79.12
A	21	Plan Reports for the Section	32.99	0.99	0.33	79.45
E	4	Maintain and Revise Stock Levels	35.53	0.92	0.33	79.77
A	20	Plan Record Keeping for the Section	30.71	1.06	0.33	80.10

Apoendix II *(Continued)*

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
J	19	Perform Hematology Procedures for Erythrocyte Fragility Tests	59.14	0.55	0.32	80.42
M	30	Perform Biochemical Procedures for Serum Frog Test for Pregnancy	40.61	0.78	0.32	80.74
F	6	Perform Bacteriological or Chemical Examinations of Water	41.37	0.74	0.31	81.05
H	6	Stain Mycology Specimens	48.22	0.62	0.30	81.34
N	17	Perform Urinalyses for Urinary Calcium	54.57	0.54	0.30	81.64
N	14	Perform Urinalyses for Porphyrins Tests	54.57	0.54	0.30	81.94
G	3	Maintain Stock Cultures	35.79	0.82	0.29	82.23
C	7	Evaluate the Adequacy of Routine Reports	29.44	0.98	0.29	82.52
O	15	Submit Tissue Specimens to AFIP or Histopathology Centers	32.99	0.87	0.29	82.81
A	7	Coordinate Work Activities with Other Sections	36.55	0.77	0.28	83.09
A	14	Establish Procedures for Special Tests	36.29	0.74	0.27	83.36
B	2	Direct Subordinates in Maintaining Performance Standards	30.96	0.87	0.27	83.63
E	10	Procure and Store Biological Items	35.53	0.75	0.27	83.89
H	3	Identify and Classify Fungi	36.04	0.73	0.26	84.16
O	2	Assist with Autopsy	39.34	0.66	0.26	84.42
F	4	Perform Bacteriological or Chemical Examinations of Food Products	40.86	0.63	0.26	84.67
L	9	Perform First Aid for Shock	51.02	0.49	0.25	84.92
K	2	Prepare Antigens	32.49	0.77	0.25	85.17
F	15	Prepare Specimens for Training or Reference	36.29	0.67	0.24	85.42
N	13	Perform Urinalyses for Phenylpyruvic Acid Test	46.95	0.52	0.24	85.66
E	1	Supervise the Maintenance of Laboratory Supplies	23.60	1.02	0.24	85.90
B	5	Direct the Maintenance and Utilization of Equipment, Supplies and Work Space	27.92	0.86	0.24	86.14
A	3	Assign Specific Work to Individuals	30.96	0.78	0.24	86.38
C	18	Resolve Technical Problems of Subordinates	28.43	0.83	0.24	86.62
M	19	Perform Biochemical Procedures for Creatinine Clearance Tests	32.23	0.73	0.23	86.85
D	8	Indoctrinate Newly Assigned Personnel	35.28	0.67	0.23	87.09
C	14	Investigate Possible Sources of Staphylococcus Outbreaks	28.43	0.82	0.23	87.32
A	25	Plan Work Flow	25.13	0.92	0.23	87.56
C	9	Evaluate Work Performance of Subordinates	23.35	0.95	0.22	87.78
M	15	Perform Biochemical Procedures for Carbon Monoxide Determinations	39.09	0.57	0.22	88.00
I	8	Prepare Culture Media	29.70	0.73	0.22	88.22
A	11	Develop or Revise the Organization of the Section	26.40	0.81	0.21	88.43
B	4	Direct Subordinates in the Observance of Safety Practices	27.66	0.77	0.21	88.64
J	9	Perform Hematology Procedures for BleedingTime Ivy Method	29.44	0.71	0.21	88.85
D	18	Show How to Locate and Interpret Technical Information	25.89	0.78	0.20	89.06
A	18	Plan and Schedule Work Assignments	24.11	0.83	0.20	89.26
M	29	Perform Biochemical Procedures for Salicylate Level	32.49	0.61	0.20	89.46
C	16	Recommend Special Corrective Action for Recurring Problems	26.65	0.72	0.19	89.65
C	8	Evaluate the Maintenance and Use of Equipment, Supplies and Work Space	23.86	0.80	0.19	89.84
N	18	Perform Urinalyses for Urinary Chlorides	35.03	0.54	0.19	90.03

Appendix II *(Continued)*

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
C 11	Inspect and Evaluate Adherence to Established Standards of Sanitation, Cleanliness and Neatness	18.78	0.99	0.19	90.21
L 12	Process Blood for Packed Cells	34.01	0.54	0.19	90.40
A 17	Establish Work Priorities	22.08	0.83	0.18	90.58
J 22	Perform Hematology Procedures for Fibrinogen Estimations	35.28	0.49	0.17	90.76
E 6	Maintain Files of Laboratory Correspondence	22.59	0.76	0.17	90.93
C 10	Initiate Unsatisfactory Reports on Equipment	24.37	0.70	0.17	91.10
B 12	Supervise the Preparation and Maintenance of Records and Reports	19.04	0.88	0.17	91.26
F 2	Assist Officers or Scientists in Research Assignments	18.53	0.89	0.17	91.43
N 19	Perform Urinalyses for Urine Electrolytes Tests	28.43	0.58	0.16	91.59
A 2	Assign Space for Equipment and Supplies	26.40	0.61	0.16	91.75
D 9	Interpret Policies and Directives to Subordinates	23.60	0.68	0.16	91.92
J 26	Perform Hematology Procedures for Prothrombin Consumption Test	26.40	0.60	0.16	92.07
I 7	Identify Parasitic and Disease-Carrying Arthropods	25.89	0.60	0.15	92.23
M 41	Utilize Methods for Gravimetric Procedure	18.27	0.84	0.15	92.38
C 3	Evaluate Compliance with Established Work Standards	16.50	0.91	0.15	92.53
A 13	Establish Performance Standards	15.99	0.87	0.14	92.67
E 8	Make Local Purchase of Supplies	17.51	0.79	0.14	92.81
D 1	Administer Written or Performance Tests	17.01	0.79	0.13	92.94
K 10	Perform Serological Procedures for Complement Fixation Tests	19.04	0.70	0.13	93.08
F 17	Collect Biopsy or Autopsy Specimens Directly from Patients	21.32	0.62	0.13	93.21
J 10	Perform Hematology Procedures for Bone Marrow Examinations	22.08	0.59	0.13	93.34
B 7	Maintain Files of Publications	17.01	0.77	0.13	93.47
A 4	Assist Officer in Charge in Establishing Organizational Policy	20.56	0.63	0.13	93.60
E 2	Handle Property Turn-In	18.02	0.70	0.13	93.73
B 1	Direct Subordinates in Maintaining High Standards of Personal Hygiene	17.77	0.68	0.12	93.85
D 7	Give Training or Lectures to Non-Medical Laboratory Personnel	18.27	0.66	0.12	93.97
F 1	Assist in Epidemiological Investigations	20.30	0.59	0.12	94.09
F 8	Perform EKG Tests	13.71	0.87	0.12	94.21
I 4	Perform Microfilarial Examinations	23.60	0.49	0.11	94.32
E 9	Prepare Work Orders or Work Requests	18.27	0.62	0.11	94.44
A 6	Compose Local Medical Laboratory SOPs	18.02	0.63	0.11	94.55
C 2	Evaluate Adherence to Work Schedules	14.21	0.78	0.11	94.66
D 4	Develop On-The-Job Training Materials	15.99	0.69	0.11	94.77
A 16	Establish Sanitation Standards	13.45	0.80	0.11	94.88
M 39	Utilize Methods for Electrophoresis	10.15	1.05	0.11	94.99
A 1	Assign Personnel to Duty Positions	18.53	0.57	0.11	95.09
F 7	Perform BMR Tests	16.75	0.62	0.10	95.20
A 19	Plan Medical Laboratory Activities	15.23	0.67	0.10	95.30
M 23	Perform Biochemical Procedures for Lactic Dehydrogenase Tests	13.45	0.75	0.10	95.40
M 22	Perform Biochemical Procedures for Insulin Tolerance Tests	16.24	0.61	0.10	95.50

Appendix II *(Continued)*

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
K 3	Prepare Specimens for Virus Isolation	17.26	0.56	0.10	95.59
C 5	Evaluate Procedures for Storage, Inventory and Inspection of Property Items	11.42	0.83	0.10	95.69
A 23	Plan the Physical Layout of the Medical Laboratory Facilities	14.21	0.67	0.10	95.78
J 23	Perform Hematology Procedures for GG Test	13.45	0.71	0.10	95.88
D 19	Supervise On-The-Job Training Programs	12.44	0.75	0.09	95.97
D 12	Review Training Progress of Individuals	12.69	0.73	0.09	96.07
C 17	Resolve Personal Problems of Subordinates	15.48	0.60	0.09	96.16
K 9	Perform Serological Procedures for Colloidal Gold Test	14.97	0.59	0.09	96.25
B 3	Direct Subordinates in Maintaining Security Standards	13.45	0.63	0.09	96.33
O 14	Stain Specimens for Microscopic Study	7.11	1.19	0.08	96.42
D 14	Rotate Duty Assignments of Personnel	12.69	0.66	0.08	96.50
F 5	Perform Bacteriological or Chemical Examinations of Sewage	14.97	0.52	0.08	96.58
D 5	Evaluate Training Effectiveness	10.15	0.75	0.08	96.65
D 3	Conduct Conferences and Classes	12.18	0.63	0.08	96.73
M 7	Perform Biochemical Procedures for Barbiturate Level	14.21	0.54	0.08	96.81
M 10	Perform Biochemical Procedures for Blood PH Tests	17.26	0.44	0.08	96.88
M 12	Perform Biochemical Procedures for Calculus Analyses	9.39	0.80	0.08	96.96
O 7	Prepare Routine Stains	8.38	0.90	0.08	97.03
J 7	Perform Hematology Procedures for Acid Hemolycins Tests	8.88	0.82	0.07	97.11
O 12	Section Tissue in Microscopic Blocks	4.82	1.51	0.07	97.18
I 10	Perform Serological Tests for Parasites	12.18	0.59	0.07	97.25
O 17	Use Microtome	5.84	1.24	0.07	97.32
J 16	Perform Hematology Procedures for Cryoglobulin Tests	14.21	0.51	0.07	97.40
D 10	Maintain Training Records	11.17	0.65	0.07	97.47
M 28	Perform Biochemical Procedures for PBI Tests	6.60	1.08	0.07	97.54
I 9	Maintain Parasite Cultures	11.42	0.62	0.07	97.61
J 15	Perform Hematology Procedures for Coagulation Times by Modified Howell Method	10.91	0.63	0.07	97.68
M 9	Perform Biochemical Procedures for Blood Oxygen Tests	12.69	0.54	0.07	97.75
O 11	Prepare Tissue for Fixation, Dehydration, and Infiltration of Paraffin	6.35	1.04	0.07	97.81
D 2	Arrange for Training Aids, Space and Equipment	9.64	0.64	0.06	97.88
O 16	Use Autotechnicon	6.85	0.90	0.06	97.94
C 13	Inspect the Physical Layout of the Medical Laboratory Facilities	9.39	0.66	0.06	98.00
O 5	Mount Tissue Section in Preparation for Microscopic Study	5.08	1.20	0.06	98.06
F 21	Collect Serous Cavity Specimens Directly from Patients	10.15	0.57	0.06	98.12
M 6	Perform Biochemical Procedures for Alkaloids	7.87	0.73	0.06	98.18
A 8	Design Organizational or Functional Charts	12.44	0.45	0.06	98.23
O 4	Embed Tissue in Paraffin	6.09	0.92	0.06	98.29
A 24	Plan the Section Safety Program	8.63	0.65	0.06	98.34
M 36	Utilize Methods for Chromotography	5.84	0.96	0.06	98.40
F 16	Collect Bile Specimens Directly from Patients	7.87	0.71	0.06	98.46

Appendix II *(Continued)*

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
D 13	Review Training Status of the Section	7.87	0.70	0.06	98.51
K 15	Perform Serological Procedures for Strep MG Test	10.66	0.52	0.06	98.57
D 15	Schedule On-The-Job Training	8.12	0.64	0.05	98.62
G 4	Perform Animal Inoculations	8.38	0.61	0.05	98.67
O 13	Stain Pap Smears	7.11	0.70	0.05	98.72
A 9	Determine Personnel Requirements	9.39	0.51	0.05	98.77
O 18	Use Microtome Knife Sharpener	4.82	0.99	0.05	98.82
B 9	Supervise Subordinate Supervisors	5.58	0.85	0.05	98.86
D 11	Recommend Individuals for Training	7.87	0.56	0.04	98.91
M 24	Perform Biochemical Procedures for Lipids Profile	8.12	0.54	0.04	98.95
O 8	Prepare Special Stains	5.08	0.82	0.04	98.99
A 15	Establish Research Procedures	6.35	0.63	0.04	99.03
F 23	Collect Spinal Fluid Specimens Directly from Patients	5.84	0.68	0.04	99.07
B 8	Maintain Status Boards or Charts	6.35	0.62	0.04	99.11
K 1	Identify Viruses and Rickettsia	6.60	0.59	0.04	99.15
M 16	Perform Biochemical Procedures for Catecholamine Tests	5.33	0.69	0.04	99.19
A 27	Schedule Leaves or Passes	7.36	0.49	0.04	99.22
K 4	Perform Serological Procedures for Anticomplementary Retests	6.60	0.55	0.04	99.26
J 31	Perform Hematology Procedures for Thromboplastin Generation Tests	7.61	0.48	0.04	99.30
M 18	Perform Biochemical Procedures for Cortisone and Steroid Studies	3.55	0.99	0.04	99.33
C 4	Evaluate Individuals for Promotion and Upgrading	6.60	0.52	0.03	99.37
C 15	Recommend Changes in Publications	6.85	0.50	0.03	99.40
O 1	Assist in Preparation of Gross Specimens for Medical Photography	7.87	0.43	0.03	99.44
P 5	Maintain Reference File of Illustrations	4.57	0.72	0.03	99.47
O 3	Decalcify Specimens of Teeth and Bone	5.08	0.63	0.03	99.50
L 10	Perform Genotype of Animal Blood	4.57	0.63	0.03	99.53
O 6	Prepare Frozen Section of Tissue	3.81	0.75	0.03	99.56
P 1	Collect and Assemble Medical Illustration Material	5.33	0.52	0.03	99.59
K 12	Perform Serological Procedures for Hemagglutination Inhibition Test	4.57	0.57	0.03	99.61
B 6	Draft and Submit Job Descriptions	5.33	0.48	0.03	99.64
N 11	Perform Urinalyses for Lead Tests	5.84	0.43	0.02	99.66
G 5	Perform Animal Virulence Tests	2.28	1.06	0.02	99.69
B 10	Supervise the Disaster Control Program	3.55	0.64	0.02	99.71
C 12	Inspect and Evaluate the Maintenance of Status Boards or Charts	3.55	0.61	0.02	99.73
A 22	Plan Status Boards or Charts	3.81	0.52	0.02	99.75
O 10	Prepare Tissue for Cellodian Embedding and Sectioning	1.78	0.95	0.02	99.77
G 7	Perform Fluorescent Antibody Technique	3.30	0.51	0.02	99.78
G 9	Prepare Autogenous Vaccines	3.05	0.47	0.01	99.80
F 13	Prepare Specimens for Electron Microscopy	1.52	0.86	0.01	99.81
P 2	Distribute Medical Illustration Material	2.79	0.45	0.01	99.82
D 16	Select and Assign Instructors	2.28	0.49	0.01	99.84

Appendix II *(Continued)*

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
C	19	Write Technical Papers for Publication	2.03	0.50	0.01	99.85
M	3	Operate Spectro-Fluorometer	1.52	0.65	0.01	99.86
Q	1	Assist Medical Radiological Laboratory Officer in Preparing and Counting Samples	1.27	0.75	0.01	99.86
A	12	Draft Budget Estimates	2.28	0.39	0.01	99.87
P	3	Draft and Prepare Illustrations	1.27	0.69	0.01	99.88
P	4	Duplicate Illustrated Materials	2.28	0.38	0.01	99.89
D	17	Select Individuals for Specialized Training Courses	2.28	0.37	0.01	99.90
Q	3	Conduct Tests for Presence and Measurement of Radioactivity	1.27	0.55	0.01	99.91
M	35	Perform Biochemical Procedures for Vitamin Assays	1.27	0.47	0.01	99.91
M	31	Perform Biochemical Procedures for Serum Magnesium Tests	1.52	0.35	0.01	99.92
Q	8	Record and Summarize Data	0.76	0.64	0.00	99.92
B	11	Supervise the Health Physics Program	1.02	0.46	0.00	99.93
M	26	Perform Biochemical Procedures for Noradrenaline Studies	0.76	0.61	0.00	99.93
Q	4	Count Fluid Specimens	0.76	0.56	0.00	99.94
Q	12	Use Scaling Devices	0.51	0.69	0.00	99.94
Q	2	Calibrate Instruments	0.51	0.68	0.00	99.94
Q	10	Use Crystal and Liquid Scintillation Detectors	0.25	0.63	0.00	99.94
Q	9	Segregate and Prepare Radioactive Specimens for Measurement of Radioactivity	0.51	0.31	0.00	99.95
Q	11	Use Geiger-Mueller Equipment	0.25	0.58	0.00	99.95

APPENDIX III

TASK JOB DESCRIPTION FOR JOURNEYMEN DISBURSEMENT ACCOUNTING SPECIALISTS (N=532)

D-TSK		TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
E	2	Answer Inquiries Concerning Military Pay or Allowances	51.32	7.08	3.63	3.63
E	35	Provide Counter Service for Military Pay Section	37.59	7.39	2.78	6.41
E	10	Compute Changes to MPRS	33.08	6.84	2.26	8.67
J	10	Compute Travel Allowances	20.68	10.43	2.16	10.83
E	27	Prepare Coding Sheets of Changes to MPRS	25.94	7.63	1.98	12.81
E	1	Align Military Pay Records (MPRS) for Pay Computation	34.02	5.71	1.94	14.75
J	20	Maintain Individual Travel Records (AF Form 1267)	20.68	9.02	1.87	16.61
E	8	Code Changes to MPRS	27.07	6.84	1.85	18.47
E	3	Assemble MPRS into Batches	30.64	5.93	1.82	20.28
E	22	Make Manual Entries on MPRS	29.70	5.63	1.67	21.96
J	12	Determine Validity of Travel Orders	21.05	7.39	1.55	23.51
E	33	Process Transfer-In MPRS	19.74	7.07	1.39	24.91
E	46	Write Correspondence About Military Pay Matters	28.01	4.91	1.38	26.28
J	19	Maintain Files of Travel Documents and Records	18.80	7.16	1.35	27.63
J	39	Review Travel Vouchers	17.48	7.63	1.33	28.96
E	18	Maintain Files of Military Pay Documents or Locator Cards	19.17	6.79	1.30	30.26
E	28	Prepare Pay Adjustment Authorizations	26.32	4.84	1.27	31.54
E	39	Review or Edit Military Pay Orders or MPRS	23.87	5.28	1.26	32.80
J	6	Collect Basic Allowance Subsistence (BAS) from Military Personnel	18.23	6.88	1.25	34.05
E	36	Punch Paper Tape from Input Data Forms	20.30	6.01	1.22	35.27
J	9	Compute and Process Vicinity Travel Forms	16.92	7.06	1.19	36.47
F	19	Operate Military Pay Computer	19.55	6.03	1.18	37.64
E	34	Process Transfer-Out MPRS	17.29	6.69	1.16	38.80
J	21	Maintain Voucher Control Log for Disbursement and Collection Vouchers Processed in Travel Area	14.85	7.70	1.14	39.95
J	14	Edit Travel Documents	15.41	7.07	1.09	41.04
E	20	Maintain Military Pay Document Control Logs	14.10	7.63	1.08	42.11
E	26	Prepare Charge-Out Cards for Military Pay Section	18.42	5.84	1.08	43.19
J	1	Adjudicate and Process Collection Vouchers	18.42	5.52	1.02	44.20
E	5	Audit Change Documents Against MPOS or MPRS	18.80	5.25	0.99	45.19
E	41	Screen MPRS for Pay Exceptions Before EOM Pay Computation	18.61	5.29	0.98	46.17
E	7	Close or Open MPRS Manually	17.11	5.62	0.96	47.13
E	38	Review Military Pay Documents for Edit Errors or Rejections	18.61	4.98	0.93	48.06
E	6	Audit Coded Changes or Manual Entries on MPRS	16.92	5.14	0.87	48.93
E	23	Match Military Pay Orders Against Other Documents	15.41	5.55	0.86	49.79
E	17	Key Punch Military Pay PCAM Cards	16.92	4.97	0.84	50.63
E	31	Process Separation or Discharge Actions	13.35	6.11	0.82	51.44

The abbreviation "MPRS" in task statements stands for "Military Pay Records."

APPENDIX IV

TASK JOB DESCRIPTION FOR MILITARY PAY (COMPUTER) (N=102)

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
F 19	Operate Military Pay Computer	87.25	8.68	7.58	7.58
F 8	Edit Change Tape Input for Errors	76.47	6.74	5.16	12.73
F 3	Close or Open MPRS by Computer	70.59	5.47	3.86	16.60
F 27	Reconstruct MPRS	77.45	4.74	3.67	20.26
F 11	Maintain History Files of Punch Paper Tape (Input and Output)	66.67	5.13	3.42	23.68
F 21	Prepare Military Pay Reports such as Allotment Reconciliation, Accrued Military Pay, or FICA	75.49	4.52	3.41	27.10
F 22	Prepare or Verify Daily Trial Balance of Computer Transactions	69.61	4.54	3.16	30.26
E 36	Punch Paper Tape from Input Data Forms	52.94	5.55	2.94	33.20
F 17	Maintain or Verify Batch Control Logs and Files	67.65	4.33	2.93	36.13
F 28	Review Military Pay Printouts	62.75	4.16	2.61	38.74
F 13	Maintain Magnetic Strips or Tapes, Tape Control Log, or Tape Files	56.86	4.24	2.41	41.15
F 7	Convert Manual MPRS into Mechanized MPRS	53.92	4.31	2.33	43.47
F 23	Prepare Supplemental Accrual Adjustments	55.88	3.73	2.08	45.55
F 18	Monitor Programs for Errors	50.98	3.90	1.99	47.54
F 1	Balance Daily or EOM Cumulative Payments and Collections for Military Pay Section	48.04	4.01	1.93	49.47
F 15	Maintain Military Pay Computer Unit Control Register	43.14	4.38	1.89	51.36
F 24	Process Allotment PCAM Cards to MPRS and Prepare Submission for Automatic Digital Network (DATE) System	43.14	4.32	1.86	53.22
F 20	Prepare EOM Voucher or Report Data for Military Pay	47.06	3.81	1.79	55.01
F 31	Verify Entry of Post Payments-for-Self	46.08	3.86	1.78	56.79
E 42	Skeletonize Batch Control and Output Totals (AF Form 1935)	37.25	4.58	1.71	58.50
F 14	Maintain Magnetic Strip Printout File (AF Form 1933)	49.02	3.42	1.68	60.18
F 10	Maintain Accrual Control of Military Pay Accrual Ledgers	40.20	3.97	1.60	61.77
E 3	Assemble MPRS Into Batches	34.31	4.59	1.58	63.35
F 26	Reconcile MPRS to MPR Control Total	43.14	3.52	1.52	64.87
E 34	Process Transfer-Out MPRS	33.33	3.97	1.32	66.19
F 12	Maintain Journal Voucher Logs and Files for Military Pay Computer Unit	40.20	3.26	1.31	67.50
F 2	Balance Totals of EOM Allotment Reconciliation Reports for Military Pay	41.18	3.14	1.29	68.79
F 4	Collect Military Pay Accounting Data for Accounts Control	37.25	3.42	1.27	70.07
E 33	Process Transfer-In MPRS	33.33	3.79	1.26	71.33
F 5	Collect Military Pay Computer Unit Data for the Report of Accounting and Finance Activities (C-92)	36.27	3.20	1.16	72.49
F 16	Maintain Military Pay Subsidiary Ledgers	31.37	3.68	1.15	73.64
F 9	Input Military Pay Vouchers into the MAFR System	32.35	3.23	1.05	74.69
F 29	Update Magnetic Register	22.55	4.23	0.95	75.64
E 31	Process Separation or Discharge Actions	27.45	3.47	0.95	76.60

APPENDIX V

TASK JOB DESCRIPTION FOR PAYING AND COLLECTING (N=70)

D	TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
H	43	Prepare U.S. Treasury Checks	67.11	6.23	4.18	4.18
H	32	Prepare Military or Civilian Pay Checks for Issue or Mail	67.11	5.76	3.86	8.05
H	44	Process Vouchers Received from SMAS	68.42	5.32	3.64	11.69
H	45	Proofread, Stuff, and Mail Business Checks	63.16	5.53	3.49	15.18
H	3	Audit U.S. Treasury Checks Against Vouchers	64.47	4.90	3.16	18.34
H	47	Review Disbursement, Collection, or Adjustment Vouchers	63.16	4.82	3.04	21.38
H	29	Perform Cash and Check Accountability Functions	60.53	4.89	2.96	24.34
H	7	Count Out Cash for Payments	50.00	5.45	2.72	27.06
H	40	Prepare Summaries Such as the Daily Summary of Cash Collections or Cashier's Daily Summary	50.00	5.01	2.50	29.57
H	37	Prepare Statement of Accountability	56.58	4.32	2.44	32.01
H	21	Maintain Custody of Currencies, Checks, or Other Negotiable Instruments	44.74	5.25	2.35	34.36
H	13	Identify Payees	56.58	4.14	2.34	36.70
H	17	Maintain Check Control Record	50.00	4.50	2.25	38.95
H	9	Determine Validity of Documents Giving Basis for Cash or Check Transactions	52.63	4.14	2.18	41.13
H	2	Audit Cash Payments	48.68	4.41	2.15	43.28
H	14	Inform Owners of Lost Bonds or Checks as to Replacement Procedures	59.21	3.23	1.91	45.19
H	36	Prepare Savings Bonds or Savings Bonds Issuance Schedules	42.11	4.46	1.88	47.07
H	16	Issue Checks for Data Automation Processing	43.42	4.22	1.83	48.90
H	15	Initiate Substitute or Stop Payment Requests	63.16	2.82	1.78	50.68
H	39	Prepare Supporting Schedules to the Statement of Accountability	39.47	4.46	1.76	52.44
H	48	Review or Maintain Such Forms as the Daily Accounting Worksheet	35.53	4.89	1.74	54.18
H	4	Balance Military Payrolls with Check Listings and Computer Output	46.05	3.77	1.73	55.91
H	25	Maintain Log of Vouchers by Subject Matter Area (SMA)	44.74	3.72	1.67	57.58
H	11	Examine Voucher Control Registers Maintained by SMAs	52.63	3.12	1.64	59.22
H	42	Prepare Treasury List and Monthly Report on Treasury Checks	39.47	4.06	1.60	60.83
H	5	Cancel Inappropriate Checks	56.58	2.80	1.58	62.41
H	41	Prepare Transmittal Documents	46.05	3.03	1.40	63.81
H	18	Maintain Check Issue Control Register (AF Form 1248)	38.16	3.57	1.36	65.17
H	19	Maintain Controls on Cash Collections	39.47	3.33	1.31	66.48
H	28	Microfilm or List Checks for Deposit	38.16	3.28	1.25	67.73
H	12	Exchange Foreign Currency	23.68	5.09	1.20	68.94
H	38	Prepare Statement of Agent Officers Account (DD Form 1081)	40.79	2.85	1.16	70.10
B	13	Supervise Paying and Collecting Section	30.26	3.54	1.07	71.17
H	23	Maintain File or Log of Returned and Undelivered Treasury Checks	32.89	3.13	1.03	72.20
H	6	Collect Paying and Collecting Data for Report of Accounting and Finance Activities (C-92)	34.21	2.98	1.02	73.22

2,

APPENDIX VI

TASK JOB DESCRIPTION FOR TRAVEL PAY (N=204)

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
J 10	Compute Travel Allowances	64.71	11.04	7.14	7.14
J 20	Maintain Individual Travel Records (AF Form 1267)	66.67	9.89	6.59	13.74
J 19	Maintain Files of Travel Documents and Records	71.57	7.90	5.65	19.39
J 12	Determine Validity of Travel Orders	73.53	7.64	5.62	25.00
J 39	Review Travel Vouchers	64.22	8.15	5.23	30.23
J 21	Maintain Voucher Control Log for Disbursement and Collection Vouchers Processed in Travel Area	49.02	8.57	4.20	34.44
J 6	Collect Basic Allowance Subsistence (BAS) from Military Personnel	56.86	7.35	4.18	38.61
J 9	Compute and Process Vicinity Travel Forms	56.37	7.31	4.12	42.74
J 1	Adjudicate and Process Collection Vouchers	64.22	5.95	3.82	46.56
J 14	Edit Travel Documents	50.98	7.32	3.73	50.29
J 15	Estimate Costs of Travel and Transportation	50.00	5.76	2.88	53.17
J 17	Interpret Statutes or Directives for Questions of Entitlement to Travel and Transportation Funds	40.20	6.13	2.47	55.64
J 3	Cite Funds for Travel and Transportation	43.14	5.67	2.45	58.08
J 23	Prepare Correspondence on Travel Claims	44.61	5.10	2.28	60.36
J 13	Distribute Travel and Transportation Documents	39.71	5.70	2.26	62.62
J 16	Follow-up Unliquidated Travel and Transportation Obligations	45.10	4.98	2.25	64.87
J 32	Prepare Posting Data Transfers (POTS) for Travel	28.43	7.56	2.15	67.02
J 34	Process Documents Received on Register of Transactions by Others	32.84	6.42	2.11	69.13
J 18	Key Punch Travel Documents	25.98	7.67	1.99	71.12
J 11	Determine Travel Fund Availability	37.25	4.70	1.75	72.87
J 4	Classify Travel and Transportation Transactions	32.35	4.53	1.46	74.34
J 25	Prepare Requests for Official Distances	32.84	3.88	1.27	75.61
J 7	Collect Travel Data for Accounts Control	28.43	4.45	1.27	76.88
J 2	Certify Funds for Travel and Transportation	29.41	4.20	1.24	78.11
J 24	Prepare Miscellaneous Obligation Documents (MODS) for Travel	27.45	4.37	1.20	79.31
J 22	Post Travel and Transportation Disbursements and Collections to Fund Ledgers	19.61	6.10	1.20	80.51
J 28	Prepare Travel and Transportation Committment Documents	24.02	4.84	1.16	81.67
J 38	Review Daily Register of Meal Ticket and Transportation Transactions	20.10	4.97	1.00	82.67
J 37	Reconcile Unliquidated Obligations or Accounts Payable with Fund Ledger for Travel	20.59	4.79	0.99	83.66
J 33	Process Contractual Services Vouchers for Travel	15.69	6.01	0.94	84.60
C 4	Determine Propriety of Claims	10.29	8.31	0.86	85.45
J 35	Process Funding of Government Bills of Lading	17.65	4.79	0.85	86.30
J 31	Prepare Travel Journal Vouchers for General Ledger Accounting	21.57	3.43	0.74	87.04
A 12	Interpret Accounting and Finance Procedures to Subordinates	13.24	4.56	0.60	87.64

APPENDIX VII

TASK JOB DESCRIPTION FOR MILITARY PAY RECORDS (N=401)

CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS . . .
AVERAGE PERCENT TIME SPENT BY ALL MEMBERS . . . .
AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING . . . . .
PERCENT OF MEMBERS PERFORMING. . . . .

D-TSK		TASK TITLE				
E	2	Answer Inquiries Concerning Military Pay or Allowances	88.78	7.70	6.84	6.84
E	35	Provide Counter Service for Military Pay Section	66.58	7.62	5.07	11.91
E	10	Compute Changes to MPRS	64.09	6.91	4.43	16.34
E	27	Prepare Coding Sheets of Changes to MPRS	50.12	7.59	3.81	20.14
E	8	Code Changes to MPRS	53.37	6.81	3.64	23.78
E	1	Align Military Pay Records (MPRS) for Pay Computation	60.10	6.00	3.60	27.38
E	22	Make Manual Entries on MPRS	54.36	5.94	3.23	30.61
E	3	Assemble MPRS Into Batches	53.62	5.65	3.03	33.64
E	46	Write Correspondence About Military Pay Matters	52.87	4.92	2.60	36.25
E	28	Prepare Pay Adjustment Authorizations	50.87	4.63	2.36	38.60
E	39	Review or Edit Military Pay Orders on MPRS	45.39	5.18	2.35	40.95
E	33	Process Transfer-In MPRS	31.92	7.25	2.31	43.27
E	18	Maintain Files of Military Pay Documents or Locator Cards	37.41	6.12	2.29	45.55
E	26	Prepare Charge-Out Cards for Military Pay Section	36.91	5.48	2.02	47.57
E	20	Maintain Military Pay Document Control Logs	26.68	7.54	2.01	49.58
E	34	Process Transfer-Out MPRS	28.93	6.88	1.99	51.58
E	5	Audit Change Documents Against MPOS or MPRS	35.16	5.18	1.82	53.40
E	38	Review Military Pay Documents for Edit Errors or Rejections	33.92	5.04	1.71	55.10
E	41	Screen MPRS for Pay Exceptions Before EOM Pay Computation	31.42	5.35	1.68	56.79
E	7	Close or Open MPRS Manually	29.93	5.42	1.62	58.41
E	23	Match Military Pay Orders Against Other Documents	31.42	5.05	1.59	59.99
E	15	Distribute Military Pay Orders or Documents	27.68	5.71	1.58	61.57
E	6	Audit Coded Changes or Manual Entries on MPRS	30.92	4.94	1.53	63.10
E	36	Punch Paper Tape from Input Data Forms	26.68	5.66	1.51	64.61
E	13	Coordinate Processing of Military Pay Documents with Other Accounting and Finance Sections	29.18	4.74	1.38	65.99
E	29	Prepare Posting Media for Military Pay Section	23.94	5.57	1.33	67.33
E	17	Key Punch Military Pay PCAM Cards	25.44	5.09	1.30	68.62
E	31	Process Separation or Discharge Actions	22.44	5.54	1.24	69.87
E	43	Sort Military Pay Change Documents	24.69	4.70	1.16	71.03
E	4	Assign Control or Document Numbers to Military Pay Orders or Documents	21.20	5.20	1.10	72.13
E	45	Verify Military Pay PCAM Cards	20.70	5.18	1.07	73.20
A	12	Interpret Accounting and Finance Procedures to Subordinates	20.20	4.43	0.89	74.10
E	19	Maintain Files of Military Pay PCAM Cards	18.95	4.58	0.87	74.97
E	16	Gather Military Pay Documents or Papers for Audit	20.45	4.09	0.84	75.80
E	32	Process Submission of MPRS to AFAFC	21.45	3.81	0.82	76.62
E	21	Maintain Military Pay Manuals	23.19	3.43	0.79	77.41

APPENDIX VIII

TASK JOB DESCRIPTION FOR CIVILIAN PAY (N=14)

D-TSK	TASK TITLE	PERCENT OF MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY MEMBERS PERFORMING	AVERAGE PERCENT TIME SPENT BY ALL MEMBERS	CUMULATIVE SUM OF AVERAGE PERCENT TIME SPENT BY ALL MEMBERS
K 30	Process Payroll Changes for Civilian Employees	92.86	6.33	5.88	5.88
K 21	Prepare Computer Input for Civilian Pay Actions	92.86	6.21	5.76	11.64
K 31	Process Time and Attendance Report	92.86	5.35	4.97	16.60
K 28	Process and Post Basic Documents Authorizing Pay and Changes of Pay for Civilian Employees	85.71	5.01	4.30	20.90
K 7	Compute or Post Allowances, Deductions, or Differentials for Civilian Pay	85.71	4.93	4.22	25.12
K 38	Verify Accuracy of Payments to Civilians	92.86	4.51	4.19	29.31
K 17	Make Payroll Adjustments for Civilian Pay	100.00	4.01	4.01	33.33
K 10	Initiate Card Change to Civilian Pay Accounts	78.57	4.55	3.58	36.90
K 25	Prepare Payroll Change Slips for Civilian Employees	64.29	5.42	3.48	40.39
K 12	Maintain Civilian Individual Leave Records	92.86	3.67	3.40	43.79
K 26	Prepare Posting Media for Civilian Pay Transactions	64.29	4.94	3.17	46.97
K 13	Maintain Files of Civilian Pay Documents	92.86	3.38	3.14	50.10
K 6	Compute or Post Allotments for Civilian Pay	78.57	3.63	2.85	52.95
K 32	Open or Close Civilian Pay Records	85.71	3.25	2.78	55.74
K 29	Process Civilian Cash Awards	85.71	3.18	2.72	58.46
K 1	Audit Individual Leave Records	92.86	2.84	2.63	61.10
K 11	Issue Civilian Pay Earning Statements	71.43	3.42	2.44	63.54
K 8	Compute or Post Special Pay for Civilians Such as Firefighter Pay	85.71	2.80	2.40	65.94
A 3	Coordinate with Base Data Systems for Preparation of Machine Listings	50.00	4.30	2.15	68.09
K 24	Prepare Individual Pay Records for Civilian Employees	64.29	3.25	2.09	70.18
K 9	Examine Civilian Payroll Control Register	50.00	3.92	1.96	72.14
K 19	Post Service History and Physical Data to Individual Retirement Records	57.14	3.11	1.78	73.92
K 36	Re-establish Civilian Pay and Leave Records	64.29	2.72	1.75	75.67
K 15	Maintain Payroll Control Register for Civilian Employees	42.86	3.93	1.68	77.35
K 5	Collect Civilian Pay Data for Report of Accounting and Finance Activities	42.86	3.90	1.67	79.02
K 20	Prepare Bond Issuance Schedules for Civilian Employees	50.00	3.10	1.55	80.57
K 18	Post Civilian Pay Expense Distribution	50.00	3.01	1.50	82.08
K 14	Maintain Insurance Application File	57.14	2.32	1.32	83.40
K 22	Prepare Employee's Federal or State Tax Report	50.00	2.33	1.17	84.56
K 23	Prepare Employer's Federal or State Tax Report	42.86	2.49	1.07	85.63
A 18	Plan Implementation of Conversion from Manual to Mechanized Accounting	14.29	5.41	0.77	86.41
K 33	Reconcile Civilian Pay Commitments or Obligations With Fund Ledgers	21.43	3.26	0.70	87.10
H 47	Review Disbursement, Collection, or Adjustment Vouchers	7.14	8.82	0.63	87.73
H 9	Determine Validity of Documents Giving Basis for Cash or Check Transactions	14.29	3.96	0.57	88.30
D 8	Give Informal Training to Individuals	14.29	3.87	0.55	88.85

APPENDIX IX

SAMPLE DIFFERENCE DESCRIPTION

GROUP 1 = APPRENTICE DENTAL LABORATORY TECHNICIANS (N=30)
GROUP 2 = JOURNEYMAN DENTAL LABORATORY TECHNICIANS (N=272)

D-TSK		TASK TITLE	PERCENT PERFORMING, GROUP 2	PERCENT PERFORMING, GROUP 1	DIFFERENCE IN PERCENT PERFORMING GROUP 1 MINUS GROUP 2
K	14	Perform Dental Assistant Functions	12.87	33.33	20.47
G	3	Mix and Prepare Slurry Water	51.10	70.00	18.90
H	14	Flask Complete Dentures	54.78	73.33	18.55
M	6	Maintain Boilout Tanks	52.57	70.00	17.43
G	10	Mix or Prepare Duplicating Materials	20.96	36.67	15.71
I	3	Prepare Matrix for Denture Repair	54.41	70.00	15.59
M	7	Maintain Dehydrating Equipment Ovens	11.40	26.67	15.27
H	20	Pack Acrylic Dentures	54.78	70.00	15.22
H	10	Cure and Deflask Complete Dentures	55.51	70.00	14.49
H	26	Trim Casts	55.51	70.00	14.49
J	26	Trim and Wax-Dip Refractory Casts of Removable Partial Dentures	13.24	26.67	13.43
H	3	Articulate Cases	63.60	76.67	13.06
H	11	Eliminate Wax from Denture Molds	56.99	70.00	13.01
H	4	Bead, Box, and Pour Final Impression to Produce Stone Master Cast	47.06	60.00	12.94
H	9	Construct Trial Baseplates and Bite Rims	49.26	60.00	10.74
J	21	Soak Master Casts	29.78	40.00	10.22
M	13	Maintain Hanau Articulator and Articulator Mounting Plates	53.31	63.33	10.02

TASKS OMITTED WHERE DIFFERENCES IN PERCENT PERFORMING = 10.00 THROUGH -20.00

D-TSK		TASK TITLE	PERCENT PERFORMING, GROUP 2	PERCENT PERFORMING, GROUP 1	DIFFERENCE IN PERCENT PERFORMING GROUP 1 MINUS GROUP 2
K	17	Solder Units of Fixed Partial Dentures	33.46	13.33	-20.12
B	4	Supervise Dental Laboratory Specialists (AFSC 98250)	20.22	0.00	-20.22
M	16	Maintain Manual Casting Machines	33.82	13.33	-20.49
K	9	Fabricate Stone Dies	40.81	20.00	-20.81
I	9	Replace Tube Teeth or Facings	41.18	20.00	-21.18
K	15	Pickle or Heat Treat Gold Inlays, Crowns, or Pontics	37.87	16.67	-21.20
K	1	Cast Gold Crown, Inlay, or Pontic Backing	38.24	16.67	-21.57
K	19	Test Occlusion and Fit of Inlays, Crowns, or Fixed Partial Dentures	38.60	16.67	-21.94
I	8	Repair Metal Parts of Removable Partial Dentures	25.37	3.33	-22.03
B	13	Supervise the Fabrication of Dental Prosthetic Appliances	22.06	0.00	-22.06
K	10	Finish and Polish Gold Alloy Inlays, Crowns, or Fixed Partial Dentures	38.97	16.67	-22.30
K	18	Sprue, Invest, and Burn Out Gold Alloy Inlays, Crowns, or Pontics	38.97	16.67	-22.30
K	13	Grind in Porcelain or Acrylic Facings and Pontics	39.71	16.67	-23.04
K	2	Construct and Articulate Casts	43.38	20.00	-23.38
K	5	Fabricate Acrylic Resin Jacket Crowns	32.72	6.67	-26.05

APPENDIX X

EXAMPLE INDIVIDUAL JOB DESCRIPTION

CASE CTRL NUMBER = 1134
NAME = WITHHELD
GRADE = E-3 (A1C)
TOT MOS AFMS = 015
NO' SUBORDINATES = NONE
MAJOR COMMAND = AIR FORCE SYSTEMS COMMAND
PRES WORK ASGNMT = CIVILIAN PAYROLL CLERK
EDUCATION LEVEL = 14
PLAN TO RE-ENLIST = PROBABLY YES
I FIND MY JOB = FAIRLY INTERESTING
UTIL OF TAL/TRNG = FAIRLY WELL
JOB INSIDE US = YES
SUM TIME - CIV PAY = 99.9910,
ORGANIZATION/BASE = AEROSPACE MEDICAL DIVISION AFSC BROOKS AFB TEXAS

D-TSK	TASK TITLE	Per Cent Time Spent	Cumulative Per Cent
K 24	Prepare Individual Pay Records for Civilian Employees	8.00	8.00
K 30	Process Payroll Changes for Civilian Employees	6 67	14 67
K 17	Make Payroll Adjustments for Civilian Pay	6.67	21.33
K 15	Maintain Payroll Control Register for Civilian Employees	5.33	26.66
K 25	Prepare Payroll Change Slips for Civilian Employees	5.33	32.00
K 31	Process Time and Attendance Report	5.33	37.33
K 7	Compute or Post Allowances, Deductions, or Differentials for Civilian Pay	5.33	42.66
K 38	Verify Accuracy of Payments to Civilians	5.33	48.00
K 21	Prepare Computer Input for Civilian Pay Actions	5.33	53.33
K 28	Process and Post Basic Documents Authorizing Pay and Changes of Pay for Civilian Employees,	5.33	58.66
K 19	Post Service History and Physical Data to Individual Retirement Records	4.00	62.66
K 6	Compute or Post Allotments for Civilian Pay	4.00	66.66
K 12	Maintain Civilian Individual Leave Records	4.00	70.66
K 13	Maintain Files of Civilian Pay Documents	4.00	74.66
K 29	Process Civilian Cash Awards	4.00	78.66
K 11	Issue Civilian Pay Earning Statements	2.67	81.33
K 1	Audit Individual Leave Records	2.67	83.99
K 8	Compute or Post Special Pay for Civilians Such as Firefighter Pay	2.67	86.66
K 10	Initiate Card Change to Civilian Pay Accounts	2.67	89.33
K 32	Open or Close Civilian Pay Records	2.67	91.99
K 22	Prepare Employee's Federal or State Tax Report	1.33	93.33
K 2	Balance With Carriers on Each Type of Insurance Option	1.33	94.66
K 14	Maintain Insurance Application File	1.33	95.99
K 20	Prepare Bond Issuance Schedules for Civilian Employees	1.33	97.32
K 36	Re-establish Civilian Pay and Leave Records	1.33	98.66
K 23	Prepare Employer's Federal or State Tax Report	1.33	99.99

GENERALIZATION AND CURRICULUM DEVELOPMENT

James W. Altman
Datagraphics, Incorporated

Introduction

This discussion is limited to an attempt to answer essentially just the following two questions:

1. What varieties of transfer of training should the curriculum developer try to engineer, or at least take into account, in his design?
2. What are the principal determinants of direction and magnitude for each variety of transfer?

No attempt will be made to cover the topic of individual differences in any systematic way, despite the importance of allowing for such differences in curriculum design. Neither will any effort be made to estimate the extent to which different human characteristics are innate or amenable to change at different stages of individual development, even though assumptions concerning modifiability through experience are inherent to the curriculum design process. It is assumed in this discussion that the kinds of transfer identified will have relevance across a broad range of individual differences and many different kinds of characteristics and developmental stages. It will remain to the individual curriculum developer to apply these individual difference and modifiability considerations to particular transfer situations.

Our discussion will be organized around the following eight kinds of transfer or generalization:

1. Reinforcement expectancy
2. Stimulus repertory
3. Response repertory

62/63

4. Stimulus association
5. Response association
6. Task repertory
7. Meaningfulness
8. Self-directed tendency

Throughout, we will be concerned with cognitive, skill, and affective generalization.

Reinforcement Expectancy

The reinforcement expectancies brought by a given individual to the performance of a given task are a function of the reinforcement schedules to which the individual has been exposed in the past. Three major factors influence the saliency of prior reinforcement schedules:

1. The similarity of prior tasks (to which a given reinforcement schedule applied) to the particular task whose performance is under consideration. Other things being equal, the more similar the tasks the greater the influence of the reinforcement schedule under which prior performance was learned and maintained.

2. The recency with which the individual was exposed to a particular reinforcement schedule. Other things being equal, the more recent schedules will have greater effect.

3. The primacy with which an individual was exposed to a particular reinforcement schedule. Other things being equal, the initial reinforcement schedule to which the individual was exposed in any clearly differentiable area of activity will have a disproportionately long lasting and broadly generalized effect. In particular, repeated exposure to a pattern of failure and punishment may deeply condition affective reactions which are incompatible with effective learning.

Four characteristics of the reinforcement schedule are of particular importance in determining generalization from one performance to another:

1. Frequency
2. Strength
3. Relevance
4. Ratio

Frequency

An individual who has been on a high ratio of reinforcement will tend to extinguish his generalization from one situation to another very quickly unless he also receives a high ratio of reinforcement on later performances. In contrast, an individual who has learned to maintain (or improve) his performance on a reduced, especially a periodic, schedule of reinforcement will tend to continue to generalize his performance from one task to a related one with a much lower frequency of reinforcement.

Perhaps an imprecise but cogent moral can be drawn here: the ability to perform basic tasks well and to maintain that high level of performance without external reinforcement is an excellent basis for efficient transfer to related tasks. Tasks which require a high ratio of non-intrinsic reinforcement for performance maintenance will tend not to transfer efficiently.

Strength

There is a great deal of evidence that strong negative reinforcement can be disruptive to learning, or at least a great deal less efficacious than positive or mild negative reinforcement. Although the evidence for it is much more ambiguous and the effect less, it is probably true that excessively strong positive reinforcement can also be somewhat disruptive to learning. In any event, it seems to be a good expectation that tasks learned under conditions of excessively strong reinforcement will transfer some of the disruptive motivational effects. In contrast, a task which has been learned as a pleasant experience is likely to generalize positive anticipations to a new, but related, task learning situation.

Relevance

It is a widely accepted principle that any activity in which the learner spontaneously engages can be used as a source of positive reinforcement in learning a new task. Without explicating the underlying principle, skilled teachers have commonly used the opportunity to exercise valued skills as a selective reinforcer, as well as a mechanism for maintaining and enhancing the previously acquired skills. To the extent that the previously mastered task is related to the task being learned, the acquired task can be not only a source of reinforcement, it can also transfer skill components directly to the new task being learned.

Ratio

Success of task performance can be a major source of positive reinforcement, and failure a major source of negative reinforcement. There is a great deal of evidence (Atkinson & Feather, 1966) that the relative strength of the tendency to achieve success versus the tendency to avoid failure generalizes for a given individual across a variety of situations and is relatively enduring.

It is suggested that the frequency with which the individual meets success early versus failure, and the nature of consequences which flow from success versus failure have a powerful influence. That is, an individual who has frequently encountered success, has received relatively satisfying consequences, and has not experienced either excessive amounts of or consequences from failure will tend to be mostly achievement motivated. In contrast, an individual who has experienced mostly failure or relatively severe consequences from failure will tend to be more motivated to avoid failure than to seek success.

We may note also that an individual with any significant achievement motivation will tend to lose motivation in a situation where the challenge is either too great for a reasonable probability of success or where skills are sufficient to ensure success. Maximum appeal will be presented by new tasks of intermediate (around 50 percent chance of success) difficulty. In contrast, the individual whose primary motivation is the avoidance of failure will prefer situations where successful performance is ill-defined and avoid learning situations involving clear definitions of success, particularly those with intermediate chances of success.

Stimulus Repertory

Prior familiarity with the stimulus clusters involved in the performance of a new task can facilitate the learning of that task. Almost always, such prior familiarity will result in positive effects on the learning process, not in conflict or negative transfer. Thus, exposure to and familiarization with a wide variety of stimulus situations seem to be educationally valid and unambiguously beneficial to the student. The pleasant personalizations used in introducing very young children to letters and numbers, for example, seem to have merit in building an educationally relevant stimulus or perceptual repertory for the child.

Response Repertory

Just as the student's ability to cope with new tasks may be facilitated by prior familiarization with relevant stimulus configurations, it may also be facilitated by a previously established repertory of relevant responses. As with the building of a stimulus repertory, a rich and varied response repertory will almost never conflict with new learning. It may lack relevance and contribute nothing, but if it has relevance it will contribute in a positive manner to the learning of new tasks.

Both stimuli and responses, however, tend to have associative qualities which can be troublesome as well as desirable. The associative qualities of stimuli and of responses will be discussed in turn.

Stimulus Association

Based on his prior experience, the student develops expectations concerning the responses that will be associated with particular stimulus configurations. Thus, if a stimulus pattern is involved in a prior task, the student will tend to expect the same response to be demanded in a later task.

If this expectation is correct, positive transfer of learning will occur. However, if the student activity demanded in response to the original stimulus pattern is different for the new task, negative transfer of learning will occur. The greater the number of stimuli from the original task which demand the same response in the transfer task, the greater the amount of positive transfer from stimulus association. Conversely, the greater the number of stimuli from the original task which demand different responses in the transfer task, the greater the amount of negative transfer from stimulus association. Both types of effects from stimulus association may occur for a given pair of prior and transfer tasks, tending to cancel out each other.

Response Association

Response association has effects very analogous to those for stimulus association. Except that here we are concerned with the nature of expectations that students will have for responses demanded in the transfer task rather than those they will have for stimuli involved. Thus, the student will tend to expect the same stimuli to elicit a given response on the transfer task as elicited it on the original task.

If this expectation is correct, positive transfer will occur. However, if the stimuli which elicit the response on the new task are different, negative transfer of learning will occur. The greater the number of responses on the transfer task which are elicited by the same stimuli as in the original task, the greater the amount of positive transfer from response association. Conversely, the greater the number of responses on the transfer task which are also demanded by the original task but by different stimuli, the greater the amount of negative transfer from response association. Both types of effects from response association may occur for a given pair of prior and transfer tasks, tending to cancel out each other.

One can readily see that stimulus association and response association are closely related in that the identical stimulus-response bonds for original and transfer tasks enter into both types of association. However, the two types of association are not necessarily the same. For example, none of the responses from the original task may be involved in the second task--resulting in no response association. Yet, all of the stimuli involved in the original task may also be involved in the transfer task, but eliciting quite different responses from those in the original task. This would result in a high degree of negative transfer from stimulus association.

Task Repertory

Education is concerned with the student's task repertory in at least two important ways. First, education is supposed to provide the student with tasks which will have significant utility over some non-trivial period of time--and preferably throughout his remaining life. Values involved in the selection of tasks include compatibility with social objectives; the individual's capabilities, limitations, and motivations; and the constraints under which the educational process must be carried out--all considerations which we cannot afford to discuss in this paper. However, there is an additional consideration which is particularly poignant here: tasks for which education provides an opportunity to achieve performance capability should be basic in some sense. That is, they should have broad rather than narrow applicability in the student's life.

What this broad applicability means is a source of seemingly endless debate among educationists. We shall not seek to fuel the fires of that debate, except to point out that the kinds of analyses implied herein for determining generalization potential within the educational process almost certainly have relevance to the determination of what task capabilities are likely to generalize most broadly to future life situations.

The second way in which education is concerned with the student's task repertory is the concern for exploiting performance capabilities acquired in previous task learning in the learning of future tasks. In a very real sense, this is precisely the issue which we have been addressing in our discussion of the previous five types of generalization. To Dr. Robert M. Gagne (1965, for example), we can ascribe credit for pointing out what has very quickly come to be accepted as obvious--there is considerable merit in identifying behavioral clusters whose mastery can contribute to future learning in a direct and total fashion.

Thus, one cannot only identify dimensions of task similarities, he can also identify useful subtask and task units which, if properly mastered, can be fitted in their entirety into larger performance units. Such sequential or hierarchical fitting of learned tasks into future performances can lead to essentially perfect positive transfer of training.

Meaningfulness

We have identified some of the characteristics of task learning situations which make for transfer from one situation to another. Thus far, we have simply looked at reinforcement and task similarities as a basis for generalization of learning. There are also reasons to believe that students can profit from the structuring of intellectual capabilities within a broad cognitive structure (Ausubel, 1963).

Perhaps the central fact about the added efficiency to be gained in learning and retaining within meaningful structures is that cognitive structuring takes place within the student. Structuring the curriculum does not necessarily mean that additional meaningfulness will be imparted to the student. Rather, as he acquires new information and capabilities, they must be actively integrated with and differentiated from his existing repertory. The curriculum design can facilitate such integration and differentiation both through its own structure and from the nature of practice situations provided as individuals acquire new knowledge and skills.

Self-Directed Tendency

In discussing reinforcement expectancies, we touched briefly on the effect of reinforcement schedules on achievement motivation. There is, however, a great deal more to the student's acquisition of self-directed learning tendencies. Most educationists would probably agree that a, perhaps the, major goal of education is to generate increased potential and motivation in the individual to undertake self-directed learning.

We have already identified one characteristic of learning situations which is conducive to undertaking the learning of tasks for which failure is not only possible but also moderately likely. This characteristic involves exposing the individual to learning situations for which failure is neither almost certain nor will result in severe consequences.

But there is another side to this. Bandura (1969) has demonstrated, across a wide variety of situations, that individuals who are themselves directly given positive reinforcements or who see others generally rewarded for low quality performance will tend to apply inadequate standards to their own self-monitored performance. He has also reported that young people are sensitive to inconsistency in the application of standards by authority figures--with level of self-applied standards suffering significantly from observation of such seeming inconsistencies.

There is also another side to our prior observation that achievement-oriented individuals will tend to lose their propensity for a particular task as their skills develop to the point where they can always succeed at the task. First, given some reason for excellence of task performance, the individual may raise his standards for performance on the task to the point where he will implicitly non-reinforce his own performance for levels of achievement which others would consider more than satisfactory. Second, given the appropriate broad goal and access to information concerning the performance capabilities required to achieve it, the individual is likely to initiate his own progression of learning from easier to increasingly more difficult tasks. His progress can be self-monitored and reinforced. But for the individual to undertake such a self-directed course of learning, certain conditions must obtain (Brehm & Cohen, 1962):

1. The individual must perceive a dissonance between his current state of capability and some desired state.

2. The individual must correctly perceive that the situational context is one which will permit him to acquire capabilities on his own volition and under his own performance monitoring.
3. The individual must perceive that new capabilities will reduce the dissonance between his current and his desired state.

Of course, the greater the successful experience with self-directed learning, the greater generalized tendency the individual will have for it.

Conclusion

To the best of my knowledge, no major curriculum development effort has systematically tried to exploit all of these types of generalization. Without such a systematic attempt, it is difficult to believe that educational optimization will be approached.

REFERENCES

Atkinson, J.W., & Feather, N.T. (Eds.) A Theory of Achievement Motivation. New York: John Wiley, 1966.

Ausubel, D.P. The Psychology of Meaningful Verbal Learning. New York: Grune & Stratton, 1963.

Bandura, A. Principles of Behavior Modification. New York: Holt, Rinehart and Winston, 1969.

Brehm, J.W., & Cohen, A.R. Explorations in Cognitive Dissonance. New York: John Wiley, 1962.

Gagne, R.M. The Conditions of Learning. New York: Holt, Rinehart and Winston, 1965.

AN EMPIRICAL PROCEDURE FOR IDENTIFYING THE STRUCTURE OF THE TECHNICAL CONCEPTS POSSESSED BY SELECTED WORKERS

Jerome Moss, Jr. and David J. Pucel
Brandon B. Smith,
Frank C. Pratzner

Minnesota Research Coordinating Unit for Vocational Education
University of Minnesota

The Problem

The identification of the concepts to be learned and the manner in which they should be organized for instruction are critical steps in the process of vocational curriculum development. Vocational educators now lack the techniques required to accurately and precisely identify the nature and structure of the cognitive competencies actually required for satisfactory job performance in an occupation or a group of occupations. As the importance of cognitive competencies to occupational performance continues to increase in relation to psychomotor competencies, the inadequacies of current analysis techniques will become even more debilitating.

The present methods of selecting and organizing informational content for vocational programs typically begin with the subjective, inferential identification of needed cognitive competencies. Workers are observed and the specific knowledge believed to be needed to perform occupational tasks is inferred; supervisors are asked to estimate the concepts needed by satisfactory workers; or workers are asked to tell what they know. And in each case the results are biased by investigator suggestion, by perceptions of social acceptability, by lack of ability to consciously introspect or to observe, or by unrealistic occupational expectations. After subjectively identifying the cognitive competencies of the occupation (usually in the form of lists of objectives or content topics), "experts" try to logically organize and arrange content into what is hoped will be a psychologically efficient manner. Rarely do two independent attempts at analyzing occupations or organizing content ever conclude with identical or even similar results.

Recent attempts to form occupational "clusters" have used similar subjective techniques to identify the knowledge common to several occupations. Moreover, in forming clusters, these attempts have completely ignored the very real possibility that the most efficient functional organization of that "common" knowledge may be quite different in each of the occupations concerned.

From a more general viewpoint, educational theorists have been expounding the belief (Ausubel, 1963; Bruner, 1960; Mandler, 1962) that content organization is an important variable in student learning. A problem common to all persons trying to investigate the effects of content organization upon learning is to empirically determine the optimal content organization that, if developed by learners, would allow them to most efficiently apply the content learned.

The three studies conducted to date at the Minnesota Research Coordinating Unit (Moss and Pucel, 1967; Smith, 1968; Pratzner, 1969) are an attempt to develop and test an empirical, objective procedure for identifying both the technical concepts actually possessed by workers on-the-job <u>and</u> their psychological structure. In other words, we have been experimenting with a methodology -- a curriculum tool -- for producing <u>maps</u> of the technical concepts possessed by selected workers. The underlying assumption is that if we can identify persons who are performing on the job in the manner we wish our student to emulate, and if we can empirically identify the psychological organization of the particular conceptual knowledge possessed by these persons, we will then have an organizational structure of the content that can be used as a model toward which we may direct student learning. This is not to say that one need only teach the model. A curriculum needs to be developed that would lead the students to formulate their personal facsimiles of the model conceptual structure.

Rationale for the Procedure

The rationale for this series of studies is based upon the work of James Deese at Johns Hopkins (1962, 1964), Bertram Garskof and John Houston at the University of Michigan (1963), and Paul Johnson at the University of Minnesota (1964, 1967). All of these men are interested in verbal learning problems and use the free association technique to assess the structure of concepts. Their work has made it possible for us to make most of the following assumptions with reasonable assurance.

1. Occupations have bodies of knowledge which are related to quality of performance in the occupation.

2. The technical knowledge of an occupation possessed by an individual is composed of concepts, which are the psychological meanings -- the understandings -- of the things, processes and units of measure of that occupation.

3. Individuals organize their technical concepts into an integrated network or structure; the position of a particular concept in the structure is dependent upon its functional relationship to other concepts.

4. Terms or words can be viewed as verbal labels for underlying concepts.

5. Workers who are performing satisfactorily in an occupation have acquired the verbal tags necessary to identify their concepts.

6. The associative meaning of a concept is defined as the total free associative response distribution which a given stimulus word elicits. (Appendix A provides an illustration of a free association instrument which elicits a free associative response distribution).

7. The concepts underlying the free associative response distribution of words are located in the same psychological environment as the stimulus-word concept; that is, they are located close to the stimulus concept in the individual's conceptual structure. The responses given first represent concepts closer to the stimulus concept than the responses given later.

8. The technical vocabulary of an occupation, which identifies the technical concepts of that occupation, can be determined by repeated administrations of a free-association instrument, which is revised between each administration so as to include the new responses not previously used as stimuli. The procedure is continued until all (or at least all the representative) technical words have been identified.

9. The associative relatedness of <u>two</u> concepts, that is their psychological proximity in the structure of concepts, is determined by the relative amount of overlap between their two response distributions or associative meanings. The greater the similarity or overlap between the free response distributions to the two stimulus word concepts the greater the associative relatedness of the concepts, and the closer they are in the conceptual structure. For example, <u>identical</u> response distributions will be obtained only from two identical stimulus word-concepts, or if two stimulus word-concepts are psychological synonyms and appear in the same conceptual associative environment.

10. The associative structure of technical concepts can be generated for an individual or a group of people by calculating a matrix of associative relatedness measures between all possible pairs of stimulus word-concepts in the technical vocabulary. The magnitude of the relatedness measure indicates the amount of overlap between the response distributions for two stimulus words, and can be viewed as an index of the psychological distance between the two stimulus word-concepts. (Appendix B provides a simple illustration of generating conceptual structure from measures of associative relatedness).

11. The structure of concepts revealed by the matrix of associative relatedness measures is complex and can be simplified by subjecting it to various types of multidimensional solutions to identify the higher-order, more inclusive structural concepts. Higher-order concepts are those whose associative meanings have something in common with the associative meanings of two or more other independent lower-order concepts.

In summary, then, we believe that if persons who are performing optimally in some occupation can be identified, free association methodology can be employed to empirically and objectively identify their technical conceptual structure. We will then possess a model or map which represents the cognitive goals of instruction, and which provides clues for curriculum development.

Methodology

The three investigations conducted at the Minnesota Research Coordinating Unit were designed to develop and test the free association methodology. The first study (Moss and Pucel, 1967) determined that the methodology could yield reliable data and produce a conceptual map with face validity for the radio and television repair occupation. The second study (Smith, 1968) showed that the methodology resulted in conceptual maps which were sufficiently precise to be related to quality of performance in the radio and television repair occupation. The third study (Pratzner, 1969) successfully replicated the previous work using a "closely related" occupation, radio communications repair; in addition, the study compared the conceptual structures of workers in the two occupations and identified their common or composite conceptual structure.

The two populations employed in the three studies consisted of radio and TV and radio communications customer service repairmen. Each population was comprised of workers who were (a) journeymen with at least three years of trade experience, (b) removed from formal training for at least two years, and (c) currently employed in one of four large firms in the Minneapolis-St. Paul area. The firms had comparable facilities, operating procedures, and salary schedules, and employed at least nine other workers on the same payroll job. Firms and workers in both populations were identified, and the associative data were obtained, at one time for all three studies to insure identical conditions and facilitate within and between occupation comparisons.

A worker identification form which defined "flexible" and "inflexible" workmen was developed to assist immediate work supervisors to select a purposive sample of four pairs of flexible and inflexible workers from each population. "Flexible" workers were defined as those who satisfactorily performed a greater variety of repair tasks than"inflexible" workers. In nominating workers, the supervisors responded to such questions as: (a) Think of the variety or range of customer repair tasks or jobs your technicians are called upon to perform during the course of a year. List in rank order of preference the names of those technicians who satisfactorily perform the greatest and fewest variety of these tasks independently; (b) if a wide variety of kinds of service calls had to be assigned to technicians during the course of a work day, which technicians would you choose to repair the most novel, unusual or complex jobs, and which technicians would you be least likely to choose for these types of jobs? From supervisor nominations, the most and the least flexible workers in each of the four firms in each population were selected for the sample. Information about the backgrounds of the workers in both samples revealed that the flexible and the inflexible workers were very similar in terms of age, length of occupational experience, and in amount, kind and recency of vocational training.

Since the studies were considered exploratory, there was no real concern about producing complete conceptual maps that could be used in the development of actual curriculums. Small, local samples of workers were therefore satisfactory. Similarly, there was no need in these studies to identify and utilize the complete technical vocabulary of the radio-TV or radio communications service occupations. Instead, several vocational instructors representing each occupation were used to develop two lists of about 450 major technical words each, from which random samples of 163 radio and TV words and 184 radio communications words were then selected. Among the two lists of sample words, 131 were common to both the radio-TV and radio communications occupations. Twenty words from each sample were also randomly selected for later use in testing the reliability of the free association technique.

Each sample list of words (N = 163, N = 184) was randomly arranged into four different forms of free association test booklets in order to cancel out the possible effect of response chaining. One of the booklets was administered to each pair of flexible and inflexible workers in two, two-hour test sessions on successive days. The booklets provided enough space for each worker to write 25 free association responses to each stimulus word on the sample list. A tape recorder, with a signal tone replicated at one minute intervals, was used to control the response time per stimulus word.

The responses to each word by the four flexible workers within each occupation were combined, as were the responses by the four inflexible workers within each occupation. In this "pooling" process, only the responses given by two or more of the four workers in a group were retained. Thus, the "pooled associative meaning" given to each stimulus word by each group of four workers eliminated individual, idiosyncratic responses; it resulted in a relatively unbiased, salient, agreed-upon, rank-ordered associative meaning for each stimulus word.

The majority of calculations in the three studies used a statistic called the Relatedness Coefficient (Garskof and Houston, 1963). The RC is a measure of the extent to which two response distributions overlap; it is therefore a measure of the associative relatedness of two concepts. The size of the RC measure is inversely proportional to the psychological distance between the two concepts; an RC of .00 means no associative relatedness and an RC of 1.00 indicates that the associative meanings of the two concepts are identical.

Appendix C shows an example of the computation of an RC measure using the pooled associative meanings of two stimulus words.

RC measures were first calculated between the pooled response distributions given by each group of four workers to two repeated administrations of twenty identical stimulus words in order to estimate the reliability of free association responses.

The RC statistic was then used to calculate measures of associative relationship between all possible pairs of pooled response distributions to the complete lists of sample stimulus words (N = 163, N = 184) within the flexible and the inflexible worker groups of each occupation. This resulted in two 163 x 163 and two 184 x 184 associative structure matrices which provided the basic data for identifying the conceptual structures of the four groups of workers.

The associative structure matrices were then reduced to simple hierarchical structures by factor analysis using a principle component solution (Harmon, 1967) which was followed by varimax rotations. Operationally, the resulting factors were technically defined by those stimulus words which loaded .300 or above on a factor.

The associative meaning of each factor or cluster was determined by pooling the associative meanings of all of the stimulus word-concepts included in the cluster. The associative meaning of a cluster was interpreted as a higher order stimulus concept and a new higher order matrix of associative similarities was calculated between these concepts and then factor analyzed. This procedure was repeated until it was no longer possible to reduce the number of clusters through factoring. After determining the associative clusters of stimulus words which existed for each group of workers, associative maps were drawn. This procedure resulted in a hierarchical associative conceptual structure for each group of four workers.

The label for each higher-order concept was identified by an internally consistent method using as a base the pooled associative meanings of stimulus word-concepts. In theory, if a higher-order concept has a label, and the initial stimulus word list was exhaustive, the pooled associative meaning of one or more stimulus words would match the associative meaning of the higher-order concepts in the structure. The label for the higher-order concept would then be that stimulus word or words which most closely matched it in pooled associative meaning.

In the second study of the series, RC measures were also used to compare the pooled associative meanings possessed by the flexible and the inflexible radio-TV workers for the same stimulus words. The third study, in addition, compared the pooled associative meanings of the flexible workers in the two different occupations for the stimulus words that the occupations had in common, and then utilized those common words which proved to have highly similar associative meanings to generate a composite conceptual structure for the two occupations.

Results

The following conclusions, based upon the three studies, seem warranted despite the limitations imposed by the particular purposive samples of workers and the sets of stimulus words employed.

1. The pooled response distributions do have satisfactory reliability. The median RC measure in all three studies, for both flexible and inflexible worker groups, was about .80 based upon repeated administrations of twenty randomly selected stimulus words.

2. The associative methodology produces conceptual maps with face validity. Appendices D and E present the labeled technical conceptual structures of stimulus concepts for the groups of flexible radio and television and radio communications equipment repairmen, respectively. When experts in each occupation viewed these maps they immediately recognized the reasonableness and the functional utility of the conceptual structures, despite certain incomplete aspects of the structures due to incomplete stimulus word lists.

3. The conceptual structures of flexible and inflexible workers within each occupation differ in several highly significant ways.
   (a) Experts had some difficulty understanding the logic of the inflexible workers' structures. As an example, Appendix F presents the conceptual map derived from the inflexible radio and television repairmen.

   (b) The flexible and inflexible worker groups in both occupations differed significantly in their associative meanings of 24 and 33 percent of the initial lists of stimulus words. To the extent that associative meanings of stimulus words are different, the resultant conceptual structures of the flexible and inflexible workers must also be different.

   (c) There were visible differences between flexible and inflexible worker groups in the manner in which they organized concepts (see Appendices G and H). The flexible workers' structures were more balanced, integrated and provided for greater differentiation among concepts with specialized meanings than did the inflexible workers. In both occupations the flexible workers had four hierarchical levels of conceptual clusters while the inflexible workers had only three levels; in both occupations the flexible workers possessed over 20 percent more higher-order concepts than did the inflexible workers. The flexible workers therefore appeared to think of content more precisely than did inflexible workers.

   (d) The size of the flexible workers' technical vocabularies was larger than the inflexible workers'. In both occupations the flexible workers gave a greater number of total responses and a greater number of different responses than did the inflexible workers. The flexible workers also tended to agree more upon their responses (longer pooled response distributions) than did the inflexible workers.

(e) Flexible and inflexible groups used their vocabularies in different ways. Different terms assumed major emphasis in the associative usage of the two groups. This indicated that the two groups tended to view their vocabularies from different perspectives.

4. The conceptual structures of flexible workers in the two "closely-related" occupations differ in many significant ways.

(a) Forty-one of the 131 common technical stimulus word-concepts were significantly similar in associative meaning, but 35 words (27 percent) were significantly different (.05 level).

(b) The radio communications group possessed a proportionately larger total vocabulary, gave a greater number of different responses, and agreed more in associative meaning than did the radio-TV group.

(c) Twenty-one words of the common technical vocabulary were used in disproportionate ways by the two groups of flexible workers.

(d) The major portion of the technical clusters in the two associative structures were labeled differently and had different associative meaning for each group. (As previously noted, technical experts agreed that both structures were theoretically consistent and logically defensible).

5. The associative methodology produces composite conceptual structures representing clusters of concepts common to "related" occupations at higher levels of abstraction.

Appendix I depicts the composite technical associative structure of common stimulus word-concepts for flexible workers in the radio-TV and radio communications repair occupations. Electronic experts felt that the composite structure represents clusters of concepts at a more general and abstract level than in either of the two occupational structures. The experts agreed that the composite structure did not logically draw concepts from any particular part or level of the separate structures for flexible workers, but rather integrated concepts from all levels and parts of both structures. [The composite structure was also considered incomplete, but this was anticipated because of the delimited list of original stimulus words used and the criterion employed in defining common words with significantly similar associative meaning.]

In summary, the free association methodology appears to be capable of empirically and reliably generating a conceptual map of a given occupation which has face validity for experts in that occupation. The methodology is sensitive enough to produce maps which differentiate between workmen performing the same tasks at different qualitative levels. The methodology also provides a means to identify the composite conceptual structure of two or more occupations.

The results of the series of investigations completed to date provide strong encouragement for further basic study of the free association methodology and of its applications to curriculum development and to the evaluation of achievement.

The present studies have not established a causal relationship between conceptual structure and performance, although such a relationship appears logically reasonable. A study underway is therefore designed to determine whether pre-selected "flexible" and "inflexible" structures can be deliberately taught to students and, if learned, whether the structures will differentially effect the functional use of the concepts involved.

Another needed area of study is exploration of the sensitivity of the methodology to sampling differences. For example, if several samples of "flexible" workers in the same occupation were compared, how similar would their conceptual structures be?

A third line of basic investigation using the methodology could determine the relationships between conceptual structure and other personal characteristics (e.g. intelligence, cognitive style, creativity).

The development of more efficient computer-based techniques for generating and labeling conceptual structures represent an important fourth area of basic effort.

Perhaps the most fruitful potential applications of the free association methodology are in curriculum development. The procedure does not yield the specific, detailed technical content to be included in a curriculum. It does yield, in the form of conceptual structure, the cognitive goals of instruction with clues to curriculum content selection and organization. The conceptual structure of a given occupation therefore represents the essential starting point for developing curriculum for specialized vocational instruction. The composite conceptual structure of occupational "clusters" provides prerequisite curriculum information for a broader form of vocational or prevocational instruction. In both cases, of course, the conceptual maps depict only the structure of the "best" workers we can presently find; we can never be certain that the structure identified is "ideal." On the other hand, the methodology can be sufficiently automated to insure that occupations can be monitored regularly for change. Consequently, studies might begin to translate conceptual maps into curriculums. For example, conceptual structure could be related to required manipulative competencies. The methodology might be applied to determine desirable worker affective structures. The effects of various content organizations upon the formation of conceptual structure could be studied. The relative efficacy of various kinds of experiences to develop the desired concepts might be investigated.

If conceptual maps are indeed accurate reflections of occupational performance, then the maps should be useful in predicting job satisfactoriness. Pencil and paper tests can be devised which measure key differences between the conceptual structures of "good" and "bad" workmen in an occupation and administered, for example, to vocational students or to prospective vocational instructors as occupational competency examinations.

The foregoing suggestions for further study of the free association methodology and its potential applications is obviously not exhaustive. Rather, it is intended to be suggestive and stimulating to other researchers who, like us, may become intrigued with the possible contributions this methodology may have to the ultimate improvement of vocational education.

SELECTED REFERENCES

Ausubel, D.P. The Psychology of Meaningful Verbal Learning. New York, N.Y.: Grune and Stratton, Inc., 1963.

Bruner, J.S. The Process of Education. Cambridge, Mass.: Harvard University Press, 1960.

Deese, J. "On the Structure of Associative Meaning," Psychological Review 69:161-75, 1962.

Deese, J. "The Associative Structure of Some Common English Adjectives," Journal of Verbal Learning and Verbal Behavior 3: 437-57, 1964.

Garskof, B.D. and Houston, J.P. "Measurement of Verbal Relatedness: An Ideographic Approach," Psychological Review 70:377-88, 1963.

Harmon, H.H. Modern Factor Analysis. Chicago, Ill.: The University of Chicago Press, 1967.

Johnson, P.E. "Associative Meaning of Concepts in Physics," Journal of Educational Psychology 55: 84-88, 1964.

Johnson, P.E. "Some Psychological Aspects of Subject Matter Structures," Journal of Educational Psychology 58:75-83, 1967.

Mandler, G. "From Association to Structure," Psychological Review 69: 415-27, 1962.

Moss, J. and Pucel, D.J. "Using the Free Association Methodology to Determine the Conceptual Structure of Radio and Television Repairmen." Minneapolis, Minn.: Minnesota Research Coordinating Unit for Vocational Education, 1967. (Ditto)

Pratzner, F.C. "Testing an Empirical Procedure for Identifying Technical Associative Conceptual Structure: Discriminating Between Workmen Within and Between Two Occupations." Unpublished Doctoral Thesis. Minneapolis, Minn.: University of Minnesota, 1969. 228 pp.

Smith, B.S. "Testing an Empirical Procedure for Identifying Technical Associative Conceptual Structure: Discriminating Between Flexible and Inflexible Radio and Television Repairmen." Unpublished Doctoral Thesis. Minneapolis, Minn.: University of Minnesota, 1968. 174 pp.

Appendix A

DIRECTIONS

You will be given a key word and you are to write down as many other words which the key word brings to mind as you can. These other words which you write down may be things, places, ideas, events, or whatever you happen to think of when you see the key word.

For example, think of the word, KING. Some of the words which KING might bring to mind are written below:

King Queen

King Cole

King Ruler

King Sky

King Kingdom

King England

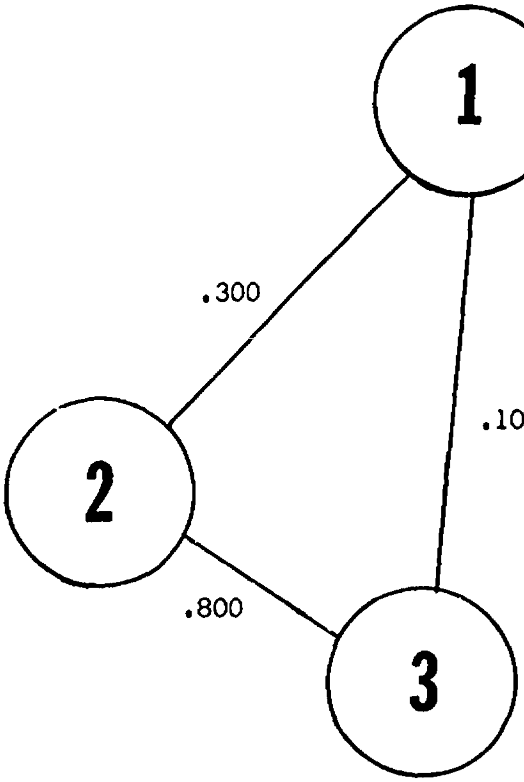
King Imperial

King Kingfish

No one is expected to fill in all the spaces on a page, but write as many words as you can which the key word brings to mind. Be sure to think back to the key word after each word you write down because the test is to see how many other words the key word makes you think of. A good way to do this is to repeat the key word over and over as you write.

Appendix B

AN EXAMPLE OF CONCEPTUAL STRUCTURE: THE PSYCHOLOGICAL RELATIONSHIP AND DISTANCE AMONG A SET OF CONCEPTS



Appendix C

DEFINITION OF (RC) RELATEDNESS COEFFICIENT

The Relatedness Coefficient (RC) is defined as the amount of observed overlap to the maximum possible overlap between two rank order, free association response distributions.

$$RC = \frac{\bar{A} \cdot \bar{B}}{(A \cdot B) - 1}$$

The product (A • B) represents the intersect which would be obtained if every element in A appeared in B (and B in A) and in the same order. A and B are operationally defined by the product sum of the longest rank ordered response distribution of the two stimulus words. Where the two stimulus words are different, a minus one (-1) is used in the denominator to represent an unbiased estimate of maximum overlap. The product $\bar{A} \cdot \bar{B}$ is the product sum of the rank orders of response commonalities observed between two response distributions.

Example

COMPUTATION OF A SAMPLE RC FOR THE STIMULUS WORD YOKE AND DEFLECTION

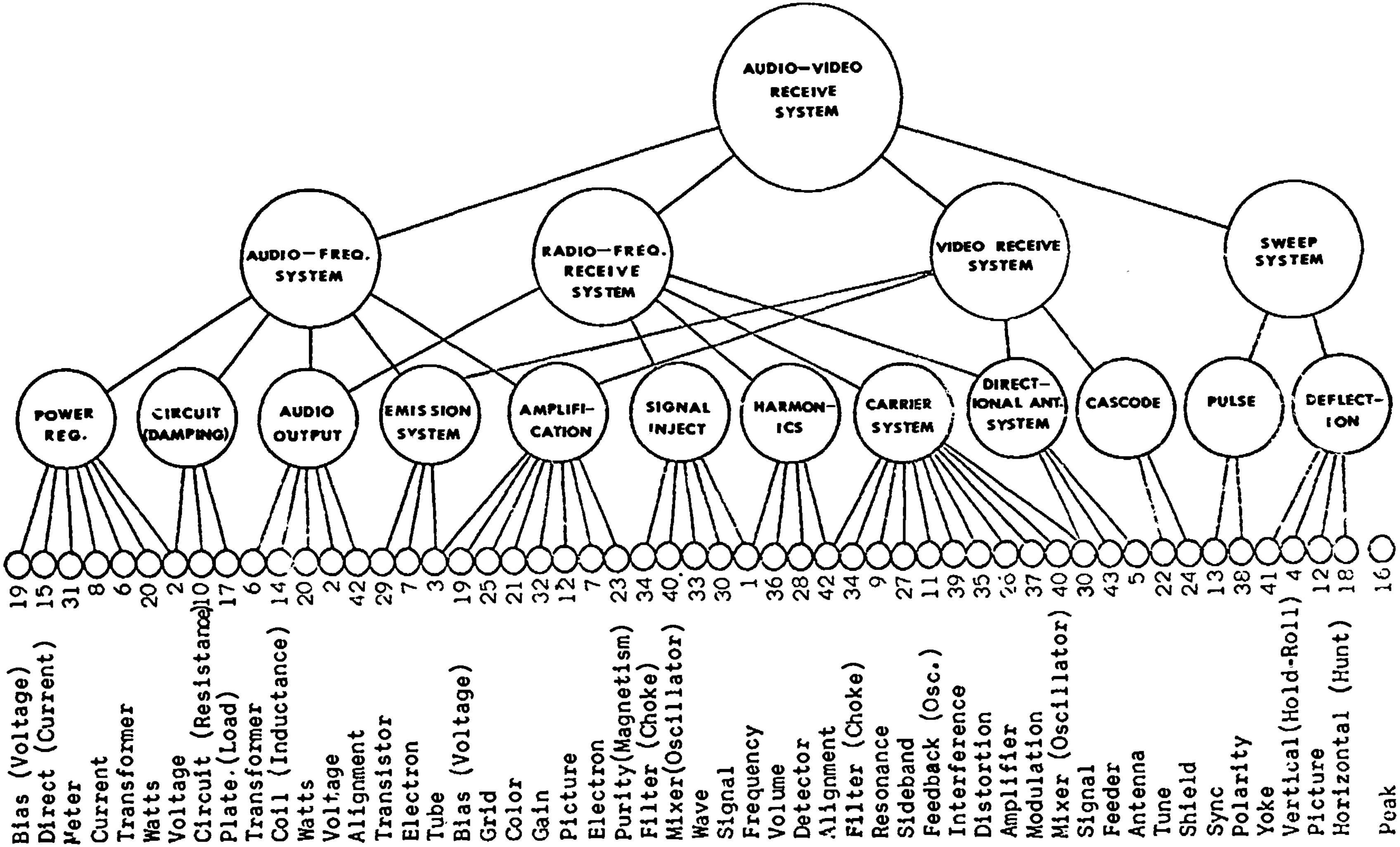
Associates to "Yoke"	Frequency	Rank	Associates to "Deflection"	Frequency	Rank
Yoke	4	6	Deflection	4	6
Deflection	4	5	Yoke	3	5
Horizontal	3	4	Horizontal	2	4
Vertical	3	3	Vertical	2	3
Ringing	2	2	Circuit	2	2
Trapezoidal	2	1			

A = Rank order of responses to "Yoke". (6, 5, 4, 3, 2, 1)
B = Rank order of responses to "Deflection". (6, 5, 4, 3, 2, 1)
C = Common Responses. (Yoke, Deflection, Horizontal, Vertical)
$\bar{A}$ = (6, 5, 4, 3)
$\bar{B}$ = (5, 6, 4, 3)

$$RC = \frac{\bar{A} \cdot \bar{B}}{(A \cdot B) -1} = \frac{(6, 5, 4, 3) \cdot (5, 6, 4, 3)}{(6, 5, 4, 3, 2, 1) \cdot (6, 5, 4, 3, 2, 1) - 1} = \frac{85}{(91 - 1)} = .904$$

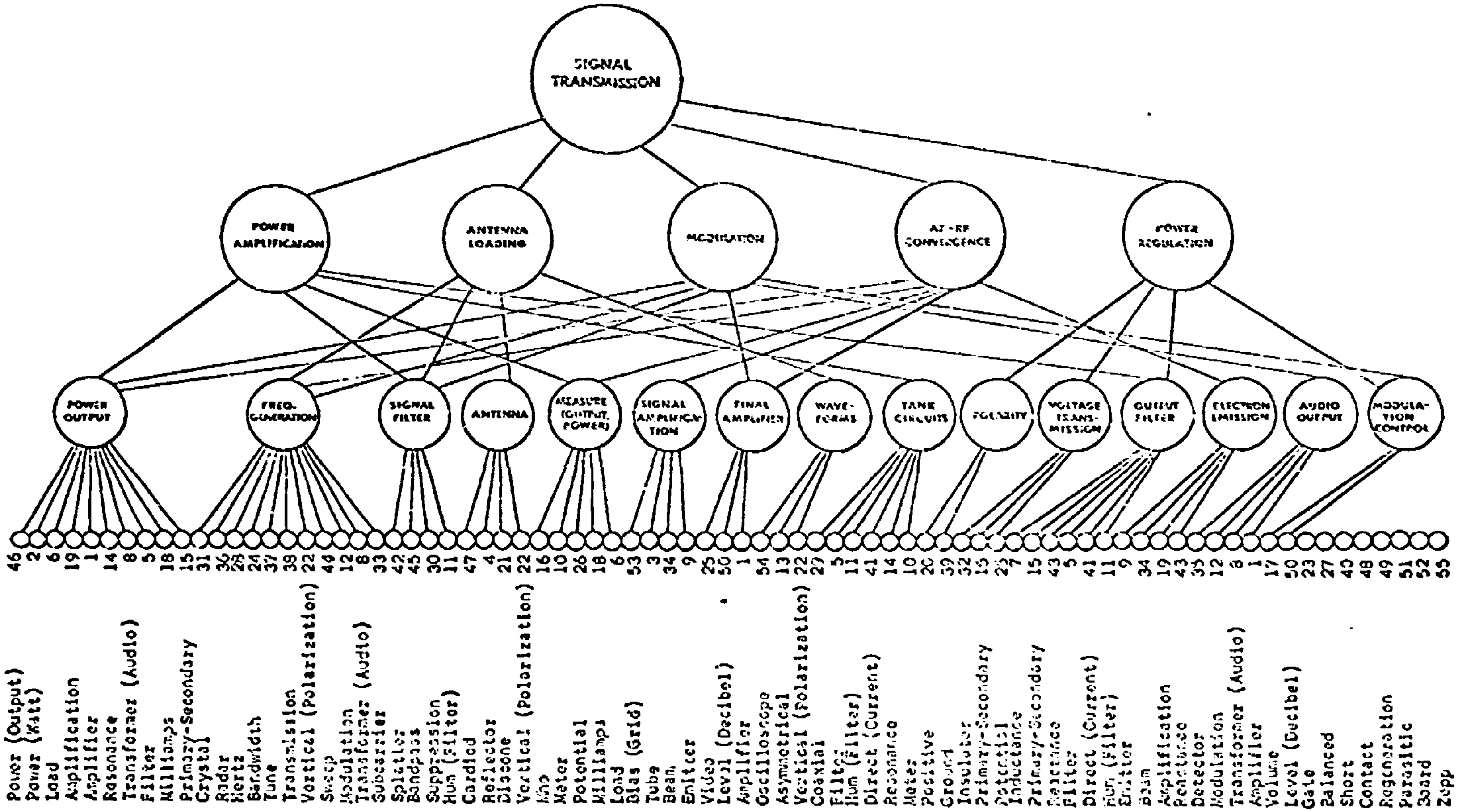
Appendix D

THE LABELED TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS CONCEPTS FOR A GROUP OF FLEXIBLE RADIO AND TELEVISION REPAIRMEN



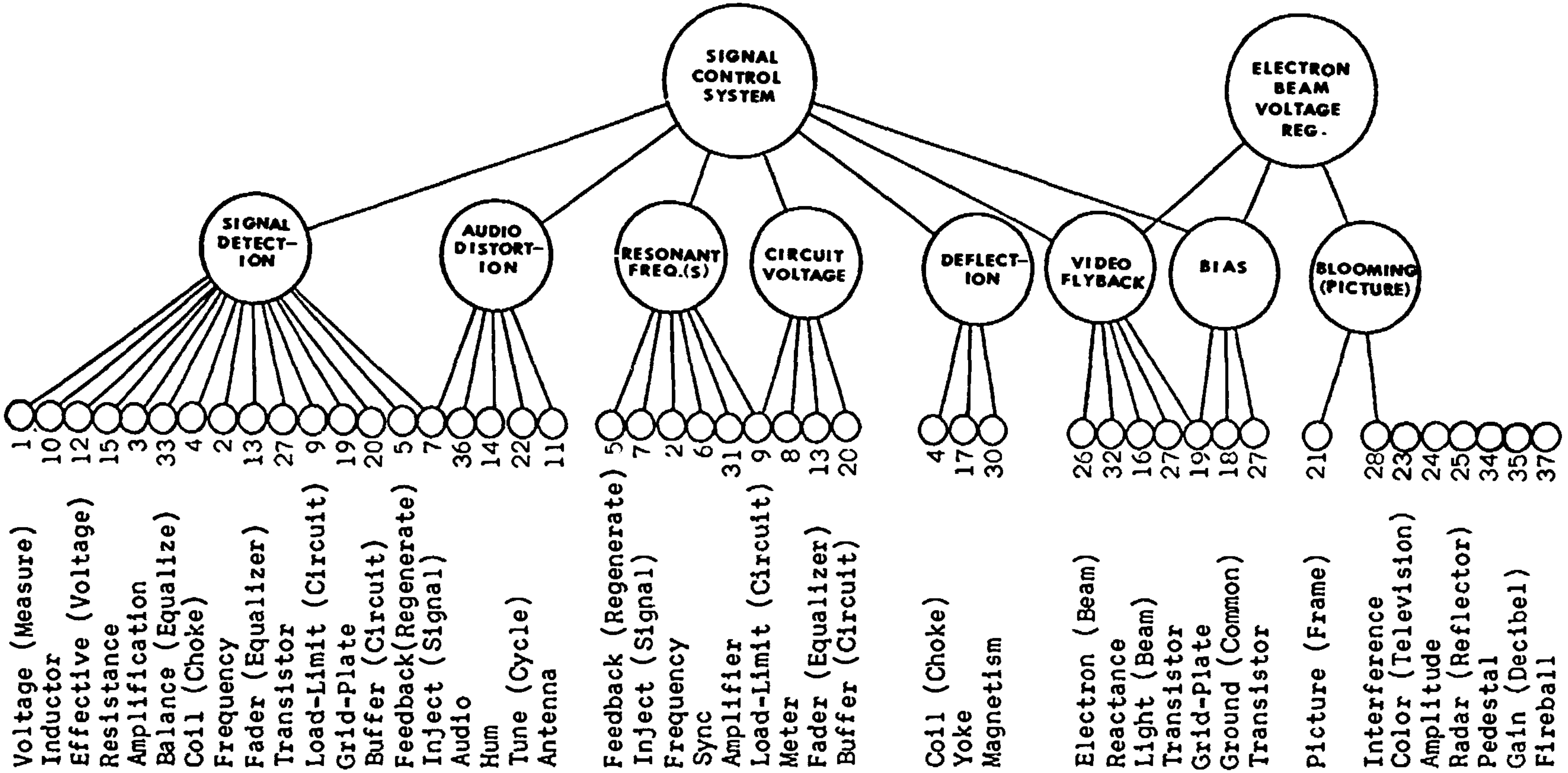
Appendix E

THE LABELED TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS CONCEPTS FOR A GROUP OF FLEXIBLE RADIO COMMUNICATIONS EQUIPMENT REPAIRMEN



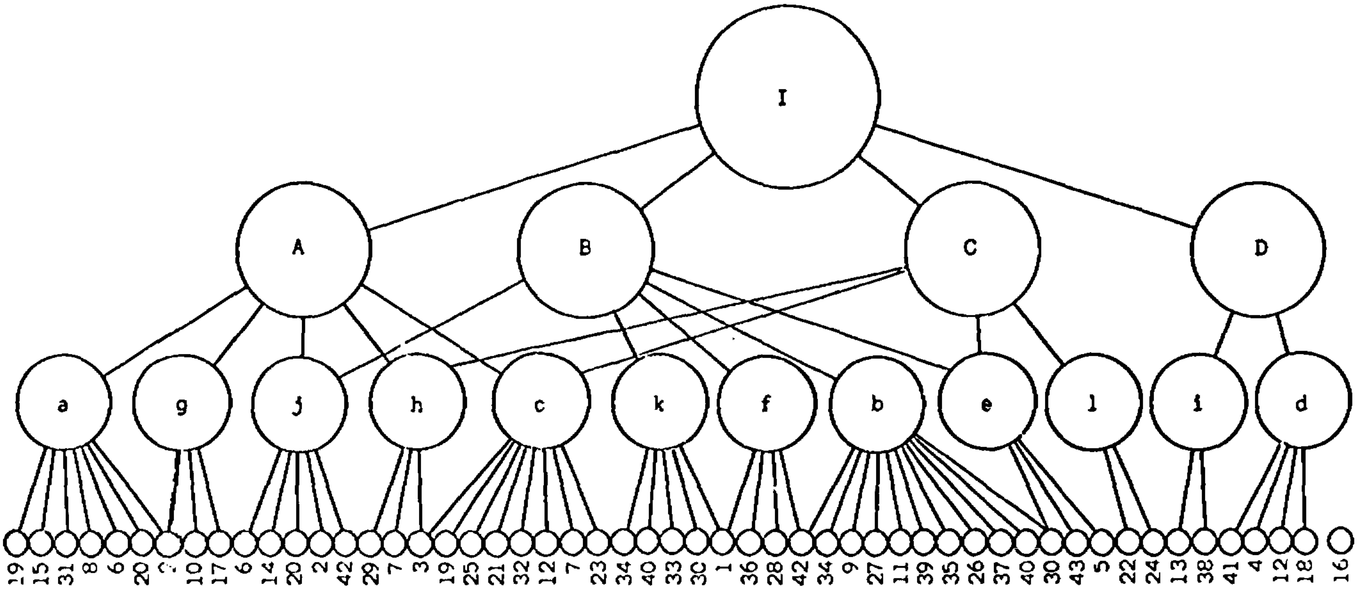
Appendix F

THE LABELED TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS CONCEPTS FOR A GROUP OF INFLEXIBLE RADIO AND TELEVISION REPAIRMEN

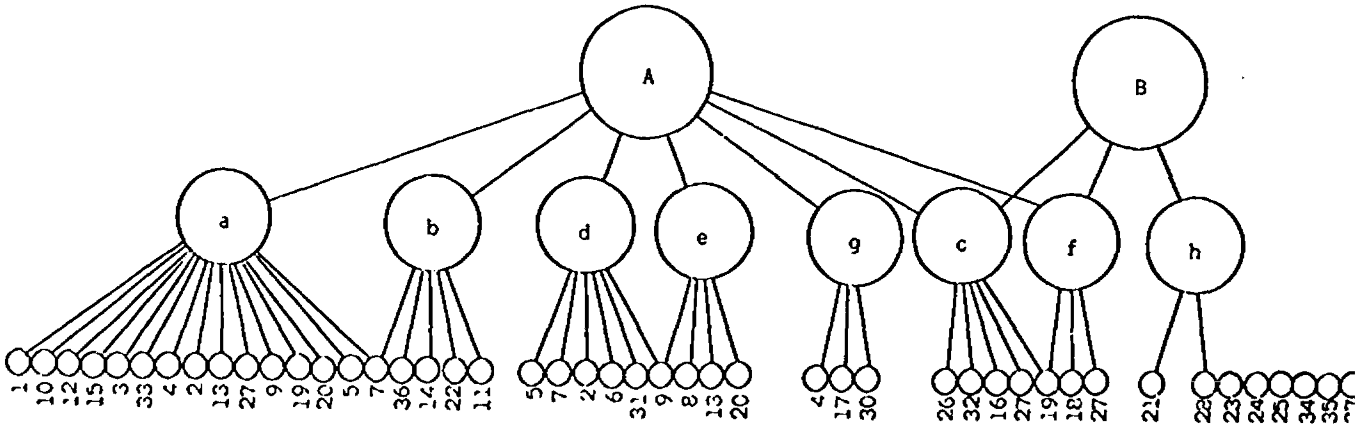


Appendix G

THE TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS WORD-CONCEPTS FOR A GROUP OF FLEXIBLE RADIO AND TELEVISION REPAIRMEN

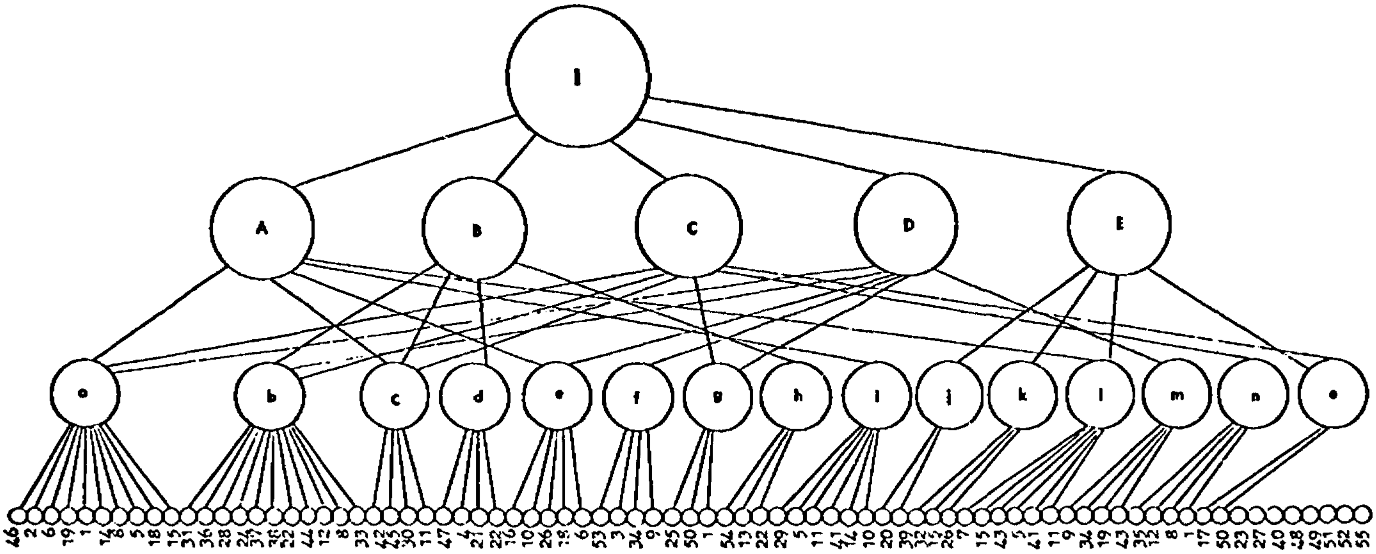


THE TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS WORD-CONCEPTS FOR A GROUP OF INFLEXIBLE RADIO AND TELEVISION REPAIRMEN

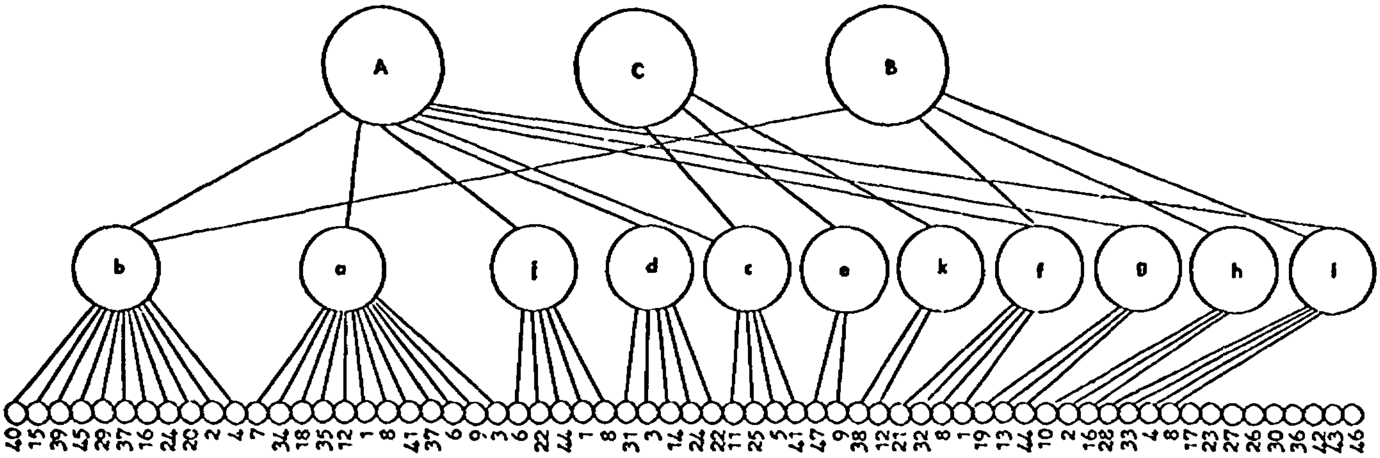


Appendix H

THE TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS WORD-CONCEPTS FOR A GROUP OF FLEXIBLE RADIO COMMUNICATIONS EQUIPMENT REPAIRMEN

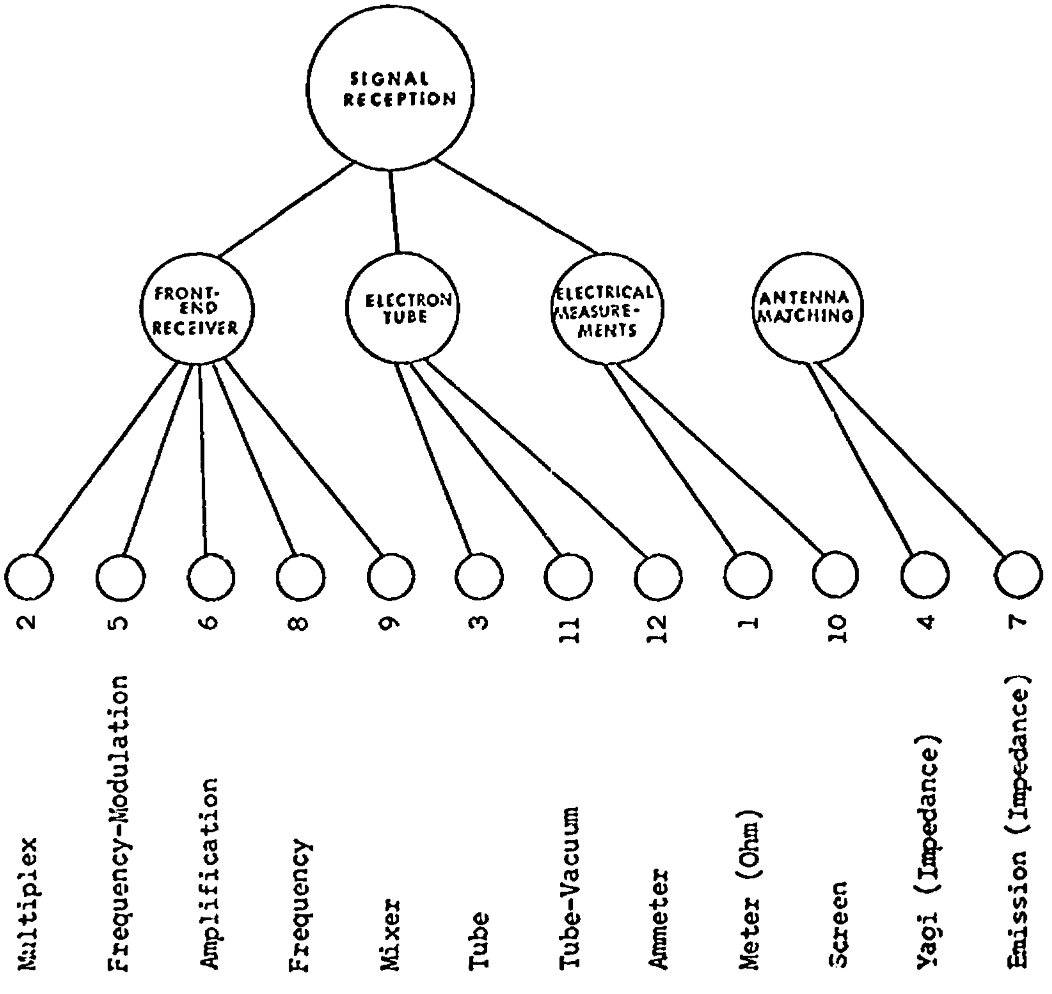


THE TECHNICAL CONCEPTUAL STRUCTURE OF STIMULUS WORD-CONCEPTS FOR A GROUP OF INFLEXIBLE RADIO COMMUNICATIONS EQUIPMENT REPAIRMEN



Appendix I

THE COMPOSITE TECHNICAL ASSOCIATIVE STRUCTURE OF COMMON STIMULUS WORD-CONCEPTS FOR FLEXIBLE WORKERS IN TWO OCCUPATIONS



STRUCTURING JOB CONTENT THROUGH A NUMERICAL TAXONOMY APPROACH TO TASK ANALYSIS

Joe Silverman
Program Director
Naval Personnel and Training Research Laboratory

Unlike curricula in general education, the utility of vocational curricula can be evaluated in terms of specific jobs or skills. It is not surprising that the common caveat for curriculum development in vocational education and job-training courses is that training objectives derive from job requirements and work behaviors. Because the utility of training content is so highly dependent on the identification and subsequent structuring of job and task behaviors, the area of task analysis has increasingly become the focus of much research.

Methods of task analysis are usually tailored to the specific purpose of a research effort and, as a result, such methods of analysis cannot easily be generalized to other problems. The research literature on task analysis is abundant and most of it has been concerned with job design and job analysis, training psychology, man-machine systems, occupational reengineering, small group research, work measurement, and problems of industrial engineering. The basic analytical framework of much of the task analysis has focused on the study of elements or technical operations in a task.

In recent years, human factors analysts and training psychologists have called for a taxonomy of tasks to provide a breakthrough in the state-of-the-art. The reasoning behind this is as follows. Currently, techniques of task analysis require that every task performed in a system or job be treated as a unique entity or aspect of the work. For example, two tasks that are identical in terms of the kind of work performed may still differ in the kind of equipment involved, environmental factors affecting the task, organizational atmosphere, operational conditions, and a multitude of other factors. In the Navy, for example, the task "alignment of a transceiver" can differ considerably from one type or model of transceiver to another, from one ship type to another, from underway conditions to inport conditions, from one electronics technician to another, etc. Therefore, task analysis of even one job or man-machine system can involve the study of an enormous number of tasks and their elements. In training naval personnel to operate and maintain modern weapons and support systems, the development of a curriculum based on such complex and extended task analyses becomes unusually difficult.

As a result, it has been proposed that research be performed to systematically classify tasks in terms of critical generalizable variables, characteristics, and attributes inherent in the task--independent of the setting or environment of the task. By classifying the behavior required in performing a task, and training personnel in the basic abilities implied by those behaviors (rather than the specific technical elements in a task), it is contended that curricula may be made more realistic in terms of task demands. Also, task analysis based on selected categories or dimensions of task behavior would constitute a major advance by eliminating the necessity for repeatedly developing and analyzing long, detailed task lists or inventories. A set of such categories of task behavior has been called a taxonomy.

A taxonomy involves the systematic differentiation, ordering, relating, and naming of type groups within a subject field. In these terms, the classification of naval ships is a kind of taxonomy wherein ships are grouped by class, type, and overall purpose (e.g., 2200 class; DD type, combatant purposes). Similarly, tasks may be ordered into groups on the basis of their relationships and distinctive names or nomenclature applied to those groups.

The taxonomic process involves the following steps:

1. Collecting samples of phenomena.
2. Describing essential features or elements.
3. Comparing phenomena for similarities and differences.
4. Developing a set of principles governing the choice and relative importance of elements.
5. Grouping phenomena on the basis of essential elements into more and more exclusive categories and naming the categories.
6. Developing keys and devices as a means of recognizing and identifying phenomena.

There have been many attempts at developing taxonomies based on the common behavioral elements in tasks. Few of these have been the result of the systematic taxonomic process described above. Some efforts have been empirical--relying on correlations of task behaviors or learning demands, and then factor analyzed to determine the behavioral categories or dimensions underlying the subject tasks. Others have employed an "armchair" approach based on their accumulated research experience. Perhaps this is why there have been such a variety of taxonomies developed to date.

Many behavioral taxonomies employ organizing benchmarks such as "sensing," "continuous perceptual motor activity,' "choice discrimination," and "deductive decision-making" to structure job behaviors. Generally, these task classifications do not yet hold great promise for current operational use in task analysis. Many of them cannot be replicated by independent investigators, or cannot be validated, or have serious problems regarding reliability. In contrast to the difficulties inherent in classifying behavior per se, the methodological problem of task taxonomy can be made tractable--at least for curricula development--by considering the behavior implicit in a carefully worded task statement.

In describing the procedures involved in job-training course design, Rundquist* discusses the role of task inventories:

> "The designer of every training course has in mind, at a minimum, a general notion of the tasks for which his course is designed and, at a maximum, has developed a systematically written list of precisely stated tasks. The problems concern, not the need for a task inventory, for this certainly is a necessity, but how it is developed, by whom, and to what level of detail."
>
> "The utility of the criterion that each task be so stated that it can serve as the behavioral element of end-of-course objective can scarcely be overemphasized. Meeting this criterion enormously simplifies the course design process. It does this by making it possible to deal with the problem of deriving the subordinate knowledges and skills needed to perform the task as an integrated part of lesson planning...this in turn makes (it) possible for end-of-course objectives to serve without modification as lesson plan objectives."

Given the feasibility of describing job behavior in terms of task statements, the problem then becomes one of grouping and structuring tasks in a way that provides information on job-performance requirements in a form suitable for curricula development. In this regard, one of the more interesting and fruitful techniques of task analysis derives from the simultaneous publication in 1957 of several papers by biological taxonomists. In common, these articles advocated the use of a more scientific approach to the problem of classifying biological organisms. It is not coincidental that the advent of the computer had an important role to play in the development of these techniques.

---

*Rundquist, E.A., Course Design and Redesign Manual for Job Training Courses, San Diego: Naval Personnel Research Activity, January 1967, (SRR 66-17: Revised).

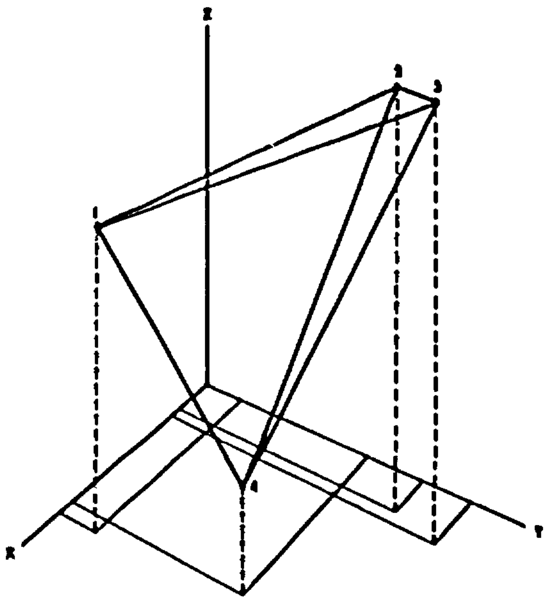
Problems of task classification, like those of biological classification, can be approached more systematically through methods of numerical taxonomy than through traditional techniques based on the judgment of different investigators. Numerical taxonomy places the procedures of task comparison and classification on an operational and quantitative basis.

In developing an occupational classification, for instance, it is necessary to compare a sample of jobs in terms of a large number of tasks performed in those jobs. With the use of a computer, it is possible to make these comparisons on the basis of a numerical yardstick which measures the precise similarity of one job to another, as indicated by the similarity of the tasks performed in each. Jobs can then be grouped into a hierarchical arrangement of occupational categories by reference to their numerical similarity and distance from one another. Conceptually, the procedures involved are relatively simple.*

First, all the tasks performed by personnel in the sample to be classified are arranged in a data matrix, and the similarities between all possible pairs of jobs are then computed based on all the tasks. One way of representing similarity is the distance between jobs in a multidimensional space, as shown in Figure 1.

FIGURE 1

DISTANCE BETWEEN JOBS BASED ON TASK SIMILARITY



---

*This discussion of the procedures involved in a numerical taxonomy of tasks has been adapted from Sokal, R.R. and Sneath, P.H.A., <u>Principles of Numerical Taxonomy</u>, San Francisco: W.H. Freeman, 1963; and Sokal, R.R., "Numerical Taxonomy," <u>Scientific American</u>, 215(6), Dec. 1966, pp. 106-116.

In Figure 1, the similarity between all possible pairs taken from four jobs (points 1, 2, 3, and 4) is estimated on the basis of three tasks, which are represented by the three coordinates (axes X, Y, and Z). The four jobs are then plotted into this three-dimensional space according to their state, or value, for the three characters. Similar jobs are plotted much closer to one another than dissimilar ones. In any real case there will, of course, be more than three tasks, and a multidimensional space--called a "hyperspace"--would be necessary.

After the similarities between pairs of jobs are evaluated by the computer, they are printed out in a "similarity matrix," which shows the mutual similarity values of every job. Each job can then be grouped on the basis of its similarity to some jobs and its dissimilarity with others. For more precise classifications, a variety of numerical clustering procedures have been developed, and these procedures are routinely carried out on the computer after the similarity matrix has been calculated.

The results of numerical classification can be represented by means of a "phenogram." These tree-like diagrams indicate the similarity between jobs or occupational groupings containing more than one job. Figure 2 shows a two-dimensional representation of the results of a numerical classification. Although this diagram distorts the original multidimensional relationships produced by the similarity matrix, as shown in Figure 1, it does reflect the similarity level at which different jobs are grouped. Moreover, it shows the classification of jobs into occupational groupings or families, and at what levels this grouping takes place.

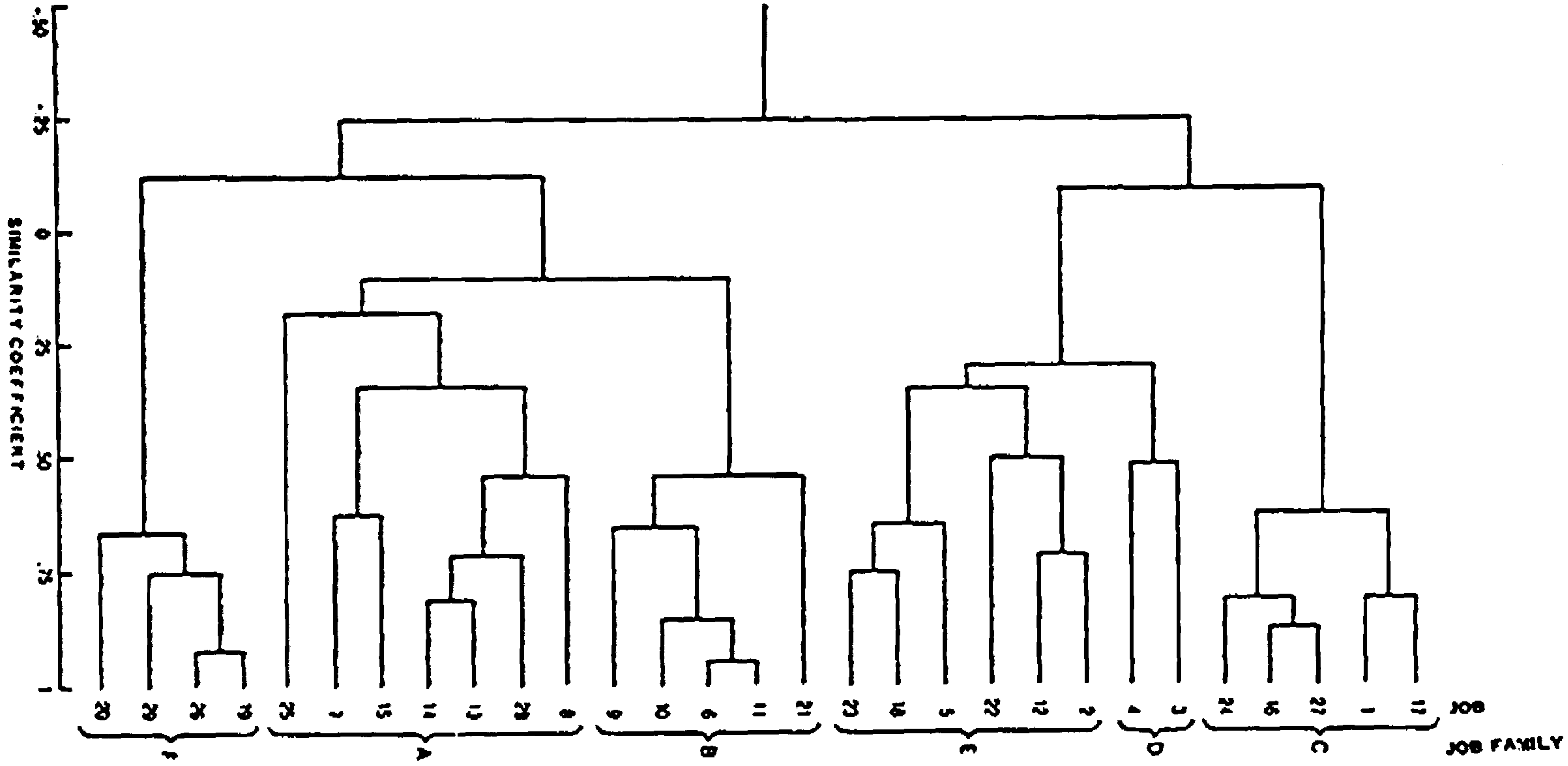
This brief overview of numerical taxonomy can be elaborated in more detail by reference to a recent research effort undertaken by the Navy. Although the main focus of the research was on methods of determining work requirements for use in occupational classification, the development of computerized techniques of task analysis proved a fortuitous by-product.

One of the technical objectives of the research was to develop a computer method for arranging a number of individual task patterns, representing job incumbents in a given occupational area, into groups or "clusters." A "cluster" is defined as a group of respondents characterized by relatively small differences in the kinds of tasks performed. In pursuing this approach, an iterative computer clustering technique was devised to group similar task patterns into homogeneous occupational segments or clusters. This technique encompasses a series of computer programs that facilitate the process of grouping task patterns and provide a variety of outputs designed to carefully regulate and control the entire procedure at any step in the process. The data collection procedures used to obtain clusters of task patterns, are set forth below.

A number of data collection instruments were devised to obtain information on the variables associated with work requirements being studied in this research, however, only the task lists are of concern for purposes of this discussion.

FIGURE 2

PHENOGRAM OF A HYPOTHETICAL JOB STRUCTURE



In developing the Task List Questionnaires, a comprehensive list of tasks performed by engineering department personnel of Navy destroyers was first developed. In its final form, this list consisted of over 500 separate items. This list was then divided into three broad work areas in engineering that appeared to be fairly discrete in terms of the work performed and the equipments involved. These are: (1) the Propulsion/ Auxiliary area, encompassing work generally performed by personnel in the occupational fields of Boilerman, Boilermaker, Machinist's Mate, and Engineman; (2) the Hull/Repair area, including the work of the Damage Controlman, Shipfitter, and Machinery Repairman; and (3) the Electrical area, covering the tasks performed by Electrician's Mates and Interior Communications Electricians. Within each major area, the task list is divided into subheadings which indicate the main categories of equipment operated and maintained in that area. The instruction page and one sample page of the Task List Questionnaire, as administered to personnel in the Hull/Repair work area, are contained in Appendix A.

These task lists were administered to about 400 engineering department personnel in a sample of six destroyers in the San Diego-Long Beach area. This represents 76% of all personnel in these departments. Each man completed only that task list which pertained to his area of work.

The problem faced at this point was how to group the task patterns of respondents so that clusters of similar tasks and task patterns would emerge in a form suitable for use in determining the technical work requirementa of a given occupational area.

This was accomplished in a number of steps. First, an index was developed to indicate the similarity of each individual's task pattern with that of every other individual in the sample. Second, various respondents were selected as "pivot men" on the basis of their task pattern variance, and other individuals were clustered around the pivot men by task pattern similarity. Third, the resulting clusters were analyzed by use of other computer routines in order to develop "optimum specialty clusters." Fourth, analytical procedures and computer programs were revised on the basis of the preceding analysis to refine both the technique and the data. This technique represents an interplay of mathematics, computer analysis, and human judgment.

Prior to the actual clustering process, each individual's pattern of tasks was compared to the task pattern of every other individual who completed the same task area questionnaire. An index of similarity was then computed for each pair of individuals based on the relative similarity of the tasks they performed.

This index is provided by:

$$S(i,j) = \frac{n[T(i,j)]}{n[T(i)] + n[T(j) - n[T(i,j)]}$$

where	$n[T(i,j)]$	is the number of tasks performed by both man i and man j
	$n[T(i)]$	is the number of tasks performed by man i
	$n[T(j)]$	is the number of tasks performed by man j

The denominator in this expression represents the total number of different tasks performed by i and j combined.

This formula generates a continuum ranging from "0," indicating total independence (i.e., no tasks in common between man i and man j), to "1," indicating complete identity (i.e., all tasks performed by i are identical to those performed by j).

For example, consider the following comparison of task patterns in which T(i) contains 10 elements or tasks and T(j) contains 15 elements:

T(i) = [A03,A14,A15,A19,B05,B17,C21,D04,E09,E10]

T(j) = [A03,A12,A14,A17,A19,B01,B02,B03,B17,C15,E10,E17,T01,T02,T03]

T(i,j) = [A03,A14,A19,B17,E10]

Note that man i has performed 10 tasks (indicated by the alpha-numeric codes) 5 of which are common with man j--who lists 15 tasks performed.

Applying the formula, we have:

$$S(i,j) = \frac{5}{10+15-5} = \frac{5}{20} = .25$$

This formula was applied to every possible pair of respondents in each task area and a matrix of mutual similarities was then generated by the computer. The size of the matrix is determined by the number of personnel associated with each of the three task lists. Thus, the Propulsion/Auxiliary Task List Questionnaire, which was administered to 278 personnel, generated a semi-matrix with m (m-1)/2 or 38,503 distinct similarities, where m equals the number of personnel. The Hull/Repair list produced a semi-matrix of 741 (i.e., 39(38)/2) indices and the Electrical list resulted in 2,775 (i.e., 75(74)/2).

The similarity matrix is in the form of a listing in which each individual is listed in serial order by identification code and all other personnel are compared with that individual by an index of similarity. For reference purposes, these data were converted to a computer-produced semi-matrix; the similarity indices are recorded in another form--that of a frequency distribution.

In order to group the tasks performed by personnel in this sample, a starting point was necessary. In the initial computer clustering technique, this point is provided by a "pivot man"--or simply, "pivot." The pivot is the reference point for the entry of other personnel into clusters. The selection of pivots is controlled by the variance of each individual's similarity indices, where the variance is computed by:

$$s^2 = \frac{n\,\Sigma X^2 - (\Sigma X)^2}{n(n-1)} = \frac{\Sigma (X-\overline{X})^2}{n-1}$$

where

X = similarity index of man i with man j, or S(i,j)

n = number of similarity indices of man i with all j

$\overline{X}$ = mean of similarity indices of man i

One of the outputs of this phase of data processing is a variance listing for each task list.

After the calculation of each variance, the individual with the highest variance is selected as the first pivot and becomes the reference point or core of the first cluster of task patterns. The rationale for this procedure is as follows. One of the requirements of clustering tasks is that the clusters be sizable, but also separate and distinct. A large variance indicates the presence of highly similar and highly dissimilar task patterns in a given individual's range of similarities--the maximum variance occurring where a man has one-half of his similarities = 0, and one-half = 1.

High variance is employed as the criterion for pivot selection for two reasons: first a pivot candidate's high variance indicates that his task pattern is very similar to those of some individuals, which assures that a relatively homogeneous cluster can be formed. Second, high variance also means that the pivot candidate's pattern of tasks differs greatly from those of other personnel, thus enabling the initial cluster to be distinct from at least a portion of the body of remaining tasks. As a result, succeeding clusters can be formed around pivots that are distinct from previous clusters.

A simplified example of the relationship between an individual's range of similarities and his variance is shown in Table I.

TABLE I

CALCULATION OF VARIANCE FOR TWO TASK PATTERN SAMPLES

Man	Similarity Index X	$X-\bar{X}$	$(X-\bar{X})^2$	s^2
i	03	-17	289	
	20	0	0	
	37	17	289	
[Mean S(i,j) = 60/3 = 20]	60		578/2 =	289
j	15	- 5	25	
	20	0	0	
	25	5	25	
[Mean S(i,j) = 60/3 = 20]	60		50/2 =	25

This example shows the case of two personnel, each with a mean similarity index of 20 and a list of similarity indices with three other personnel. For man i, the similarities are both high and low (37 and 03, respectively), while for man j the similarities are grouped around the average (i.e., 15, 20, and 25). The variance for man i is 289 while for man j, it is only 25. The two cases in this example are exaggerated to show the effect of variance in the selection of pivots, but the computer process is approximately the same. In terms of this computer program, man i is the better choice for pivot since highly similar task patterns (as represented by the S(i,j) of 37) can be clustered with him and still make provision for clustering other task patterns that are distinct (as represented by the S(i,j) of 03).

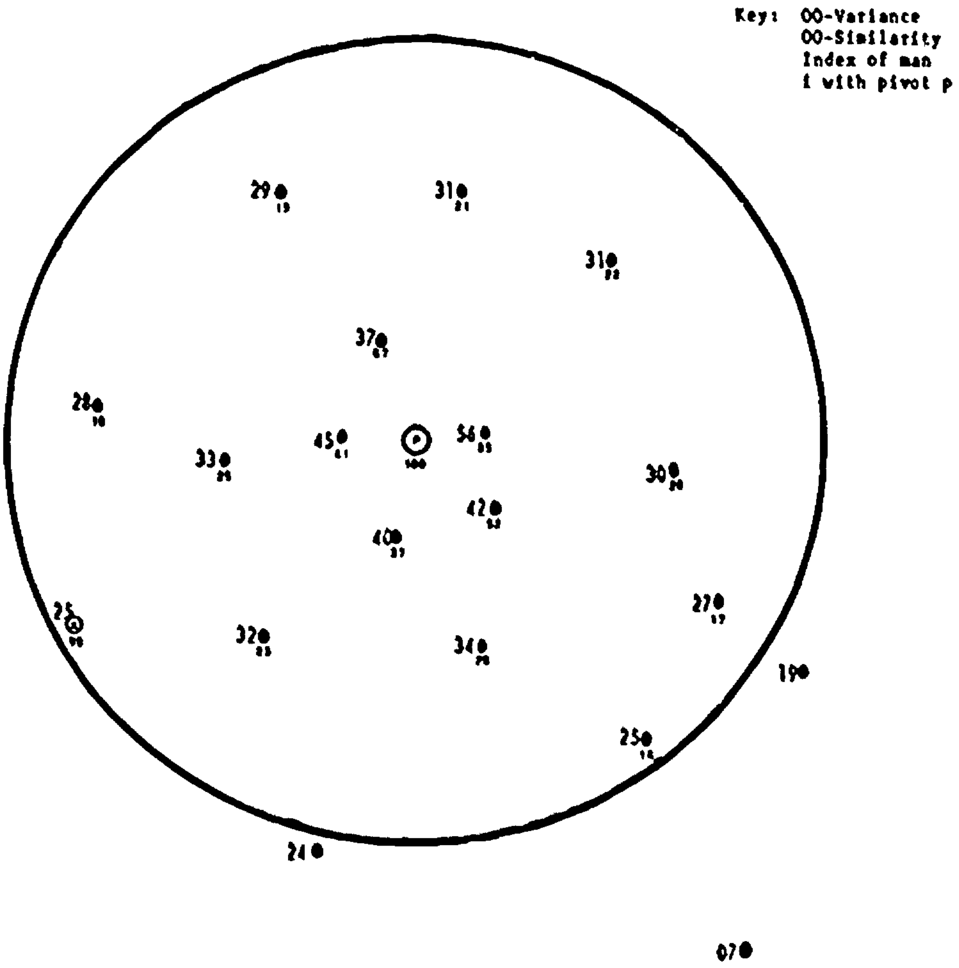
In a refinement of this procedure, the selection of pivots was improved in two ways: first, they should have a high variance, for reasons noted previously; second, they should have a relatively low similarity with each previously selected pivot man. The latter criterion enables each pivot to have a separate work area for his cluster. When two different pivots have a high similarity between them, the clusters that are formed around them are likely to be more similar than distinct. By selecting pivots who have a low similarity to preceding pivots, it is possible to avoid much of the overlapping of functional content between clusters.

The pivot selection process occurs separately for each of the three task area subsamples, and every respondent administered a task list is evaluated in terms of the two optimization criteria noted above. The function of the program is to order the men in terms of their desirability as pivots by evaluating both their individual variances as well as their similarity to previously selected pivots.

After the variance is computed for each individual, and the first pivot is selected (representing the greatest variance), the initial cluster is produced by selecting those individuals with a similarity to the pivot man above a certain threshold. A "similarity threshold" (ST) was set for each computer run in order to control the process of clustering task patterns. This threshold represents the minimum similarity acceptable for inclusion in a cluster and controls the size and homogeneity of clusters. An example of this process is shown in Figure 3.

FIGURE 3

SAMPLE CLUSTER CONFIGURATION



Note: ST=24, Therefore clustering occurs at S(i,p)=25

Once the first pivot is selected and the members of the first cluster are chosen from those personnel with similarities to the pivot >ST, the computer initiates the selection of the second cluster. This is accomplished by setting the variances of all members of the first cluster to zero so that they will be ineligible to become pivots in succeeding clusters. The second pivot is then selected as the highest remaining variance, and a second cluster of similarities >ST is generated and printed out. As before, the variances of all personnel in the second cluster are set to zero and the third pivot is obtained by again selecting the pivot candidate with the highest variance. The procedure is reiterated and clusters are produced until a pivot candidate cannot cluster at least one other individual with a similarity to the pivot higher than the threshold.

The process of cluster grouping is an experimental one; that is, a series of computer runs must be made at different similarity thresholds in order to determine which ST satisfies the criteria used to evaluate the clusters. In this research, 30 different computer runs were made in the three task areas. Since each cluster run usually differs in the number of clusters, the pattern of task association, the homogeneity of the clusters, and the identity and variance of every pivot man but the first, it is necessary to examine a series of experimental clusters in order to obtain an "optimum" cluster run. The latter results in what are termed "specialty clusters."

In order to isolate the specialty clusters in an occupational area, a few limitations must be imposed on the process of cluster analysis. First, the size of the sample in a task area dictates the upper and lower limits for a cluster in that area. For example, in this research it did not appear feasible to employ clusters of less than ten respondents. The description of clusters in terms of other variables would not be statistically meaningful with very small clusters because of the paucity of data. Similarly, excessively large clusters would exhaust most of the sample in a particular task area, leaving few respondents as a source of data to describe other clusters in the area. As a result, the particular constraints of size in this occupational sample were set within the flexible limits of between 10 and 50 personnel. The clusters which emerged did not indicate that these constraints posed a significant limitation on the process of cluster analysis.

A second constraint in designating specialty clusters involves threshold regulation. The cluster program clusters all personnel in the sample according to their highest similarity to a pivot. Because of this, there are a number of respondents' task patterns that do *not* adhere closely to any particular pivot, but are nevertheless included in those clusters to whose pivot they are *most* similar. These personnel have marginal or deviate task patterns because: (1) they were new arrivals on board ship at the time of sampling (and thus performed an erratic and incomplete list of tasks); (2) they did not complete the task list questionnaire; (3) the questionnaire was improperly filled out; (4) the survey instructions were misunderstood; or (5) simply because their task patterns were relatively unique on the particular ship(s) sampled. Whatever the reason, the task patterns associated with these personnel detract from cluster homogeneity to a significant degree. It is the precise purpose of the similarity threshold to eliminate such deviant cases, providing that cluster similarity is not promoted at the expense of a sizable portion of the sample.

In selecting an optimum set of clusters to represent a given task area, there are a series of criteria which can be used to delimit the scope of the problem. Thus, the object in making a choice among alternative sets of clusters is to (1) maximize cluster homogeneity, (2) maximize the number of clusters representing the task area, (3) maximize the number of personnel (i.e., task patterns) accounted for within the bounds of the similarity thresholds, and (4) minimize the number of clusters that exceed minimum and maximum size constraints.

In order to evaluate the task pattern differences between clusters, a computer program was developed to build a matrix of similarities the output of which provides measures of inter-cluster distance. This is done by computing the mean value of all cells in the task pattern similarity matrix of two clusters. These values (termed Cluster Distance Scores) indicate the extent to which the clusters in a set, taken two at a time, are discrete or similar. Ideally, the difference in task patterns between clusters should be significantly greater than the difference in task patterns within clusters.

Table II contains a matrix of such inter-cluster similarities for eight Propulsion/Auxiliary area clusters.

TABLE II

CLUSTER DISTANCE MATRIX FOR EIGHT CLUSTERS
IN THE PROPULSION/AUXILIARY TASK AREA

Cluster Number	m	Intra-Cluster Similarity (CVS)	Inter-Cluster Similarity (CDS)						
			C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	43	25.4	11.4	9.6	11.7	18.0	13.2	19.5	12.0
C_2	21	25.9		8.8	3.4	21.0	6.0	15.4	7.1
C_3	32	20.6			11.7	11.7	17.3	9.7	18.2
C_4	16	21.3				7.1	19.6	7.1	17.0
C_5	23	24.5					10.6	19.0	10.9
C_6	21	22.4						9.7	20.0
C_7	19	20.8							10.0
C_8	35	21.7							--

From an analysis of this matrix, it is possible to evaluate the cluster set to determine which clusters are most similar and which are most discrete. It is not the absolute cluster distance score (CDS) that is important in this evaluation; instead, it is the size of the CDS relative to the internal homogeneity (CVS) of the two clusters being compared. In all comparisons, the CDS should be smaller than the mean similarity of either of the two clusters which make up the similarity distance matrix. If this were not the case (i.e., if the mean similarity between clusters were greater than that within clusters), the rationale for maintaining separate clusters would collapse. Table II shows there are no exceptions to this research expectation. Thus, there are more differences in task patterns between clusters than within clusters.

With the designation of optimum specialty clusters noted previously, and the aid of output from the cluster distance program, it then becomes possible to describe an occupational field or task area in terms of its task pattern interaction. The relationships between relatively homogeneous segments of work requirements can be best illustrated in an n-dimensional space--which, unfortunately, is impossible in the planar surface of this paper. Nevertheless, Table II does indicate the constituents of some of these relationships. For instance, a macro-cluster can be developed from C_4, C_6, and C_8--all of which have a considerable amount of mutual task pattern similarity. On the other hand, C_2 appears to be relatively independent of all other clusters except C_5.

The task pattern relationships described above are influenced to a very large degree by the source of the data. Inasmuch as the task patterns were derived from engineering personnel on destroyers, the similarities in tasks performed between individuals and between clusters of nominally different occupational areas are much greater than would be the case for other ship types or other work situations (e.g., industrial occupations), where the division of labor and specialization of functions is more prominent. Destroyers are generally characterized by jobs which evidence a large amount of overlapping in task patterns. Because of this, the specialty clusters produced from a matrix of task pattern similarities reflect this relative lack of specialization and are much more difficult to separate clearly. However, this does not invalidate the clustering process; the clusters produced by these techniques simply reflect the way in which tasks are performed in a specific work situation.

The primary application for computer clustering techniques in this research is in the area of task analysis. All of the data processing decisions and program designs have been directed toward the development of optimum specialty clusters. These clusters, which constitute groups of homogeneous task patterns, represent structures of work requirements in which each cluster reflects a particular profile of skills and knowledges. As such, they simultaneously constitute an ordered set of training objectives and a hierarchical structure of training content organized in terms of work requirements.

SELECTED REFERENCES

Ammerman, H.L., A Model of Junior Officer Jobs for Use in Developing Task Inventories, Fort Bliss, Texas: Human Resources Research Office, Nov. 1965 (Tech. Report 65-10).

Beers, R.J., Fisher, J., Megraw, S., and Lockhart, W.R., "A Comparison of Methods for Computer Taxonomy," Journal of Gen. Microbiology, 1962, 28, pp. 641-652.

Beers, R.J. and Lockhart, W.R., "Experimental Methods in Computer Taxonomy," Journal of Gen. Microbiology, 1962, 28, pp. 633-640.

Bonner, R.E., "On Some Clustering Techniques," IBM Journal of Research and Development, Jan. 1964, pp. 22-32.

Bottenberg, R.A. and Christal, R.E., An Iterative Technique for Clustering Criteria which Retains Optimum Predictive Efficiency, Lackland Air Force Base, Texas: Personnel Research Laboratory, Mar. 1961 (WADD-TN-61-30).

Cardinet, J., "The Use of Profiles for Differential Classification," Educational and Psychological Measurement, 1959, 19(2), pp. 192-205.

Chenzoff, A.P., A Review of the Literature on Task Analysis Methods, Port Washington, N.Y.: U.S. Naval Training Device Center, June 1964 (NAVTRADEVCEN 1218-3).

Coombs, C.H. and Satter, G.A., "A Factorial Approach to Job Families," Psychometrika, 1949, 14, pp. 33-42.

Cotterman, T.E., Task Classification: An Approach to Partially Ordering Information on Human Learning, Dayton, Ohio: Wright Air Development Center, Jan. 1959 (WADC Tech. Note 58-374).

Cronbach, L.J. and Gleser, G.C., "Assessing Similarity Between Profiles," Psychological Bulletin, 1953, 50, pp. 456-473.

Curran, T.E., A Task Inventory for the Combat Information Center Watch Officer (CICWO) on a Combatant Ship Under Normal Steaming Conditions for Course Design Purposes, San Diego: U.S. Naval Personnel Research Activity, Dec. 1966 (SRR 67-9).

Driver, H.E., "Survey of Numerical Classification in Anthropology," in Hymes, D.H., (ed.), The Use of Computers in Anthropology, The Hague: Mouton, 1963.

Dunnette, M.D. and England, G.W., "A Checklist for Differentiating Engineering Jobs," Personnel Psychology, 1957, 10, pp. 191-198.

Fleishman, E.A., Development of a Behavior Taxonomy for Describing Human Tasks: A Correlational-Experimental Approach, Paper read at American Psychological Association Convention, Sept. 1965.

Folley, J.D., Jr., Development of an Improved Method of Task Analysis and Beginnings of a Theory of Training, Port Washington, N.Y.: U.S. Naval Training Device Center, June 1964 (NAVTRADEVCEN 1218-1).

Folley, J.D., Jr., Guidelines for Task Analysis, Port Washington, N.Y.: U.S. Naval Training Device Center, June 1964 (NAVTRADEVCEN 1218-2).

Gagne, R.M., (ed.), Psychological Principles in System Development, New York: Holt, Rinehart, and Winston, 1962.

Gilmour, J.S.L., (rapporteur), "The Mathematical Assessment of Taxonomic Similarity, Including the Use of Computers," (by J. Heslop-Harrison, R.R. Sokal, P.H.A. Sneath, A.J. Cain, R. Crawshay-Williams, G.A. Maccacaro, J.Z. Barnett, A.F. Parker-Rhodes, R.H. Richens, and S.M. Walters), Taxonomy, 1961, 10, pp. 97-101.

Haggard, D.F., The Feasibility of Developing a Task Classification Structure for Ordering Training Principles and Training Content, Fort Knox, Kentucky: Human Resources Research Office, Research Memorandum, Jan. 1963.

Ledley, R.S. and Lusted, L.B., "Reasoning Foundations of Medical Diagnosis," Science, 1959, 130, pp. 9-21.

Ledley, R.S. and Lusted, L.B., "The Use of Electronic Computers to Aid in Medical Diagnosis," Proceedings of the Institute of Radio Engineers, 1959, 47, pp. 1970-1977.

Leone, C.A., (ed.), Taxonomic Biochemistry, Physiology and Serology, New York: Ronald Press, 1963.

Lorr, M., "A Comparison of Two Methods of Cluster Analysis," Outpatient Studies in Psychiatry, Pre-publication Report No. 25, Sept. 1965.

Lubischew, A.A., "On the Use of Discriminant Functions in Taxonomy," Biometrics, 1962, 18, pp. 455-477.

MacCaslin, E.F., A Tentative Taxonomy of Task Demands, Paper read at American Psychological Association Convention, Sept. 1963.

McCormick, E.J., Finn, R., and Scheips, C.D., "Patterns of Job Requirements," Journal of Applied Psychology, 1957, 41, pp. 358-364.

McQuitty, L.L., "Comprehensive Hierarchical Analysis," Educational and Psychological Measurement, 1960, 20, pp. 805-816.

Michener, C.D., "Some Bases for Higher Categories in Classification," Systematic Zoology, 1957, 6, pp. 160-173.

Michener, C.D. and Sokal, R.R., "A Quantitative Approach to a Problem in Classification," Evolution, June 1957, 11, pp. 130-162.

Miller, R.B., Task Taxonomy: Inventive Approach, Paper read at American Psychological Association Convention, Sept. 1965.

Morsh, J.E., Job Types Identified with An Inventory Constructed by Electronics Engineers, Lackland Air Force Base. Texas: Personnel Research Laboratory, June 1966 (PRL-TR-66-6).

Morsh, J.E., Madden, J.M., and Christal, R.E., Job Analysis in the United States Air Force, Lackland Air Force Base, Texas: Personnel Laboratory, Feb. 1961 (WADD-TR-61-113).

Orr, D.B., "A New Method for Clustering Jobs," Journal of Applied Psychology, 1960, 44, pp. 44-49.

Palmer, G.J. and McCormick, E.J., "A Factor Analysis of Job Activities," Journal of Applied Psychology, 1961, 45, pp. 289-294.

Price, D.G., A Taxonomy for Navy Billets, Paper read at American Psychological Association Convention, Sept. 1965.

Proctor, J.R. and Kendrick, W.B., "Unequal Weighting in Numerical Taxonomy," Nature, 1963, 197, pp. 716-717.

Rogers, D.J. and Fleming, H., "A Computer Program for Classifying Plants: II. A Numerical Handling of Non-numerical Data," BioScience, 1964, 14(9), pp. 15-28.

Rogers, D.J. and Tanimoto, T.T., "A Computer Program for Classifying Plants: I," Science, Oct. 1960, 132 (3434), pp. 1115-1118.

Rohlf, F.J. and Sokal, R.R., "The Description of Taxonomic Relationships by Factors Analysis," Systematic Zoology, 1962, 11, pp. 1-16.

Rundquist, E.A., Course Design and Redesign Manual for Job Training Courses, San Diego: Naval Personnel Research Activity, January 1967, (SRR 66-17: Revised).

Selfridge, O.G. and Neisser, U., "Pattern Recognition by Machine," Scientific American, August 1960, 203(2), pp. 60-68.

Silverman, J., A Method for Structuring Technical Tasks, San Diego: U.S. Naval Personnel Research Activity, Aug. 1965 (STB 66-4).

Silverman, J., A Computer Technique for Clustering Tasks, San Diego: U.S. Naval Personnel Research Activity, April 1966 (STB 66-23).

Simpson, G.G., Principles of Animal Taxonomy, New York: Columbia University Press, 1961.

Simpson, G.G., Rose, A., and Lewontin, R.C., Quantitative Zoology, New York: Harcourt, Brace, 1960.

Sneath, P.H.A., "The Application of Computers to Taxonomy," Journal of Gen. Microbiology, 1957, 17, pp. 201-226.

Sneath, P.H.A., "Recent Developments in Theoretical and Quantitative Taxonomy," Systematic Zoology, 1961, 10, pp. 118-139.

Sneath, P.H.A. and Sokal, R.R., "Numerical Taxonomy," Nature, 1962, 193, pp. 855-860.

Sokal, R.R., "Distance as a Measure of Taxonomic Similarity," Systematic Zoology, 1961, 10, pp. 70-79.

Sokal, R.R. and Sneath, P.H.A., Principles of Numerical Taxonomy, San Francisco: W.H. Freeman, 1963.

Ton, J.T. and Wilcox, R.H., (eds.), Computer and Information Sciences, Washington, D.C.: Spartan Books, 1964.

Tryon, R.C., "General Dimensions of Individual Differences: Cluster Analysis versus Multiple Factor Analysis," Educational and Psychological Measurement, 1958, 18, pp. 477-495.

Turner, A.N. and Lawrence, P.R., Industrial Jobs and the Worker, Boston: Harvard University Press, 1965.

Ward, J.H., Jr., Hierarchical Grouping to Maximize Payoff, Lackland Air Force Base, Texas: Personnel Research Laboratory, Mar. 1961 (WADD-TN-61-29).

APPENDIX A

AN EXAMPLE OF A TASK LIST QUESTIONNAIRE

TASK LIST INSTRUCTIONS
for
HULL AND REPAIR AREA

1. The Task List on the following pages should be filled out only by enlisted personnel working in the Hull and Repair area of the Engineering Department. This includes DC's SF's, MR's and strikers for these ratings. It also includes personnel of other ratings assigned to this area.

2. The Task List is divided into 11 subject headings. Read the subject heading first to determine if the heading applies to your present work area.

    -If it applies to your work, then read each task below the heading and make an "X" on the line following each task if you have actually performed the task in your present assignment on this ship within the past 3 months.

    -If the heading does not apply to your work, go on to the next subject heading.

3. Many of the tasks contain several different parts. Be sure to check the task if you perform any of the parts, even though you do not perform all the parts.

4. Remember-

    -Do NOT check any tasks just because you "know how" to do them, or because you did them in school or in past duty assignments.

    -Do NOT check tasks which, during the past 3 months, you have supervised only.

    -Do NOT check tasks when you give only minor assistance, such as handing parts or tools to another man who is actually performing the task.

5. Do not hesitate to ask questions if you need assistance.

13. Perform angular, compound, and differential indexing; cut spur gears, T-slots and dovetails using milling machine. 13.______

14. Perform spline cutting and broaching; cut spur, bevel, helical and worm gears using milling machine. 14.______

15. Perform balancing machine operations. 15.______

16. Stow, lubricate, adjust, and clean shop equipment, machines and tools. 16.______

17. Lubricate machine tool bearings, guide-rollers, fittings and designated parts; fill oil holes and oil cups; and change oil. 17.______

18. Clean exposed surfaces of all machines and tools. 18.______

19. Check and adjust leveling of machine foundations. 19.______

20. Perform machining operations using lathe grinding attachments and milling attachments. 20.______

B. <u>PIPEFITTING</u> (Plumbing, Steamfitting, Pipe Covering, Piping and Valve Work)

1. Make temporary repairs to pipe with plugs, clamps, plastic, or patches. 1.______

2. Make permanent repairs to pipes with plugs (rivet or screws), welded or brazed patches, or by straightening and aligning. 2.______

3. Replace piping sections and fittings. 3.______

4. Layout and assemble sections of piping using templates and targets, pipe bending machines, and cutting-burring-threading machines. 4.______

5. Hydrostatically test pipes, tubes, valves and fittings. 5.______

6. Clean and flush piping and plumbing lines. 6.______

7. Determine cause of troubles in flushing and firemain systems. 7.______

8. Install, patch and repair pipe lagging and insulation, and molded pipe covering on steam, water and refrigeration lines. 8.______

SYSTEMATIC APPROACHES FOR IDENTIFYING AND ORGANIZING CONTENT FOR TRAINING PROGRAMS

Harry L. Ammerman
Human Resources Research Organization

There are many aspects to the development of curriculums for technical training. This paper concentrates on two of these matters: (1) the identification of curriculum content for specific courses of study and (2) the organization of such content in training programs. Both of these topics are discussed in the context of systematic curriculum engineering, with primary concern being devoted to specific procedural techniques to be used by training curriculum personnel.

By way of introduction, let me briefly describe my organization, the Human Resources Research Organization (HumRRO). For nearly the past 19 years HumRRO has been conducting training research under contract for the Department of the Army. Since 1967 similar research has been performed that is relevant to such non-defense agencies as the Post Office Department; Department of Transportation; Department of Labor; Department of Health, Education, & Welfare; state departments of education; and various industrial firms. A heavy proportion of the work has pertained to electrical and electronic maintenance training. However, considerable research has also been conducted for the training of equipment operators, vehicle mechanics, team operations, low-aptitude trainees, and training for leadership and supervision. This research has frequently been concerned with the development and application of innovative approaches to the solution of curriculum and instructional problems.

One of the major lessons learned in the HumRRO studies of technical training is that there is a need for a systematic, generalized procedure for building, testing, and revising training courses (McClelland, 1968).

It must be systematic to assure completeness in considering all relevant aspects of the work performance and learning requirements and generalized so that the schema can be used effectively for many very different kinds of job training courses. The evolved guidelines represent an amalgam of many researchers' thoughts, experiences, and concepts that have been developed both within HumRRO and within numerous other training research laboratories.

The HumRRO Generalized Procedure for Developing Technical Training

There are seven steps, or points, in the HumRRO procedure for systematic curriculum engineering (McClelland, 1968):

Step 1: Determine the performance required. The assumed purpose of training is to develop job-relevant human performance capabilities. Therefore, the initial and most critical step in the development of any technical training program is to specify and describe what a person must know and be able to do in the job situations for which he is being trained.

Step 2: Derive training objectives from performance requirements. Once performance requirements have been determined the next step is to derive corresponding training objectives which specify the tasks the trainee must master and to what level of proficiency. Properly established training objectives serve as a standard against which training effectiveness can be evaluated, as well as serving to communicate the intent of the instructional program.

A clear specification of an objective is considered to be a behavioral statement that describes the following elements:

(a) The particular job-relevant performance or behavior the student is expected to be able to display after training, described in terms of student actions.

(b) The relevant conditions under which such performance is to be observed.

(c) The standard of performance accuracy or speed to be attained by each student.

Three levels of behavioral objectives for training courses are distinguished. First is the general goal or purpose of a course or unit of instruction. Next is the terminal objective, which describes a meaningful unit of work activity. At the third and lowest level are enabling objectives, which describe knowledges, skills, and attitudinal behaviors that must be acquired to accomplish the terminal objective.

Step 3: Base training content on training objectives. The content of training (that which is taught) is based on the objectives, distinguishing between that content which is essential and that which is useful but not essential for school learning. Where abstract or conceptual knowledge seems required, an earnest attempt to restate such knowledge in specific items of information required for and used in job performance has been helpful. The concern here is that a school must know what to teach before it can realistically determine how to teach.

Step 4: Select appropriate training methods. Thus, Step 4 of the procedure is to select the instructional methods best suited for creating the appropriate learning experiences. Intensive research efforts have been and continue to be directed toward finding effective ways to organize and sequence training content and to select appropriate training and teaching methods for the creation of effective learning experiences. From this research are emerging several general concepts as well as specific procedural techniques.

The remaining three steps need just to be stated briefly, as they are less relevant to the techniques to be discussed in the remainder of this paper. Step 5 is to administer training so as to minimize interference with learning and maximize learning principles. In Step 6 the school-trained product is monitored. The general objective of this quality control program is to determine the responsiveness of training activities to performance requirements. Lastly, in Step 7 the training is modified as required.

Within the framework of these guidelines there are many specific techniques that need to be applied by various researchers to permit effective implementation in specific training programs. The remainder of this paper will describe several of these procedures as they pertain to the work of identifying and sequencing curricular content in Steps 1 through 4 of the above guidelines. They range from simplified job models for use by curriculum personnel, to empirical techniques for generating curricular information in as objective a manner as possible.

These procedures consist of:

1. A job model for use in creating listings of job tasks.
2. Functional context principles for content integration.
3. Hierarchical structures of technical concepts, per the notions of Moss, Pucel, Smith, and Pratzner.

Such procedures by no means represent all that is required, nor the ultimate methodologies, in curriculum development. The need for developing more effective techniques of identifying and designing training courses likely will never be satisfied, though very significant advancements have been amply demonstrated in the other papers presented at this session. Such innovative methodologies are desperately needed if systems engineering of technical training courses is to become a reality in common practice.

HumRRO experiences with technical training schools have fully shown the need for practical techniques by which school personnel can themselves derive relevant and effective curriculums. The military, through its command directives (U.S. Continental Army Command, 1968, 1966) has indicated its desire to employ certain HumRRO-based systematic approaches on a large scale. Implementation of these guidelines by in-house personnel has highlighted the need for further advances in providing user agencies with the procedural means by which they can accomplish the intent of the generalized system guidelines. Improved procedures are needed for determining the relevancy, importance, and completeness of curricular content.

Additional practical procedures are needed to permit effective grouping and sequencing of instructional units.

A Job Model for Use in Creating Listings of Job Tasks

One common means used to create a listing of tasks for a job or occupation is to ask experienced job incumbents what they do on their jobs. Probing interviews are often used to assure reasonable completeness and accuracy of these task statements. This process has often been difficult to apply, however, when the job is non-procedural or not oriented to hardware operation or maintenance. In a study of junior officer jobs (Ammerman, 1965), several ways of reorganizing available statements of supervisory and managerial actions were considered. One such grouping that appeared to account for most of the available action statements consisted of four categories:

(1) Objectives of the job that are sought by the officer (e.g., "Acts to maintain a high state of discipline in the unit"), labeled as "Job Goals and Standards."

(2) Actions to obtain these job objectives (e.g., "Recommends the type of disciplinary action to be taken"), labeled as "Controlling Activities."

(3) Actions to obtain information about states of affairs and conditions pertinent to the job, unit, or mission (e.g., "Observes military deportment of personnel"), labeled as "Information-Gathering Activities."

(4) Evaluation of job situations made on the basis of inspections, checks, observations, and communications (e.g., "Determines the troops' current opinion of the unit mess"), labeled as "Determinations."

This simplified grouping of categories for organizing existing statements of work proved useful to interviewers in breaking apart the overly general statements of job activities.

In addition to the two classes of overt job activities, inclusion in the job description process of two other components of the model is desirable to indicate the <u>intent</u> of the overt tasks that are performed. By viewing the "determinations" as <u>purposes</u> to be served by performance of "information-gathering activities," and by viewing the "job goals and standards" as <u>purposes</u> to be served by performance of "controlling activities," it became possible to probe extensively into all aspects of the job.

The "determinations," in addition to being a useful concept for the job analysis, provide meaningful units of work that an individual may be trained to accomplish with proficiency. Thus, "determinations" serve a dual role in the description of the job first as job purposes and second as tasks performed. They meet the qualifications for task statements in that they:

(1) May be expressed by an action verb plus a statement of what is acted upon (e.g., "Determine the rate of learning progress being made by a job trainee").
(2) Represent discrete and perceptible units of work, each having a definite beginning and ending within a limited period. (That is, it is reasonable for an individual to answer <u>how often</u> he performs the activity.)
(3) Are suitable for treatment by task analysis procedures, wherein it is possible to describe how, when, and why each task is accomplished on the job.

The statements of "job-goals and standards," however, do not meet the requirements for task statements. They do not state what the individual <u>does</u>, but instead define--without <u>direct</u> implications for action--the various states of affairs sought by the worker on the job. Their primary utility is as a description aid for the job analysts, with possible subsequent consideration given to the priority of each job goal and standard.

The initial job description for one officer position listed 533 controlling and information-gathering activities and 435 job goals and standards and determinations. These were distributed across the several arbitrary areas of responsibility as shown in Table I. Since the descriptive statements of job goals and standards (152) are not statements of work performance, this means there were 816 task statements, far more than typically derived for one job position.

TABLE I

DISTRIBUTION OF DESCRIPTIVE STATEMENTS

	Type of Descriptive Statement[a]			
Area of Responsibility	Physical Activities		Job Purposes	
	CA	I-GA	JG&S	Det
Tactical Operations	3	0	3	0
Operational Readiness	14	68	2	46
Organizational Maintenance	11	43	4	156
Parts Supply	16	21	11	16
Manning	12	11	12	7
Job Training	23	13	41	20
Discipline, Welfare, and Morale	19	37	18	12
Safety	21	9	18	7
Security	17	10	4	7
Additional Duties (battery level)	85	61	37	9
Secondary Duties and Details (outside the battery)	26	13	2	3
Total	247	286	152	283

[a] CA = Controlling Activities
I-GA = Information-Gathering Activities
JG&S = Job Goals and Standards
Det = Determinations

Functional Context Principles for Content Integration

Functional Context Training (FCT) is a name for a procedure-oriented approach to curriculum design that was originally developed under HumRRO research programs on the training of repairmen for electrical and electronic systems. The FCT method is based on the hypothesis that typical vocational trainees learn best when they can see a real need for the facts, procedures, and concepts they are learning, and when they have a meaningful framework within which to organize these facts. Identification of relevant course content and the sequencing of such content become the prime concerns of the FCT methodology.

The main features of the Functional Context approach to curriculum design for specific courses of study are these (Shoemaker, 1967; McClelland, 1968):

1. A meaningful and work-relevant context is provided for the learning of new and abstract material. This feature requires that a functional context be established for the total training course, thus equipping students with a framework within which they can organize new knowledge as it is acquired in each block or unit of instruction. The set of behavioral objectives derived from actual job activities, create one significant basis for defining the context, wherein the job situation also provides a framework for organizing course content. One result of applying this feature is that abstract technical and theoretical concepts cannot be grouped and taught as a separate instructional unit. Although some concepts, rules, and definitions need to be learned, they would be introduced as needed in the context of learning specific occupational procedures.

2. Within the primary context established by the work situation, the individual units of instruction are then sequenced generally as they would be encountered by a worker on the job. This is done in a "whole-to-part" sequence, from a major item of equipment down to specific piece parts, such that the relevance of instruction at each successive stage can be readily and immediately apparent to the learner. Difficult conceptual material is presented at the time it is needed for learning to perform a specific job activity. The whole-to-part sequencing within a job context is particularly suited for the beginning student who does not have adequate experience to provide a meaningful frame of reference for the course material.

3. Additional sequencing restrictions are imposed by generally requiring that each succeeding unit of instruction should introduce a few new demands for the learning of relevant principles, concepts, and skills. These units of instruction start with relatively simple job tasks which require little theoretical background and proceed in a graded series to the more complex job-related tasks.

4. Use of job-related tasks as the basis for units of instruction permits students to have a chance to apply their newly acquired knowledges

and skills soon after each is acquired. Planned sessions during which students may practice job activities help each student to see that he is learning to do a job, not simply memorizing abstract concepts or facts. The need for each theoretical fact becomes clear to the student as he learns it.

Hierarchical Structures of Technical Concepts

One recent innovation having great potential for organizing training content is the use of a word associational technique for hierarchical grouping of technical concepts, as described in the presentations by Moss, Smith, and Pratzner. The applications of the procedure thus far indicate that various subgroups of experienced technicians can reliably provide word associations that yield unique conceptual structures for each subgroup. This suggests the possibility that the technique could be useful as an empirical means by which curriculum designers could structure educational and job training courses to most effectively match the characteristics of different subgroupings of students. Thus, a class of low aptitude students might well be presented a completely different structuring of the same technical concepts from that used for high ability students.

The technique, being new, presents many challenging questions for research. For instance, how much job experience (and of what type) is necessary before persons can provide useful word associations? Do students themselves know the technical concepts sufficiently well to yield any meaningful hierarchical structure? Are similar conceptual structures provided by matched groups of respondents? What influence do aptitude, experience, verbal ability, and other such individual factors have upon derived concept structures? How many respondents are needed to provide meaningful hierarchies? What proportion, and of what types, of technical concept words are needed?

It was the intent of the present paper to begin exploring some of these questions, starting with a foreshortened, quick-look replication of the reported procedures. Using five subgroups of inexperienced students midway through a lengthy job training course, clues were sought for the following general questions:

1. Can students in training provide meaningful conceptual structures?
2. Do matched subgroups of student respondents yield similar concept groupings?
3. How do student groupings of concepts compare with those of their instructors, both those instructors with some job experience and those without any job experience?
4. Do concepts get grouped differently when the course content is organized by two different curriculum approaches, conventional versus functional context?

Procedures. Twelve students and eight instructors in a 29-week military radar maintenance course were used to provide word associations to a sample of electronic concepts. The concepts used were 68 of the most relevant terms employed in the study reported by Smith.[1] Respondents were combined, four to a group, into five groups as noted in Table II.

TABLE II

IDENTIFICATION OF STUDENT AND INSTRUCTOR GROUPS

Group Coding	
C1	Students in 16th week of Conventional electronics maintenance course.
C2	Partially matched group of students in same Conventional course.
M2	Students in 10th week of Multi-level (functional context) version of same electronics maintenance course, partially matched with Groups C1 and C2.
I1	Instructors for conventional electronics maintenance course, with no field/job experience.
I2	Instructors for conventional course, with average of 7.5 years of field/job experience.

To the extent possible the student groups were roughly matched on length of exposure to concepts of the training course, general and electronics aptitude test scores, education level, and achievement scores in the instruction so far received. See Table III for personal data summaries, including workers from Smith's Minnesota study (Smith, 1968).

Word associations were obtained in group sessions. Instructions given respondents were essentially identical to those used by Smith. Subsequent analyses tried to replicate Smith's procedures.

---

[1] For purposes of brevity in this paper, complete listings of these terms and of subsequent relatedness coefficients and factor loadings are omitted.

TABLE III

PERSONAL DATA DESCRIBING THE CHARACTERISTICS OF THE SAMPLES

	UM						
	Flexible	Inflexible	C1	C2	M1	I1	I2
Age	38.5	39.8	19.0	19.75	19.75	21.25	34.25
Education	12	11.25	12.25	13.0	12.75	14.0	12.25
Years Experience	13.75	12.50		Not Applicable			7.50
Class Standing			92.9	93.6	98.4	Not Applicable	
GT Score (general aptitude)			117.0	122.25	119.75	Not Applicable	
EL Score (electronics aptitude)			119.75	128.0	121.25	Not Applicable	

Results. First examined were selected indices of the comparability of responses between subgroups of this study and of the two groups in the study by Smith. These comparisons are recorded in Table IV. Smith's groups are identified by the label UM (University of Minnesota), flexible and inflexible.

TABLE IV

COMPARATIVE DATA ON GROUPS AND ON RESPONSES

Average Extent of Meaningfulness of the Stimulus Word-Concept

Mean number of different responses elicited in a one-minute time period:

UM (flexible) = 19.2

UM (inflexible) = 16.6

C1 = 20.2
C2 = 17.3
M1 = 19.2
I1 = 21.7
I2 = 24.1

TABLE IV (cont.)

Mean number of pooled responses per stimulus word:

UM (flexible)
= 4.3

UM (inflexible)
= 3.3

C1 = 4.5
C2 = 3.3
M1 = 4.4
I1 = 3.3
I2 = 4.3

Proportion of responses to each stimulus word given by two or more workers:

UM = .22

C1 = .22
C2 = .19
M1 = .23
I1 = .15
I2 = .18

Number of "non-meaningful" (no common associative responses) stimulus words:

UM (flexible) = 8 of 171

UM (inflexible) = 11 of 171

UM (both) = 3 of 171

C1 = 1 of 68
C2 = 1 of 68
M1 = 0 of 68
I1 = 5 of 68
I2 = 1 of 68

Size and Usage of Technical Vocabulary

Total of different words in pooled responses:

UM (flexible) = 200
UM (inflexible) = 131

Student/Instructor Total = 94

Number of stimulus words appearing in pooled response distributions:

UM = 84 of 200

Student/Instructor Total = 48 of 94

Organization of Technical Concepts

Number of stimulus words not loading .30 or above on any factor:

UM (flexible) = 1 of 163

UM (inflexible) = 3 of 160

C1 = 10 of 68
C2 = 23 of 68
M1 = 11 of 68
I1 = 22 of 68
I2 = 13 of 68
All = 3

In general, all groups were reasonably providing the same number of responses to each stimulus word. Size and organization of technical vocabularies were understandably different between students and experienced workers. Differences resulting from the length of word lists must be considered when comparing the two studies. Smith used 171 stimulus words, and there were only 68 in the present study.

Four technical words occurred very frequently in the student/instructor pooled responses. These were "current," "frequency," "tube," and "voltage." Their relative frequency of occurrence was highly comparable with usage in the Smith study.

Of primary interest are the factors derived for each subgroup, using the relatedness coefficient between paired stimulus words per Smith's Minnesota study. For present purposes, the principal components factor analysis program derived only the first ten factors in each of the studies. On the average, this accounted for 36 percent of the variance in each study. First-order factors were labeled as in the previous research.

Table V compares the first ten first-order factors for each subgroup with the Minnesota factor with which each is most highly correlated. Twenty-one of the Minnesota factors were comparable to some extent, with eight of them consistent with three or more of the student/instructor subgroups.

TABLE V

COMPARISON OF FIRST-ORDER FACTORS

		Student/Instructor Subgroups				
UM First-Order Factors		C1	C2	M1	I1	I2
1	Frequency	2	-	-	10	-
2	Voltage	1	-	-	-	-
3	Tube	-	-	-	-	3
4	Vertical (Hold-Roll)	10	6	7	5	10
7	Electron	8	-	2	3	-
8	Current	-	3,10	4	7	1
10	Circuit (Resistance)	-	-	-	4	-
14	Coil (Inductance)	-	5	6	-	9
15	Direct (Current)	-	-	1	-	-
17	Plate (Load)	-	8	-	-	4
19	Bias (Voltage)	3	-	-	-	-
20	Watt	4,6	7	9	9	6
25	Grid	-	1	-	8	5
26	Amplifier	9	-	-	-	-
31	Meter	-	9	-	-	-
32	Gain	5	-	-	-	-
33	Wave	-	4	-	6	-
35	Distortion	-	-	-	-	7
37	Modulation	-	2	10	2	2
38	Polarity	7	-	8	1	-
42	Alignment	-	-	3,5	-	8

At this first-order factor level it would appear that there is little comparability between the three student groups, the two instructor groups, or between students and instructors. Perhaps larger listings of stimulus (concept) words are required, especially to sample effectively the total domain of concept factors. However, the derivation of only the first ten factors may have unduly contributed to this apparent lack of inter-group consistency. Apparently, this technique requires rather large listings of stimulus words, and also requires factor derivation that accounts for much more than a third of the variance. Even so, half of the ten derived factors for any subgroup were matched in at least one other subgroup.

For only one subgroup, student group C1, did any second-order factors appear. This is shown in Figure 1, along with derived labels for each factor and the associated stimulus words having highest loadings greater than .30 on each first-order factor.

This technical conceptual structure was examined for meaningfulness by two experienced curriculum specialists concerned with the electronics maintenance course. Initially they sought to rename some of the factors:

Power Supply and Operating Voltages for Factor A (Output).

Measurements for Factor F (Pulse).

Modulation for Factor B (Choke).

Polarity for Factor 7 (Pulse).

Oscilloscope with regard to Signal Channel for Factor 8

(Oscilloscope).

Grid (Screen) with regard to Tube or CRT for Factor 3 (Grid)

Factor 8 (Oscilloscope) seemed to them as pertaining to use of the scope as a display system instead of as a test instrument. Factors C,D, and E (8, 10, and 3) together seemed to comprise factors relevant to the CRT display subsystem. Factor A and Factors 4, 6, and 1 apparently constituted the basic electronics portion of the instruction. All-in-all they found the structure of little value to them in structuring a training course.

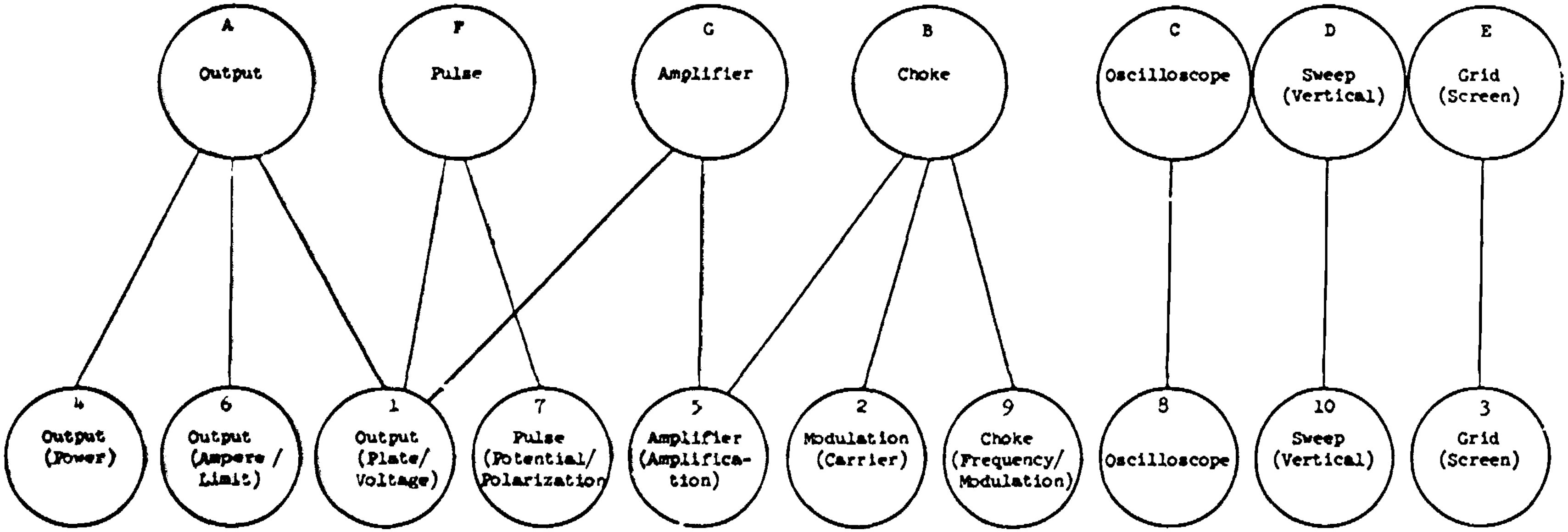
Further discussion revealed the view that the derived structure represented an academic structuring of high school physics. It was not job-oriented in radar terms. It only portrayed principles, and the labels did not apply to the training course as they knew it.

These curriculum specialists wanted the structure to inform them how specific radar equipment chassis differed with regard to the concept terms.

This review tended to point out a major difference between current curriculum organization for a specific job-oriented training course, as

FIGURE 1

THE TECHNICAL CONCEPTUAL STRUCTURE FOR A GROUP OF STUDENTS (C1)
ENROLLED IN A MILITARY RADAR MAINTENANCE PROGRAM



STIMULUS WORD LOADINGS PER FACTORS

Factor 4		Factor 6		Factor 1		Factor 7		Factor 5		Factor 2		Factor 9		Factor 8		Factor 10		Factor 3	
Power	.92	Direct	.65	Amplitude	.64	Potential	.74	Amplifier	.86	Wave	.77	Choke	.83	Oscilloscope	.83	Vertical	.50	Grid	.66
Watt	.88	Level	.62	Peak	.61	Polarization	.72	Amplification	.70	Frequency	.74	Inductor	.71	Blanking	.75	Sweep	.41	Shield	.61
Ampere	.40	Ampere	.60	Regulation	.58	Pulse	.71	Gain	.59	Audio	.71	Receiver	.36	Video	.48	Pentode	.30	Screen	.61
Bandwidth	.39	Surge	.57	Load	.58	Voltage	.70	Microphone	.56	Modulation	.65	Frequency	.34	Sync	.46	Grid	.34	Pentode	.55
Output	.35	Inductance	.45	Excitation	.56	Voltmeter	.61	Video	.50	Harmonic	.64	Modulation	.33					Vacuum	.55
Positive	.33	Meter	.43	Output	.56	Positive	.56	Volume	.44	Bandpass	.57	Inductance	.33					Gate	.54

opposed to traditional vocational education curriculums in the public schools. In the first instance the training content is equipment specific. In the latter case the schools seemingly organize content around logical outlines of principles and concepts, without concern for specific equipment applications. This is consistent with an often expressed goal of preparing vocational students for a wide family of jobs.

Discussion. While this shortened version of the word-association technique does not resolve any of the original questions, it does point out the need for attention to be paid to the selection of stimulus words. Depending on the curricular goals, different types of concept structures need to be sought.

Some response and structural consistency was apparent even in this quickened application of the technique. Obviously there are many procedural questions that need exploring before this approach can become an operational tool of curriculum designers, but it should have sufficient potential usefulness to warrant further research. Even inexperienced job trainees were able to provide numbers of associations to each stimulus word. Their inexperience showed through in their lack of having developed a unique and meaningful structure of technical concepts.

Availability of Time to Apply Innovative Procedures

Many instructional planners and classroom teachers, on being told of a need for a more rigorous procedure in deciding what are the pertinent goals of instruction, will often say that they have neither the time nor the resources to seek out performance requirements with the rigor that supposedly is desirable. In a survey of eight Army service schools(Ammerman, Melching, 1966), it was found that anywhere from 8 to 68 hours of decision effort to every hour of scheduled instruction went into the process of determining what should be taught. This does not include the time spent in preparing the actual instruction. These were not courses in which only one instructor was involved, but were training courses having large numbers of students.

As shown in Table VI, for training in equipment maintenance the ratio was 8 to 1. For job training that did not involve equipment operation or

TABLE VI

DECISION/INSTRUCTION RATIOS

Instructional Scope	Hours of Decision Effort to Hours of Scheduled Instruction
Equipment Maintenance Training	8 to 1
Non-Equipment Job Training	18 to 1
Career Preparation (advanced)	68 to 1

maintenance, the ratio was 18 to 1. And in an advanced career preparation course, where the instructors are the acknowledged subject-matter experts, the ratio rose to a high of 68 to 1. This last value included the time required for the instructors to maintain their expert knowledge, much as academic teachers must do.

On the basis of these values, it appears that much effort is currently being expended in making instructional decisions. For example, 1 1/2 man-years of effort expenditure were being used for each complete consideration of an 8-week equipment maintenance course. And this was repeated for each periodic review or updating of the course.

The main conclusion that can be drawn from the previous discussion is that instructional institutions and staff now appear to have the necessary time and resources to devote to curriculum development for job training programs. The need, however, is to redirect previous attempts at curriculum reform, to seek and/or develop more rigorous procedures for determining the performance requirements and standards for various jobs.

REFERENCES

1. Ammerman, Harry L., A Model of Junior Officer Jobs for Use in Developing Task Inventories. HumRRO Technical Report 65-10, November, 1965.
2. Ammerman, Harry L., and William H. Melching. The Derivation, Analysis and Classification of Instructional Objectives, HumRRO Technical Report 66-4, May, 1966.
3. McClelland, William A., and J. Daniel Lyons, Guidelines for Manpower Training as Developed by the Human Resources Research Office. HumRRO Professional Paper 43-68, December, 1968.
4. Shoemaker, Harry A., The Functional Context Method of Instruction, HumRRO Professional Paper 35-67, July, 1967.
5. Smith, Brandon B., Testing an Empirical Procedure for Identifying Technical Associative Conceptual Structure: Discriminating Between Flexible and Inflexible Radio and Television Repairmen. Unpublished Doctoral Dissertation, University of Minnesota, Minneapolis, Minnesota, 1968.
6. U.S. Continental Army Command. Systems Engineering of Training (Course Design), CONARC Regulation 350-100-1, 1 February, 1968.
7. U.S. Continental Army Command. Student Performance Objectives. CONARC Pamphlet 350-14, December, 1966.