# R E P O R T   R E S U M E S

ED 013 318 VT 002 219

DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL, THE SEQUENCING OF LEARNING UNITS. SEVENTH QUARTERLY TECHNICAL REPORT.

BY- MORRISON, EDWARD J. LECZNAR, WILLIAM B.
AMERICAN INST. FOR RESEARCH IN BEHAVIORAL SCIENCES

REPORT NUMBER BR-5-0009 PUB DATE 31 DEC 66
CONTRACT OEC-5-85-019
EDRS PRICE MF-$0.25 HC-$1.64 41P.

DESCRIPTORS- *VOCATIONAL EDUCATION, *CURRICULUM DEVELOPMENT, CURRICULUM RESEARCH, LEARNING ACTIVITIES, SECONDARY EDUCATION, *SEQUENTIAL PROGRAMS, SEQUENTIAL APPROACH, ARTICULATION (PROGRAM), *CAREER CHOICE, VERTICAL ORGANIZATION, HORIZONTAL ORGANIZATION, PROJECT ABLE, LEARNING STRUCTURES,

THE PRINCIPAL GOAL OF PROJECT ABLE IS TO DEMONSTRATE THE INCREASED EFFECTIVENESS OF INSTRUCTION WHERE THE CONTENT IS DERIVED FROM AN ANALYSIS OF DESIRED BEHAVIOR AFTER GRADUATION. IT ALSO ATTEMPTS TO APPLY NEWLY DEVELOPED EDUCATIONAL TECHNOLOGY TO THE DESIGN, CONDUCT, AND EVALUATION OF VOCATIONAL EDUCATION. THIS REPORT CONSIDERS THE PROBLEM OF SELECTING SEQUENCES FOR LEARNING UNITS SO THAT STUDENTS ACQUIRE THE DESIRED PERFORMANCE CAPABILITIES SYSTEMATICALLY AND EFFICIENTLY. SECTION ONE REVIEWS A PLAN WHICH ALLOWS STUDENTS TO QUALIFY FOR SUCCESSIVELY HIGHER-LEVEL JOBS AND PROVIDES A SERIES OF POINTS AT WHICH STUDENTS MAY LEAVE THE CURRICULUM IN ACCORDANCE WITH THEIR CAPABILITIES AND NEEDS. SECTION TWO DISCUSSES AN ANALYTIC PROCEDURE FOR DERIVING LEARNING STRUCTURES, FIRST DESCRIBED BY R. M. GAGNE. IT PROVIDES AN ANALYSIS OF THE KINDS OF PERFORMANCE CAPABILITIES WHICH MUST BE ACQUIRED, RATHER THAN AN ANALYSIS OF SUBJECT-MATTER LOGIC. SECTION THREE REVIEWS THE MAJOR FACTORS AFFECTING A SEQUENCE THROUGH THE EXERCISE OF AVAILABLE SEQUENCE OPTIONS AND BY THE ADDITION, REPETITION, AND DELETION OF UNITS FROM THE SEQUENCE. THE FINAL SECTION OF THE REPORT CONCERNS EMPIRICAL TEST AND REVISION OF THE INITIAL SEQUENCE DESIGN. (PS)

SEVENTH QUARTERLY TECHNICAL REPORT

Project No. 5-0009

Contract No. OE-5-85-019

# DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

## The Sequencing of Learning Units

31 December 1966



U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

# DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

## The Sequencing of Learning Units

Project No. 5-0009
Contract No. OE-5-85-019

Edward J. Morrison
William B. Lecznar

31 December 1966

The research reported herein was performed pursuant to a contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

American Institutes for Research
Pittsburgh, Pennsylvania

TABLE OF CONTENTS

ACKNOWLEDGMENTS

An effort so large and complex as Project ABLE can succeed only through substantial cooperative contributions by many persons. Of course, as a practical matter, a division of labor must be made and primary responsibility for particular tasks must be borne by individuals. But the sources of ideas and other contributions employed on any one task quickly become obscure in the kaleidoscopic daily interactions among people working together toward common goals. This report, like every product from Project ABLE, is a consolidation of contributions from many sources.

Although it is not possible to acknowledge all contributions individually, two groups deserve special mention. First, thanks are due to the many members of the faculty, administration, and staff of the Quincy Public Schools who have given generously of their time, effort, skill, and good will to aid the project in many ways. The Quincy School Committee not only approved the project, but has provided sustained support and encouragement throughout. Superintendent Robert E. Pruitt was instrumental in the conception and development of the study and has continued to provide the project with inspiring and determined leadership. Maurice J. Daly, Assistant Superintendent, Vocational-Technical Education, has contributed ideas and counsel from his years of experience and has supported the project directly and actively in innumerable ways. The membership of the Educational Policies Committee has devoted many hours as a group and as individuals to the concepts, goals, policies, and implementing procedures associated with the project. The Guidance and Research Department, the school principals, the curriculum consultants and committees, the Quincy Vocational-Technical School Advisory Committee, the librarians, and many other individual members of faculties and staffs have contributed to the project in many ways and on many occasions.

The second group to whom special recognition is due is all of the members of the project organization listed on the following pages. Their sustained, cooperative, and imaginative efforts in this difficult and important undertaking are the key to success.

## POLICY GROUP

| | |
|---|---|
| Robert E. Pruitt | Superintendent, Quincy Public Schools |
| Maurice J. Daly | Assistant Superintendent, Vocational-Technical Education, Quincy Public Schools |
| Dr. James W. Altman | Vice President, American Institutes for Research |

## ADVISORY PANEL

| | |
|---|---|
| Ann E. Donovan | U. S. Office of Education |
| Dr. Richard B. Ford | Carnegie Institute of Technology |
| Dr. Hamden L. Forkner | Columbia University (Ret) |
| Dr. Robert M. Gagné (Chairman) | University of California, Berkeley |
| Norman C. Harris | University of Michigan |
| Dr. Joseph T. Nerden | North Carolina State University at Raleigh |
| Dr. Robert C. Slack | Carnegie Institute of Technology |

## PROJECT STAFF

<u>Quincy Public Schools</u>

| | |
|---|---|
| Robert J. Breagy | Metals and Machines |
| D. Edwin Cain | Power Mechanics |
| John P. Carroll | Business Education |
| Peter J. Chrisom | Social Studies |
| Joseph P. Cunniff | Business Education |
| Bernard A. Dodd | Metals and Machines |
| Michael Golub | Social Studies |
| Edward T. Hannon | General Piping |
| Mary F. Hayes | Home Economics |
| Donald R. Kaupp | Electro-Electronics |
| Francis E. Leporini | General Woodworking |
| Peter J. Ligor | Science |
| Walter E. Lunsman | Graphic and Commercial Arts |
| Charles J. Magnarelli | Power Mechanics |
| John E. McNamee | General Piping |
| Paul E. Milward | Electro-Electronics |
| Francis L. Mullen | Guidance |
| Thomas J. Murphy | English |
| Russell I. Rayner | Science |
| Edmund Repucci | Foods Preparation |
| Anthony J. Rizzotti | Power Mechanics |
| Philip A. Ryan | Mathematics |
| Paulajane Schwarz | Social Studies |
| Charlotte A. Scott | Health Occupations |
| Paul Tranford | Graphic and Commercial Arts |
| George J. Umscheid | Computer Data Processing |
| Thomas F. White | Mathematics |
| William Yee | Metals and Machines |

American Institutes for Research

Jeanne F. Abele
Claire M. Harkins
Vivian M. Hudak
Boyd Kowal
William B. Lecznar
Dr. Edward J. Morrison (Project Director)

# FOREWORD

This report, submitted in compliance with Article 3 of the contract, reports on technical activities of Project ABLE during its seventh quarter of operation, 1 October through 31 December 1966. A brief overview of the project is presented first, followed by a report summary. The major portion of the report addresses the problem of selecting sequences for learning units such that students acquire the desired performance capabilities systematically and efficiently.

OVERVIEW: Project ABLE

<u>A Joint Research Project of</u>: Public Schools of Quincy, Massachusetts and American Institutes for Research

<u>Title</u>: DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

<u>Objectives</u>: The principal goal of the project is to demonstrate increased effectiveness of instruction whose content is explicitly derived from analysis of desired behavior after graduation, and which, in addition, attempts to apply newly developed educational technology to the design, conduct, and evaluation of vocational education. Included in this new technology are methods of defining educational objectives, deriving topical content for courses, preparation of students in prerequisite knowledges and attitudes, individualizing instruction, measuring student achievement, and establishing a system for evaluating program results in terms of outcomes following graduation.

<u>Procedure</u>: The procedure begins with the collection of vocational information for representative jobs in eleven different vocational areas. Analysis will then be made of the performances required for job execution, resulting in descriptions of essential classes of performance which need to be learned. On the basis of this information, a panel of educational and vocational scholars will develop recommended objectives for a vocational curriculum which incorporates the goals of (a) vocational competence; (b) responsible citizenship; and (c) individual self-fulfillment. A curriculum then will be designed in topic form to provide for comprehensiveness, and also for flexibility of coverage, for each of the vocational areas. Guidance programs and prerequisite instruction to prepare junior high students also will be designed. Selection of instructional materials, methods, and aids, and design of materials, when required, will also be undertaken. An important step will be the development of performance measures tied to the objectives of instruction. Methods of instruction will be devised to make possible individualized student progression and selection of alternative programs, and teacher-training materials will be developed to accomplish inservice teacher education of Quincy School Personnel. A plan will be developed for conducting program evaluation not only in terms of end-of-year examinations, but also in terms of continuing follow-up of outcomes after graduation.

<u>Time Schedule</u>: Begin 1 April 1965

Complete 31 March 1970

Present Contract to 30 June 1967

## REPORT SUMMARY

During the present reporting period, technical activity emphasized (1) continued tryout of the junior high school guidance program and development of procedures and devices for its evaluation, (2) development of measures for assessing student achievement of instructional objectives, and (3) preparation of learning units. This report on the problems of designing effective sequences for learning provides a sequel to the preceding quarterly report on the design of learning units. Major sections of the report consider: the gross sequence established by general curriculum policies, the specific sequence requirements due to the structure of objectives, major factors affecting the efficiency of learning sequences, and empirical test and revision of the initial sequence design.

During the next quarter, the design and sequencing of learning units and the development of the accompanying achievement measures will absorb a major portion of project activity. In addition, the collection of data for evaluation of the junior high guidance program now in tryout will continue, development of senior high guidance program plans and materials will continue, and plans for teacher training will be outlined.

THE SEQUENCING OF LEARNING UNITS

A curriculum may be defined as an organized sequence of instructional situations by which students acquire selected capabilities. Previous reports in this series have considered the selection and definition of student capabilities which are the objectives of the curriculum (Morrison, 1965b; Morrison, & Gagné, 1965), the design of instructional situations or learning units for acquisition of the capabilities (Morrison & Lecznar, 1966b), and the development of measures whereby students demonstrate achievement of the objectives (Morrison & Lecznar, 1966a). The present report is concerned with the problems of organizing the learning activities into effective sequences.

The first three sections of the report deal with the initial design of the learning sequence. Section one outlines the gross sequence established early in development by general policy decisions. Section two discusses the more specific sequencing requirements imposed by the structure of learning objectives. Section three reviews major factors affecting the efficiency of a sequence. The final section of the report concerns empirical test and revision of the initial sequence design.

## General Policy and Administrative Requirements

In any curriculum development, there are questions of general policy, strategy, and procedure which must be resolved in order to proceed with the technical development. No curriculum could achieve every possible educational goal, include every desirable learning, employ every available teaching method or technique, solve every identifiable problem, or otherwise be totally comprehensive. A curriculum must have focus. That is, it must select some things for inclusion and omit others. Priorities for accomplishment must be set and the curriculum designed to enhance the probabilities of the higher priority accomplishments under the real-world conditions of its operation.

The choices and decisions made in response to these general questions usually have pervasive effects on many aspects of the curriculum. For Project ABLE, the major decisions and their effects are exhibited in some detail in the project proposal (American Institutes for Research & Quincy Public Schools, 1964) and in the previously cited reports on the selection and definition of objectives and on identification and design of learning units. The cumulative effect of many such decisions on the content and sequence of the curriculum is seen in the curriculum outline (Morrison & Gagné, 1965) reproduced in summary form in Appendix A. This outline allocated the time available to students in each school year 9 through 14 to carefully defined subject-matter areas and, thus, provided sequences for large blocks of learning activity. The rationale for the selection and ordering of activities is discussed in the report which presents the outline and need not be repeated here. The importance of the outline in the present context is the gross initial framework it provided for the development of more detailed learning sequences.

The curriculum outline as initially defined was modified and augmented in order to deal with three kinds of problems. These problems and the curriculum remedies provided are discussed below.

Exploration, informed choice, and basic skills. There is appreciable evidence that young people have difficulty in choosing and developing appropriate careers. Thus, Project TALENT (Flanagan & Cooley, 1966), in its comprehensive study of a national sample of high school students, found that students' occupational and career choices were highly unstable over the period from grade nine to one year after high school graduation. Only 17 percent of male graduates chose the same occupation a year out of school that they chose as ninth graders. Only 31 percent of them chose the same career they elected in twelfth grade. Similarly, Eninger (1965) found that less than half of the graduates from vocational courses were employed in the occupations for which they prepared. Possible explanations for this substantial instability in career development are numerous. Probably, several factors are important.

Lack of knowledge is one possible contributor to the difficulty students have in choosing and maintaining a stable career development pattern. Many students must make educational and occupational choices without substantial knowledge about the nature and requirements of available opportunities or about their own capabilities and interests. The sheer number and variety of recognizably different occupations (U. S. Dept. of Labor, 1965) is sufficient to make it very unlikely that a student's casual contacts would provide him with occupational information adequate for an informed career choice. If, in addition, he and his parents have limited data about himself and little knowledge of the implications of personal data and of occupational information for appropriate choices, uncertainty or error must be a frequent result.

Another potential source of instability in career choice is the change to be expected in the student and in his occupational opportunities during the several years he spends in high school. Adolescence is a period of rapid and sometimes confusing change and development (Stone & Church, 1957). Values, interests, and goals undergo frequent revision during this period and may differ substantially from those held later in life. In addition to changes to be expected in students, the pattern of demand for skills and knowledge is changing continuously in the marketplace (U. S. Dept. of Labor, 1964; Venn, 1964). The occupational goals which are available to the student therefore change to some extent even while he is preparing for a career. Stability of specific career choices during adolescence would be remarkable under such conditions.

In consideration of these difficulties, several decisions affecting the sequence of learning were taken to assist students to cope with the problems of career choice and preparation. First, a special kind of guidance program (Morrison & Hudak, 1966) was prescribed for the three junior high years which precede the first major career decision faced by each student: tentative selection of a high school course of study at the end of ninth grade. The individualized guidance program attempts to provide each student and his parents with useful information about the student, about occupational opportunities, and about educational routes to those opportunities. It also provides instruction in systematic procedures for arriving at career decisions and educational choices. Thus, the program is designed to reduce career-choice instability, insofar as it is due to lack of knowledge, and to provide career decision-making skills which will enable the students to make rational choices whenever his goals or opportunities change.

The second decision intended to assist students in career choice and preparation was for a ninth grade course in "basic technology" (Morrison &

Gagné, 1965). This course, originally planned for tenth grade, was moved to ninth to follow the acquisition of basic intellectual tools, precede specific occupational preparation, and parallel the last phase of the vocational guidance program. The course attempts to provide the student with basic capabilities found in a previous study (Altman, 1966) to be useful in a wide variety of occupations. It is intended to be useful preparation even in a situation marked by changes in the student's goals and in the opportunities available to him. In addition, it is hoped that the course will contribute to an improved basis for informed career planning and for the choice of specific vocational training.

A third decision was to provide each student with an opportunity to explore a variety of occupations before making a relatively firm career choice. Thus, insofar as possible in tenth grade, each student will be allowed to take beginning learning units in several vocational areas. In this way, he will have an opportunity to encounter the different kinds of tasks and requirements available in the various areas and have some improved basis for his choice of occupation.

These three decisions represent a concerted attempt to prepare students during the period preceding specific vocational training to make better informed, systematic, and stable career choices and to tolerate subsequent changes in their goals and opportunities.

<u>Career sequences and multiple exit points</u>. A general goal for the curriculum is that each student should have the opportunity to achieve marketable vocational competence at whatever level his capabilities, efforts, and time permit. It is intended that students with outstanding ability and students with limited ability both will find their needs met by the curriculum and that any student will be able to leave the curriculum at any time, within broad limits, with some marketable skills.

To facilitate achievement of this general goal, it was decided to arrange specific vocational training in each area so that the learning sequence parallels the skill-career progression of jobs in that area insofar as possible. Thus, in each vocational area, we tried to select a sequence of jobs such that a large proportion of the skills and knowledges of any job also are required for successful performance of jobs later in the sequence. In this arrangement, a student may acquire capabilities in a sequence which qualifies him for successively higher-level jobs and may emerge from training with capabilities appropriate for a variety of jobs in his vocational area. This sequencing of vocational training provides multiple exit points from the curriculum which students may take depending upon their abilities and needs. Each exit point, however low it may be on the career hierarchy, represents successful learning and demonstrable achievement by the student.

The arrangement of learning activities to parallel the job sequence has two main effects on the sequence of individual learning units. First, learning units are grouped according to the jobs to which they apply and then the groups are arranged in correspondence with the sequence of jobs. Thus, the job hierarchy prescribes a sequence for <u>groups</u> of learning units, not for the individual units within a group.

A second, more subtle effect of this arrangement may cause a learning unit to appear which would not otherwise be included, or cause it to occupy a place in the sequence which is different than it would be were training designed for only one exit job. These results are due to the fact that the job sequences do not constitute perfect hierarchies of skills and knowledge. Most, but not all of the capabilities required for adequate performance of a job (say, wireman) also are required for higher-level jobs (e.g., electrical appliance repairman). Those learning units required <u>only</u> for the lower job (wireman) are included under the present plan. They would not be included if training provided qualified exit only at the higher level (repairman). Similarly, it may be necessary to introduce a topic either earlier or later in the total learning sequence than would be the case without multiple exit provisions. Thus, some loss of efficiency in training for the higher-level jobs may be introduced by the provision for multiple exits. However, the penalty for this strategy generally is quite low and is considered to be a small price for the increase in vocational versatility accruing to students who reach the higher levels, and for increased assurance that the less promising students will achieve some employable capabilities.

Administrative considerations. Whatever the desirable goals for the curriculum, the program of learning activities must fit into the available time and facilities, must satisfy various laws and regulations, and must be compatible with a wide variety of operating conditions. To accomplish this, many minor and some major adjustments in sequence and timing are required. It would be neither practical nor useful to identify these here. However, a few important kinds of administrative considerations can be discussed as examples.

Several vocational areas are affected by legal and accreditation requirements. In most such instances, entry to accredited specific training for the occupation requires either high school graduation or a minimum age or both. Specific vocational preparation in these areas must be delayed, usually until grades 13 and 14, even if students would be capable of learning the required content earlier. Further, certain prerequisites to entry into training often are stated in terms of course titles and credits. Such regulations establish constraints on the learning sequences available for some vocational areas and on the timing of career choices. A different educational program is to be expected for grades 10-12 under these regulations than would obtain were the program defined only by analysis of what the graduate must know and be able to do in the vocation.

Various other requirements affect the curriculum pattern and learning sequence by the control they impose on time. Thus, such factors as tradition, teachers' contracts, and school system financing limit the school day to a given number of hours and the school year to a certain number of days. Regulations governing such important programs as accreditation, reimbursement, and apprenticeship credit specify some courses, some kinds of learning activity, and the number of hours and proportion of school time to be devoted to some parts of the curriculum. It is not contended that these influences are necessarily to be decried or that they cannot be changed. It is a fact, however, that collectively they currently limit the time available for allocation to learning activities considered important to the goals of a new curriculum, restrict the freedom with which time can be distributed among learning activities, and insert learning activities which do not necessarily fit neatly in the rest of the learning sequence. These constraints require adjustments in the sequences which otherwise would be chosen.

Finally, there are many practical operating givens which must be taken into account when a learning sequence is being selected. These facts of life vary from one school's situation to another and must be dealt with individually. One noteworthy example of this type is the problem of scheduling. This is a particularly difficult problem when only part of a student body is to adopt a new curriculum and when facilities, faculty, or portions of the curriculum are to be shared by the different parts of the total enrollment. It may not always be possible to offer courses or schedule learning activities at the optimum point in each student's sequence of study and alternative sequences must be found.

Summary. This section reviewed several general influences which together prescribe the gross outline within which detailed sequences of learning activities can be specified. In this outline, preparation for career decisions and versatility is provided prior to vocational commitment through a special guidance program in grades 7-9, a course in grade nine directed to development of basic and generalizable vocational capabilities, and opportunity for vocational exploration during grade ten. Subsequently, the outline provides that in each course of specific vocational preparation, the learning sequence be arranged in parallel with a skill-career progression in jobs. This plan allows students to qualify for successively higher-level jobs and provides a series of points at which students may exit from the curriculum in accordance with their capabilities and needs.

The sequence of this outline is intended to meet the needs of students for more stable and circumspect career choices, for more adequate responses to changes in occupational opportunities and in their own goals, and for the opportunity to achieve vocational competence at their own levels of ability and aspiration. It should be noted, however, that the sequence outlined so far has not been determined in any important respect by consideration of the nature of what is to be learned. Neither has the sequence of individual learning units within major blocks of the curriculum been determined. These two matters are the subject of the next section.

## Learning Structures

Whatever other factors may influence the sequencing of learning activities, first priority must be given to the orderly acquisition of prerequisites for each thing to be learned. If, for example, a student must learn A before it will be possible for him to learn B, then A must occur sometime before B in the learning sequence. A large number of such dependencies might be expected in any curriculum, even for a limited subject-matter area. Furthermore, individual dependency relationships may have connections with each other (as when, say, C and D are prerequisites for A, and D also is prerequisite for E). All of these relationships taken together would constitute a hierarchical structure for the subject-matter area based on the order in which things must be learned. Such learning structures must be represented faithfully in the instructional sequence finally selected. Their derivation and characteristics are the major concern of this section. First, however, we will examine briefly the apparent role of learning structures in determining current educational sequences and note the importance of stating instructional objectives in terms of students' performances.

Learning structures and current curricula. In its broad outlines, education long has been organized as if at least some knowledge is structured hierarchically. That is, it has been assumed that students must learn some things before they will be able to learn others. "Tool" skills and ideas appear very early in the curriculum as preparation for later work which depends on those basic competencies. Sequences of courses are arranged with the intention to build on past, prerequisite learning as, for example, in the familiar sequence of arithmetic, algebra, geometry, trigonometry, and calculus.

When common educational sequences are examined in more detail, however, their hierarchical character seems much less distinct. Algebra 1 is established as prerequisite to Algebra 2, for example; but the actual content of Algebra 1 often varies from class to class and from school to school. At least some things, and usually many things, learned in Algebra 1 are not used as a basis for learning something else in Algebra 2. Students "pass" from Algebra 1 to Algebra 2 with widely different amounts and kinds of competence in the subject matter. Some students have mastered every topic, whereas others have mastered only some, possibly none. Within Algebra 1, topics often are studied in different orders by different groups of students, and the sequence of learnings while working on any one topic varies greatly.

It would seem that the learning sequences of public school curricula often are arranged in accordance with the general assumption that some knowledge is hierarchical, but the specifics of the learning structures seem not to be well defined. Yet, if knowledge in an area is structured naturally in such a way that learning one thing depends upon previous learning of some other things lower in the structure, then explication of the structure is of the utmost importance to education. Specification of any relevant learning structures which exist is a necessary precondition for prescription of successful learning sequences. Violation of a sequence, by omiss. n or rearrangement of the elements, or by advancing students who have not mastered the elements must result in failure of the instructional regimen and dependence upon extemporaneous "filling in" by students.

So far as the writers know, there has been no formal attempt to define the entire learning structure of any major body of knowledge such as mathematics, English, physics, or social studies, nor should there have been. Such an undertaking would be prohibitively costly and imprudent, at this time at least. No practical curriculum could include all of any such structure. Further, only a small part of a large structure would be related to the instructional goals of any particular school or curriculum. What is needed in educational practice is a statement of the particular goals held for a curriculum and a means for defining the learning structures supporting those goals. Some substantial progress has been made in meeting these needs.

The importance of performance objectives. It is apparent that one must select what is to be taught before he attempts to define the supporting learning structure or to devise an instructional sequence. What seems not to be apparent in all cases is how to define "what is to be taught." In a more detailed review of this problem (Morrison, 1965b), it was concluded that neither a logical outline of subject matter nor broadly-stated long-range educational goals could serve effectively as the objectives of instruction and the basis for curriculum development. It was considered necessary that instructional objectives be defined which are unambiguous statements of student performance and which include the criteria for success and the important conditions under which the performance is to take place. In Glaser's (1966) terminology, the component repertoire, rather than the content repertoire, must be specified. This conclusion requires instructional objectives stated in terms of observable things the individual student is able to do as a result of his learning. It does not allow for objectives stated only in terms of the teacher's actions, of the textbooks or other materials used, of the topics addressed, or even of unobservable changes in students.

Statements of instructional objectives in performance terms seem to be relatively uncommon in public education (Lindvall, 1964) even though their importance was recognized years ago by some (e.g., Tyler, 1934), now is recognized by many (c.f., Gagné, 1965a) and has been demonstrated in a variety of subject-matter areas (Glaser, 1965). The lag in widespread development and use of performance objectives seems in our experience due to at least three major obstacles. First, there is the notion that "understanding," "valuing," "reasoning," "comprehending," and other obviously desirable inferred characteristics of the student are ignored, or at least depreciated, by such behavioristic objectives. Secondly, some doubt that performance objectives can be stated for their subject matter. Thirdly, the preparation of a comprehensive set of objectives meeting the stated requirements is an exacting, time-consuming job for which not everyone has the necessary skills.

The first two of these sources of difficulty seem to be due to a misinterpretation. That is, the requirement for performance objectives does not ignore or depreciate the inferred characteristics considered by many to be important educational goals. The argument simply is that they have educational importance only in terms of their relations with the students' capabilities. If "understanding" something is important, then it is important because students who "understand" are able to do something, perhaps many things, other students cannot do. The concept "understanding" is a label applied to individuals who demonstrate a particular set of capabilities. Performance objectives simply require that we specify the capabilities, however complex or simple, an individual must acquire in order to qualify as "understanding" what is taught. Those who believe their subject-matter area is not susceptible to performance analysis run the risk, as Mager (1962) points out, of being unable to show that anything at all has been learned.

The difficulty and cost of preparing performance objectives is a real and persistent obstacle. When the subject matter is not well delineated and when even general goals are uncertain, the problems can be severe and require application of the greatest talent. Markle's (1965) cogent summary of the problems faced in attempting to define and analyze objectives in English illustrates this kind of situation. Yet it is essential, even in difficult subject-matter areas, to persist until performance objectives are obtained. Among the many reasons for seeking them, two are of major importance in the present context: performance objectives are the necessary basis for (1) an assessment of the learning accomplished by individuals and of the effectiveness of learning sequences, and (2) the derivation of learning structures in which necessary learning sequences are defined and in which effective conditions of learning can be identified for the elements of the sequences. It is to the process by which learning structures are defined in support of performance objectives that we turn now.

<u>The derivation of learning structures</u>. Usually, before the terminal objectives can be written for a curriculum (of whatever length), it is necessary first to define the domain of potential objectives and to select from this domain a limited number of objectives for which the curriculum will provide preparation. A general procedure for this analysis and its application in Project ABLE have been described in previous reports (Morrison, 1965b; Morrison & Gagné, 1965; Morrison & Lecznar, 1966b). The principal concern in defining the domain of objectives is to be comprehensive so that no important potential objective or class of objectives is overlooked in the selection process. The form of description used in defining the domain can vary to accommodate the idiosyncracies of the domain, so long as it provides a comprehensive inventory of the kinds of performances which could be objectives of the curriculum.

The terminal objectives selected from the inventory for a curriculum normally are complex performances in the sense that they require the integration of several other performances. Thus, for example, when properly specified conditions and criteria are added, an objective for a course in electronics repair might be, "Restores malfunctioning television sets to proper operation." Similarly, an objective for a French course might be, "Translates into English any passage from a contemporary French-language newspaper." In order to accomplish any such objective, one first must be able to do several things which are components of the terminal achievement. In the television example, the student would have to be able to identify the symptons of malfunction, to enumerate possible causes, to perform a sequence of diagnostic tests, etc.

Gagné (1962; 1965a; 1966) has suggested that subordinate performance capabilities be identified by asking the question of each objective, "What would the learner have to know how to do in order to perform this task, given only instructions?" A more complete statement of the question, and one which takes into account both the components of the objective and the unity of the capabilities to be learned is, "What previously learned capabilities must be assumed if the student is to learn this (terminal) capability under a single set of learning conditions?" The answer to this question is a set of capabilities prerequisite to achievement of the terminal objective. Students must learn these things before they can learn the terminal performance. The terminal objective and its prerequisites provide the beginning of the hierarchical learning structure we seek. The same analytic procedure applied to the newly defined objectives will yield another set of prerequisite capabilities and another level in the structure. The procedure can be repeated as each new set of prerequisites is identified until a level is reached at which all of the capabilities are within the repertoires of beginning students. At this point, a structure has been defined in which the sequential relations necessary for learning have been identified.

This procedure has been applied to a variety of subject-matter areas and many examples are cited or presented by Gagné (1965b; 1966). One of these is displayed in Appendix B. An interesting example is described by Kersh (1965) who illustrates a method for including in the structure specific provisions for motivation, discovery processes, and transfer. The application of the procedure in Project ABLE was described in an earlier report (Morrison, 1965b). In all of these applications, the resultant structures have certain characteristics which are reviewed briefly below.

Characteristics of the learning structures. It should be noted first that application of the procedure has consistently produced hierarchical structures defining essential sequential relations. Although it is conceivable that analysis of some subject matter might not produce the multi-tiered hierarchy described by Gagné, none has been reported. It is clear that the procedure can be expected to identify structures of knowledge in many areas. The essential requirement is that objectives be stated in behavioral terms.

A second characteristic of the learning structures, first noted by Gagné (1962), is that the capabilities to be learned are increasingly simple and more general as one proceeds from top to bottom in the hierarchy. At each level, capabilities also are different from those for which they are prerequisite. Each capability in the structure is an entity in which component capabilities are organized and applied in concert to accomplish a new kind of performance.

A third characteristic of the learning structures derived by this procedure is that they often differ considerably from those implied by textbooks. This is because the elements of the structure and their locations are determined primarily by the nature of the performance capabilities to be learned and by the instructional procedures and conditions appropriate for learning those capabilities. They are not determined primarily by consideration of subject-matter logic or the relations among common subject-matter topics. The subject-matter content is not ignored in developing the learning structure, but the analysis assumes that different learning conditions are required for various kinds of capabilities and that the kinds of capabilities themselves form a hierarchy (Gagné, 1965b). Consequently, emphasis in the analysis is on identification of the kinds of performance desired of the student and on sequencing the kinds of performance so as to assure efficient learning.

A fourth characteristic, then, is that the structure provides for the acquisition of capabilities, with respect to a given content, in a sequence consistent with a hierarchy of types or kinds of capabilities. Gagné

(1965b, p. 247) argues that, " . . . to achieve the objective that is a

1. higher-order principle requires learning conditions for a principle plus prerequisite (subordinate) objectives of principles or concepts;

2. principle requires learning conditions for a principle plus prerequisite (subordinate) objectives of concepts;

3. concept requires learning conditions for a principle plus prerequisite (subordinate) objectives of multiple discriminations;

4. multiple discrimination requires learning conditions for multiple discrimination plus prerequisite (subordinate) objectives of verbal or motor chains; and

5. chain requires learning conditions for a chain plus prerequisite (subordinate) objectives of Ss $\longrightarrow$ R connections."

Learning structures based on this hierarchical conception would introduce the learning of higher-order principles only after the acquisition of all related, subordinate principles or concepts. The learning of principles would be introduced only when prerequisite concepts had been learned, and so on.

Altman (1966) has proposed a more extensive behavior classification which preserves Gagné's hierarchical formulation and includes categories proposed by others (Melton, 1964). Appendix C presents a table from Altman's report illustrating each kind of behavior for several content areas.

At this point, it is important to note that not all sequencing problems are resolved by the learning structures derived in the manner described so far. The learning structures do define the essential sequences for a variety of objectives and subject-matter areas and they do exhibit many desirable characteristics. At the same time, they leave other problems unresolved. Thus, a fifth characteristic is that the prerequisites derived for any objective are determined by the analyst's choice of a method for performing the kind of task defined by the objective. For example, the objective "adds signed numbers" could be accomplished in any of several ways. Two common methods are: (1) to use the number line, or (2) to use rules about the manipulation of signs. The prerequisites for these two methods are not identical and the learning structure supporting the addition of signed numbers by one method would differ from the structure derived for the other method. In the electronic repair example cited earlier, TV sets may be restored to proper operation by any of a variety of systematic methods. The method(s) chosen by the analyst will determine the prerequisite learning structure to some extent. The analyst makes his choice from the known methods by using information about such matters as the generalization and retention characteristics of the various methods, the kinds of performances most probably to be required of the student later, the time required to become proficient in the methods, and the difficulty or cost of supporting the learning activity. All of these considerations are apart from the basic question defining the procedure by which prerequisites are identified. The important observation to be made now is that the procedure accomplishes its objective which is to define <u>an</u> effective learning structure and prescribe for <u>that</u> structure the essential sequences of learning achievements. It does not necessarily define the only learning structure which could support the terminal objective and it may not define a learning structure which is best for all curriculum purposes.

Characteristic <u>six</u>, related to number five, is that these learning structures, being products of a fallible, rational process, require empirical evaluation. Of course, tryout is needed simply to demonstrate that students accomplish the desired learning. In addition, however, experience with these structures and with those developed by other procedures (Glaser, 1965) has shown that data from empirical test can be used to identify effective and ineffective units, errors in sequencing, the need for new or additional objectives and units, the need to eliminate material, etc. In his later writing, Gagné (1966) describes such diagnostic evaluation as an integral part of the process of curriculum development. More will be said in a later section about empirical test of the structures.

Finally, the <u>seventh</u> characteristic to be noted is that the structures may be described in general as partially-ordered sets and, consequently, prescribe only some of the sequence decisions required of the director of a student's learning. Consider, for example, the limited structure shown in Appendix B. In general, sequences are prescribed in the vertical, but not the horizontal dimension. Thus, for example, Vb must be learned before IVd and IVb, and IVd must be learned before IIIb and IIb. But there is no indication as to whether Va comes before Vb or vice versa. Presumably, it is a matter of indifference, so far as the structure is concerned, which of these is learned first so long as both are in the student's repertoire, along with the other prerequisites, when he attempts to learn IIb. This is the most commonly reported kind of structure. Other forms, which are special cases of the general form, are conceivable. Thus, a completely ordered structure might occur in which each objective has a single prerequisite or in which a single best sequence is otherwise identified. Conversely, there might be a completely unordered structure in which everything to be learned is independent of everything else so that the sequence in which things are learned is of no consequence. No example of either of these has come to the attention of the writers, though small areas within a curriculum may illustrate both of these forms.

It should be remembered that we have been talking here about learning structures and the necessary sequential relations they specify among objectives. When such a structure has been defined, the teaching sequence normally is only partially determined. If it is comprehensive, the learning structure will specify all of the capabilities which <u>must</u> be acquired and all of the sequential relations which <u>must</u> be observed if the terminal objective is to be achieved. So long as the teaching sequence includes these prescriptions, the learning structure is satisfied. But the partially-ordered characteristic of the structures requires that numerous additional decisions about sequence be made when students are given learning assignments. Sometimes, these decisions are made once and the result is a single teaching sequence for all students. In other cases, each available decision is taken for each student separately and the result is many teaching sequences. Either way, the learning structure is satisfied if all essential objectives are included and if all of the essential sequences are preserved.

Summary. In order to achieve a learning objective, the student usually must approach the learning task with a certain repertoire of previously acquired capabilities. Each of these prerequisites to achievement of the final objective is itself a learning objective which can be achieved only if still other capabilities have been acquired. The total pattern of such dependency relations among all of the capabilities to be learned en route to the final objective constitutes a hierarchical learning structure. The basic requirement for an effective instructional sequence is that it preserve the order of learning tasks implied by the structure.

Although many current public school curricula seem not to be based on well-defined learning structures, such structures can be developed if objectives for a curriculum are stated as performance capabilities desired of students. An analytic procedure for deriving learning structures, first described by Gagné, has been adapted for use in Project ABLE. The procedure provides an analysis of the kinds of performance capabilities which must be acquired, rather than an analysis of subject-matter logic, so the resulting structures and sequences often are different from those implied by textbooks. Characteristically, their sequences begin with relatively simple and general capabilities and proceed to the more complex and specific kinds which commonly serve as course and curriculum objectives. The structures resulting from this procedure provide for the orderly acquisition of prerequisites for each thing to be learned and, thereby, specify the minimum set of sequential relations necessary for an effective instructional sequence. They do not normally specify all sequence decisions, however, and the director of a student's learning must make some of them. So long as the instructional sequence presents all elements of the structure in their prescribed order, the learning structure is satisfied. The structures and sequences derived by this procedure are the products of a purely rational process and subject to a variety of judgmental errors. They must, therefore, be subjected to empirical verification.

## Instructional Efficiency

So far, this report has considered two kinds of requirements which influence decisions about the sequence of learning activities. The first section examined the influence of philosophical and general operational considerations as imposed through policy and administrative decisions. Influences of this kind affect the sequence of large blocks of the curriculum, such as whole courses, primarily. The second section dealt with constraints imposed by the nature of what is to be learned as reflected in the learning structures which must be preserved by instructional sequences to support the achievement of particular learning objectives. Influences of this kind determine necessary sequence conditions within large blocks of the curriculum among specific topics and objectives. Together, these two kinds of requirements define sequences of learning achievements which are necessary to accomplishment of curriculum objectives. Within these essential restraints on sequence, however, some additional decisions are required and some maneuvering is possible to enhance the efficiency of the instructional regimen. After noting the ways in which sequences can be manipulated within established constraints, this third section identifies some major kinds of decisions which affect the efficiency and sequence of learning activities.

Permissable types of sequence manipulation. There are three principal ways in which instructional sequences may be manipulated without violating the requirements of the learning structures from which they derive.

1. Exercise of options

   As noted in the discussion of learning structures, the instructional sequence is only partly determined by the structure. The sequence in which some things are learned is not important to the orderly development of prerequisites. The arrangement of these learning units can be adjusted freely. Similarly, two or more whole structures may have no necessary sequential connections and, therefore, can be sequenced as desired to satisfy other concerns.

2. Additions and repetitions

   The learning structures provide sequences in which critical learning achievements must occur. Perhaps it is more precise to say that the structures identify for each thing to be learned those capabilities which the student must possess at the time he undertakes that learning task.

Provided the instructional sequence assures this condition, learning units may be added to the set required by the learning structure. As a corollary to this manipulation, units may be repeated in the instructional sequence without violating the requirements of the structure.

3. Deletions
Although the student must approach each learning task with the prerequisite capabilities, there is no requirement that he obtain those prerequisites from the curriculum. Any capability in the sequence which the student already has acquired and has available when needed may be deleted from his instructional sequence. Of course, if terminal objectives are changed so that objectives lower in the learning structure become the new end points of a curriculum, then all units after the new end points in the sequence are deleted.

Several important kinds of provisions concerning the efficiency of a learning regimen make use of these allowable manipulations of the sequence.

Individual learning prescriptions. A major advantage of curricula based on such learning structures as are described in this report is that they facilitate the diagnosis of the learning needs of individual students and the prescription of learning activities. Since the structure specifies the performance capabilities which must be learned, it is possible at the outset to test each student for those capabilities and to enter him into the instructional sequence wherever his entering state of learning requires. Thus, each student might start at a different point in the sequence and, because of the particular pattern of capabilities with which he began, follow a sequence which differs in several ways from that of every other students. In this kind of instructional arrangement, students would not all be working on the same learning activity at the same time. Different students would spend different amounts of time on any particular unit before demonstrating mastery of the unit and readiness for the next element of the sequence. Some units might be deleted from a student's schedule upon demonstration that he had acquired those capabilities already. Conversely, remedial units could be added to provide any necessary capabilities which were absent from the repertoire of a student. For particularly rapid students, units could be added to enrich their education in accordance with their individual interests and needs. Optional sequences could be employed to give each student choices among the things yet to be learned at particular points in his progress.

It should be emphasized that these advantages of individually prescribed instruction depend upon (1) knowing with precision what the student must learn and (2) knowing at any time what the student has learned. The learning structures provide the former, but the demonstration of mastery for each element in the learning structure is of equal importance and requires the development of an adequate performance test for each thing to be learned (Morrison & Lecznar, 1966a). Great instructional efficiencies are available, however, when the sequence of learning activities is tailored to the needs of individual students.

<u>Practice</u>. Many things which must be learned in school curricula require practice for their acquisition. Frequently, additional practice, repetition, or review also is required periodically to maintain a capability in the student's repertoire. Efficient practice and review schedules are important to the success of many learning programs and decisions about these schedules have effects on instructional sequences. Whether instruction is individually prescribed or not, options available in the structure may be exercised so as to introduce early in the sequence the learning of skills requiring the most practice. The portion of the structure in which such skills occur may be selected as a starting point. Subsequently, practice or review units may be added as necessary to maintain proficiency and ensure that the capability is available when it is needed in a new learning task. The conditions and schedules for effective practice and review differ from one kind of capability to another. However, since additional units may be added to the sequence of a learning structure wherever needed, sufficient latitude is available within the requirements of any learning structure to accommodate the necessary variety of systematic plans for practice, repetition, and review.

Generalization and transfer. Virtually all learning in school is intended for use in situations different from those in which the original learning took place. The most obvious instance is the intention that capabilities (e.g., arithmetic) learned in school be used in every day life (e.g., making change). Many capabilities acquired in one learning sequence are intended to be used in others also. Thus, the concept of gravity learned in a physics sequence is useful in biology, the operations of calculus learned in a mathematics sequence are useful in physics, and the communications skills learned in an English sequence are useful in a vocational course. Finally, as evidenced by the learning structures, a capability acquired at one point in a learning sequence is intended to be used later in the same sequence to acquire a new capability.

If generalization and transfer are so important as outcomes of learning, then specific provisions need to be made to facilitate their occurrence. The kinds of transfer desired can be stated as performance objectives and included in the development of learning structures (Kersh, 1965). When this is done, one result to be expected is that the relations among otherwise separate structures will need to be specified and learning sequences will have to be coordinated. Thus, the prerequisites for a unit in a machine operation sequence might include units in the physics and mathematics sequences. Explicit recognition of these relations would result in a "master" structure in which the learning sequence might proceed from mathematics to physics to machine operation. Practical scheduling considerations might prohibit the free movement of students from one facility to another just at the optimum time in such a sequence, but the essential order could be maintained by ensuring in the example cited that the mathematics and physics prerequisites were accomplished at some time prior to the unit in machine operation. Provisions like those illustrated are necessary to make transfer possible by ensuring that capabilities acquired in one sequence are available when needed in another sequence. Whether effective transfer occurs or not depends, however, on the learning conditions established for the new learning task and on the conditions under which the capability was acquired originally.

Another probable result from stating performance objectives for generalization of particular capabilities is that sets of units will be required in which the student applies a capability to a variety of situations. Thus, a troubleshooting procedure might be applied to a variety of malfunctions or equipment, a concept might be extended to a more diverse set of objects or ideas, or a physical principle might be used in problems from several different content areas. Some units of this type would appear in every student's learning sequence. Others could be made available to students as time and interest permitted the enrichment of their education. Such optional units could be added at the end of a general sequence or, if more desirable administratively, at any point in the sequence at which the prerequisites had been acquired. A similar provision, which probably is more difficult to arrange, would accomplish generalization objectives for capabilities in one sequence by the way in which learning units are constructed or added in other sequences. For example, generalization of a capability in the mathematics sequence might be facilitated by providing learning units requiring application of the capability to problems in physics, social studies, and business sequences.

Summary. The efficiency of a curriculum may be enhanced by provisions for individual learning prescriptions, effective practice and review schedules, and generalization and transfer of learned capabilities. Such provisions are possible within the essential requirements established by policy decisions and by learning structures. This section briefly reviewed ways in which these provisions could be implemented through the exercise of available sequence options and, under certain conditions, by the addition, repetition, and deletion of units from the learning sequence.

## Testing the Sequence

In all that has gone before, we have been concerned with rational procedures by which sequences of learning activities can be defined. These procedures are designed to include all considerations known to be important for sequencing learning activities. But it is easy to err and to arrange activities in less than optimum order when using rational analysis alone. Consequently, the sequences derived by rational analysis are viewed most accurately as trial sequences which must be evaluated empirically.

The two basic questions to be answered empirically about a sequence are: (1) do students acquire the intended capabilities, and (2) are the learning activities sequenced so as to facilitate learning of these capabilities. The data required to answer both questions are the results from tests (Morrison & Lecznar, 1966a) which report for each learning unit in the sequence whether or not the student has acquired that capability. Each test would be a pass-fail assessment of performance rather than an evaluation of the student by comparison with the performances of others. Question (1) would be answered directly by the results of these tests administered to students before and after instruction.

The assessment of sequence requires analysis of dependency relations among results from tests on individual learning units administered to students of the curriculum. The basic result expected from a proper sequence is that all, or nearly all, of the students passing a unit also would pass units presumed to be its prerequisites. Pass-fail data from the tests, arranged in a student-by-learning-unit matrix, and data on proportions of students passing each unit provide evidence on the validity of the initial sequence assumptions, possible rearrangements, and the need for additional units. These data show whether all or most students who passed the items relating to a higher unit also passed the items representing a lower unit. Whether two units have a coordinate or sequential relationship can be as assessed through examination of their dependency on a third or next-lower unit in the series. The need for an additional unit to fill a gap between two units may be determined by noting if the number of students who performed successfully on a higher unit is considerably fewer than those who passed the immediately preceding units. That is, were the students able to progress to the higher unit from the capabilities acquired from lower units? Finally, the test data can give a clear indication of "out-of-sequence" units when many students pass the higher unit, but relatively few pass the lower unit.

## REFERENCES


Altman, J. W. Research on general vocational capabilities (skills and knowledges). Pittsburgh: American Institutes for Research, March 1966.

American Institutes for Research and Quincy Public Schools. Development and evaluation of an experimental curriculum for the new Quincy (Mass.) vocational-technical school. Pittsburgh: American Institutes for Research, November 1964.

Eninger, M. U. The process and product of T&I high school level vocational education in the United States: The product. Pittsburgh: American Institutes for Research, September 1965.

Flanagan, J. C., & Cooley, W. W. One-year follow-up studies. Technical Report to the U. S. Office of Education, Cooperative Research Project No. 2333. Pittsburgh: Project TALENT Office, University of Pittsburgh, 1966.

Gagné, R. M. The acquisition of knowledge. Psychological Review, 1962, 69, 355-365.

Gagné, R. M. Analysis of instructional objectives. In R. Glaser (Ed.), Teaching machines and programed learning II: Data and directions. Washington, D. C.: National Education Association, 1965, pp. 21-65. (a)

Gagné, R. M. The conditions of learning. New York: Holt, Rinehart and Winston, Inc., 1965. (b)

Gagné, R. M. Curriculum research and the promotion of learning. Invited address to meetings of American Educational Research Association, Chicago, February 1966.

Glaser, R. (Ed.) Teaching machines and programed learning, II: Data and directions. Washington, D. C.: National Education Association, 1965.

Glaser, R. The design of instruction. In J. I. Goodlad (Ed.), Sixty-fifth Yearbook of the National Society for the Study of Education, Part II, 1966.

Kersh, B. Y. Programing classroom instruction. In R. Glaser (Ed.), Teaching machines and programed learning, II: Data and directions. Washington, D. C.: National Education Association, 1965, pp. 321-370.

Lindvall, C. M. (Ed.) Defining educational objectives. Pittsburgh: University of Pittsburgh Press, 1964.

Mager, R. F. Preparing instructional objectives. Palo Alto, Calif.: Fearon, 1962.

Markle, Susan M. Programed instruction in English. In R. Glaser (Ed.), Teaching machines and programed learning, II: Data and directions. Washington, D. C.: National Education Association, 1965, pp. 546-583.

Melton, A. W. (Ed.) Categories of human learning. New York: Academic Press, 1964.

Morrison, E. J. Development and evaluation of an experimental curriculum for the new Quincy (Mass.) vocational-technical school. Pittsburgh: American Institutes for Research, June 1965. (a)

Morrison, E. J. The problem of defining objectives. Pittsburgh: American Institutes for Research, September 1965. (b)

Morrison, E. J., & Gagné, R. M. Curriculum implications of the study of objectives. Pittsburgh: American Institutes for Research, December 1965.

Morrison, E. J., & Hudak, Vivian M. A vocational guidance plan for junior high school. Pittsburgh: American Institutes for Research, March 1966.

Morrison, E. J., & Lecznar, W. B. The roles, characteristics, and development procedures for measures of individual achievement. Pittsburgh: American Institutes for Research, June 1966. (a)

Morrison, E. J., & Lecznar, W. B. The development of learning units. Pittsburgh: American Institutes for Research, September 1966. (b)

Stone, L. J., & Church, J. Childhood and adolescence: A psychology of the growing person. New York: Random House, 1957.

Tyler, R. W. Constructing achievement tests. Columbus: The Ohio State University, 1934.

U. S. Department of Labor. Occupational outlook handbook. Washington: U. S. Government Printing Office, 1963-1964.

U. S. Department of Labor. Dictionary of occupational titles, Volume II: Occupational classification and industry index. Washington: U. S. Government Printing Office, March 1965.

Venn, G. Man, education, and work. Washington: American Council on Education, 1964.

## PLANS FOR NEXT QUARTER

The following activities are planned for the quarter ending 31 March 1967:

1. Development of learning units and accompanying proficiency measures will continue as the major technical activities for the project.

2. Data collection for evaluation of the junior high guidance program will continue.

3. Development of senior high guidance program objectives will be completed and specification of student activities required to meet those objectives will be initiated.

4. Details of a plan for preparation of teachers to implement a curriculum that has individualized learning as a major feature will be outlined.

APPENDIX A

Proposed Curriculum

| Grade 9 | Periods |
|---|---|
| Social Studies (Industries and occupations) | 5 |
| Vocational Guidance | Various |
| Other Subjects | 35 |
| Physical Fitness | ( ) |
| | 40 |

| Grade 10 | |
|---|---|
| Specific Vocational (shop or laboratory) | 15 |
| Fundamentals of Technology (individualized, shop related) | 5 |
| Mathematics (numerical communication) | 5 |
| English (communication; literature) | 5 |
| Social Studies (economics and sociology of industry, occupations) | 5 |
| Physical Fitness | ( ) |
| Elective | 5 |
| Vocational Guidance | Various |
| | 40 |

| Grade 11 | |
|---|---|
| Specific Vocational (shop or laboratory) | 15 |
| Fundamentals of technology (individualized, shop related) | 5 |
| Mathematics (numerical communication, including trigonometry) | 5 |
| Science (applied human physiology) | 5 |
| English (communication, literature) | 5 |
| Physical Fitness | ( ) |
| Elective | 5 |
| Vocational Guidance | Various |
| | 40 |

**Grade 12**

| | Periods |
|---|---|
| Specific Vocational (shop or laboratory) | 15 |
| Fundamentals of Technology (individualized, shop related) | 5 |
| Social Studies (American history, citizen in modern society) | 5 |
| Science (physics, chemistry) | 5 |
| English (communication, literature) | 5 |
| Physical Fitness | ( ) |
| Elective | 5 |
| Vocational Guidance | Various |
| | 40 |

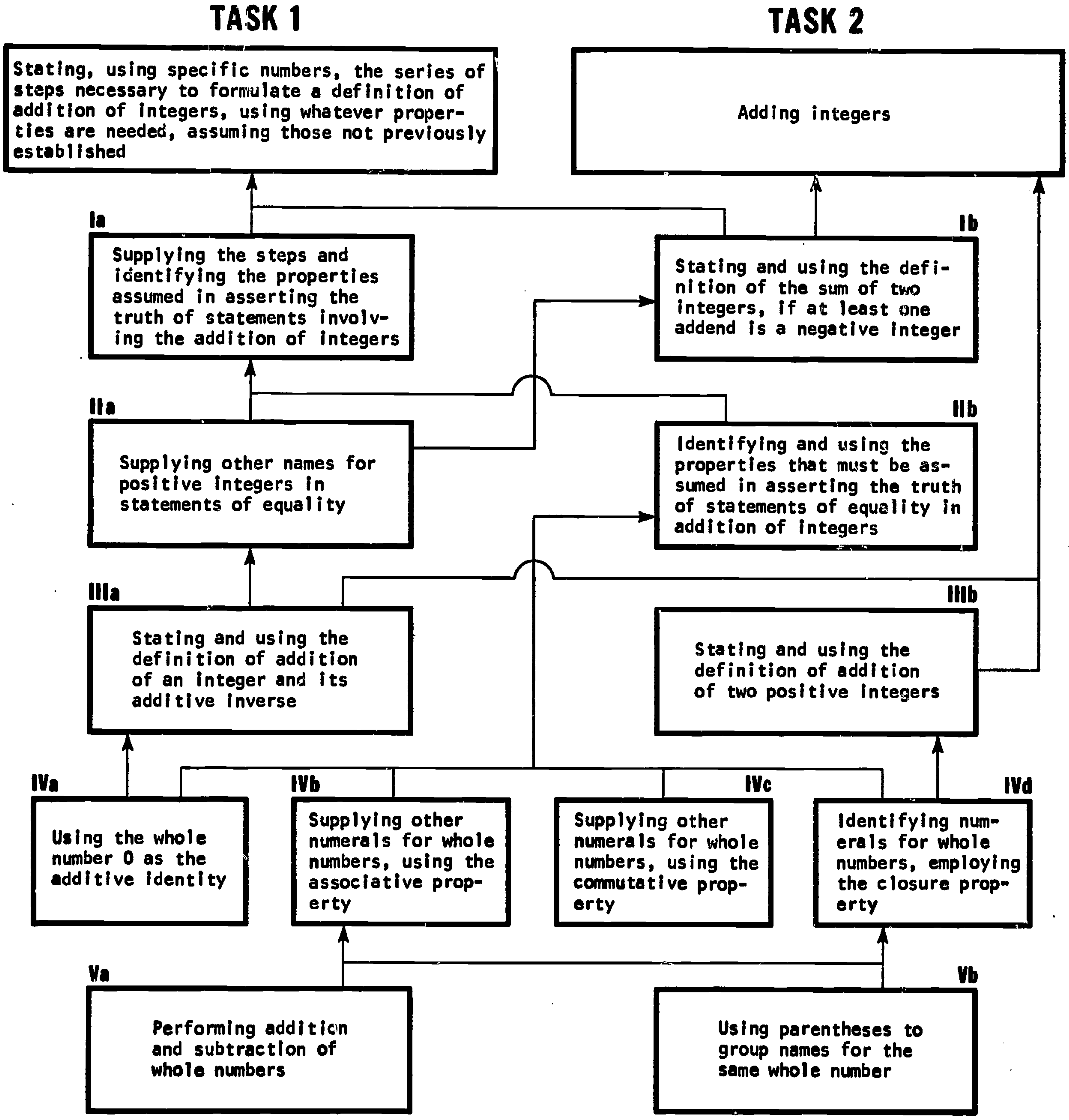
**Grade 13**

| | |
|---|---|
| Specific Vocational | 15 |
| Electives (adapted to specific programs) | |
| Social Studies--American Institutions | 5 |
| Mechanical Drafting | 5 |
| Technological Processes in Industry | 5 |
| Engineering Mathematics | 5 |
| Technical Report Writing | 5 |
| Science | 5 |
| Physical Fitness | ( ) |
| Others | 5 |
| To Make | 40 |

**Grade 14**

| | |
|---|---|
| Specific Vocational | 15 |
| Electives (adapted to specific programs) | |
| Social Studies - Organizations, Supervision | 5 |
| Machine Design | 5 |
| Mathematics, advanced | 5 |
| Science | 5 |
| Public Speaking | 5 |
| Physical Fitness | ( ) |
| Others | 5 |
| To Make | 40 |

APPENDIX B




A curriculum hierarchy on the addition of integers. (From Gagné, R. M., Mayor, J. R., Garstens, H. L., & Paradise, N. E. Factors in acquiring knowledge of a mathematical task. Psychological Monographs, 1962, 76, Whole No. 526)

# APPENDIX C

## Sample Behaviors for Each Psychological Process--Content Area Combination

(From Altman, J. W. Research on general vocational capabilities (skills and knowledges). Pittsburgh: American Institutes for Research, March 1966)

| Psychological Processes | Content Areas | | | | | |
|---|---|---|---|---|---|---|
| | Mechanical | Electrical | Spatial-Structural | Chemical and Biological | Symbolic | People |
| Sensing | Perceiving a change in the sound of a motor. | Perceiving a light change intensity. | Perceiving that a line is changing thickness. | Perceiving change in the color of a solution. | Perceiving that a line of letters is not being typed straight. | Perceiving that a customer is changing position in a barber chair. |
| Detecting | Perceiving a crack in a gear. | Perceiving damage to wire insulation. | Perceiving a brace that is not securely fastened. | Perceiving the presence of sediment in a solution. | Perceiving that an equal sign is missing from an equation. | Perceiving a skin rash. |
| Chaining or Rote Sequencing | Placing a washer on a bolt before tightening a nut. | Stripping wire before fastening it to a terminal. | Making a rough pencil sketch before inking a drawing. | Washing a vessel before sterilizing it. | Checking all receipts before entering them on the books. | Introducing all people before starting a conference. |
| Discriminating or Identifying | Identifying which gear is REVERSE. | Identifying which fuse in a central box is to be pulled. | Identifying which line on a drawing defines the width of a house. | Identifying a one litre measure in the glass equipment storage cabinet. | Discriminating the English a from the Greek alpha. | Identifying a particular individual in a crowded room. |
| Coding | Writing the name of a part found to be faulty. | Recording a voltage measurement. | Marking off a length of board to be cut from dimensions on a drawing. | Writing the time for a chemical reaction as shown on a stopwatch. | Rewriting ten as 10. | Tallying customers as they enter a door. |
| Classifying | Differentiating gears from wheels. | Differentiating resistors from capacitors. | Recognizing targets of military significance from aerial photographs. | Differentiating acids from bases. | Differentiating active from passive sentence forms. | Differentiating subordinates, peers, and superiors. |
| Estimating I (discrete case) | Estimating when to stop a machine so the drive wheel will stop at a desired position. | Estimating the average voltage from a fluctuating needle. | Estimating when to stop spray painting over a given area. | Estimating when a chop should be turned over in a fry pan. | Estimating how many more iterations will be required for satisfactory solution of a heuristic problem. | Estimating how much time will be required to consumate a sale. |
| Estimating II or Tracking | Keeping a moving vehicle on the road. | Tuning a receiver to peak performance. | Drawing a freehand curve. | Focusing a microscope. | Handwriting. | Maintaining a desired distance from a dancing partner. |
| Logical Manipulation | Working out the efficiency of an engine from standard formulas. | Application of Ohm's law. | Scaling a drawing. | Computing proportionate mixes. | Computing income tax. | Applying a standard form of interaction analysis to conference transcripts. |
| Rule Using | Using a longer wrench if a nut does not loosen. | Checking a circuit "downstream" next after an out-of-tolerance indication. | Laying out a right triangle if a leveling instrument is not available. | Partially washing a slide in cold water if a blood sample appears purple. | Showing a result as loss rather than profit if costs exceed income. | Taking pulse from temporal, carotid, or femoral artery if radial pulse is weak. |
| Decision Making | Selecting the type of engine to be designed for a new vehicle. | Choosing nuvistors over transistors in design of a given circuit. | Selecting the style of building to suggest to a potential customer. | Choosing the proper spectrometer for a chemical laboratory. | Deciding on the proper statistical routine. | Choosing a sales campaign for a new product. |
| Problem Solving | Developing a design for a new type of engine. | Developing a simplified model of radio interference. | Developing structural design to eliminate internal supports. | Developing a more rapid technique for making cell sections. | Developing a more efficient routine for computing correlations. | Developing an improved approach to customer service. |