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MODIA: Vol. 2, Options for Course Design

Polly Carpenter-Huffman

A Project AIR FORCE report
prepared for the
United States Air Force

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

This report documents research conducted under Project AIR FORCE (formerly Project RAND) by The Rand Corporation. The work described here was performed as part of the project entitled "Analysis of Systems for Air Force Education and Training" under Rand's Manpower, Personnel, and Training Program. It is the second in a series presenting Rand's MODIA planning system. MODIA, a *M*ethod *O*f *D*esigning *I*nstructional *A*lternatives, is a system of people, computer programs, and procedures that allows the rapid specification and simulation of courses of instruction during the early stages of instructional design. It augments and can be used in the present Air Force instructional systems development process.

The development of MODIA has been supported by the Deputy Chief of Staff/ Personnel, Headquarters United States Air Force, and the Air Training Command, especially DCS/Technical Training, the Training Development Directorate, and personnel at the Keesler School of Applied Aerospace Sciences. It is part of Rand's continuing research effort in the areas of planning and management in education, education technology, and the cost and effectiveness of education systems.

The series of MODIA reports includes:

R-1700-AF, *MODIA: Vol. 1, Overview of a Tool for Planning the Use of Air Force Training Resources*, Polly Carpenter-Huffman.

R-1701-AF, *MODIA: Vol. 2, Options for Course Design*, Polly Carpenter-Huffman.

R-1702-AF, *MODIA: Vol. 3, Operation and Design of the User Interface*, Polly Carpenter-Huffman and Ray Pyles.

R-1703-AF, *MODIA: Vol. 4, The Resource Utilization Model for Instructional Course Design*, Margaret Gallegos.

R-1704-AF, *MODIA: Vol. 5, A User's Guide to the Cost Model*, Ron Hess and Phyllis Kantar.

MODIA is the product of many people. The author is especially indebted to Bernard Rostker, director of the Manpower, Personnel, and Training Program, whose unflagging support has made MODIA possible. Nicki King, Philip Doughty, Robert Rippey, and David Pelletier contributed suggestions that improved clarity and content. Helen Turin created the format of publication in addition to editing the manuscript. The formidable typing chores were dispatched by Alma Gould and Marilyn LaPrell. Sally Belford prepared the pasteup for the printer.

This report comprises comprehensive descriptions of MODIA options for course design and discusses their training-related rationale.

SUMMARY

This report provides a comprehensive introduction to MODIA (*M*ethod *O*f *D*esigning *I*nstructional *A*lternatives), a system for planning a training course that was developed to help the Air Force improve the management of training resources. MODIA is designed primarily for the use of the five technical training centers of the Air Training Command (ATC). These account for the bulk of technical training, which is a major Air Force activity in that about 25 percent of Air Force personnel graduate annually from formal courses at a cost of over $600 million.

Over a third of the 300,000 different course hours in the technical training curriculum are substantially revised or newly prepared annually. Thus, in the normal course of events, ample opportunities arise for improvement of the management of training resources.

MODIA is a systematic process for planning the mix of students, instructors, materials, equipment, and facilities and the procedures by which all of these elements work together to effect student mastery of the subject matter. MODIA helps planners to create a detailed description of course operation and to derive an estimate of course cost consistent with the description. This encourages planners to devise and compare alternative plans for training courses.

Volume III in this series gives detailed instructions for operating the User Interface, the computer program that helps planners describe the training course design. Other volumes describe the computer programs that constitute MODIA—the User Interface, the Resource Utilization Model, and the Cost Model. This volume helps planners choose MODIA options that meet the requirements of the training course they are planning. It describes principles of training course design in terms of alternative choices, discussing the pros and cons of each choice as it affects course operation, cost, or instructional effectiveness. Thus, it encourages planners to consider alternative course designs. It also relates MODIA options to the data and information MODIA requires for producing detailed descriptions of course operation.

The first section of the report describes MODIA's purpose and general structure and the purpose of the report, and gives an overview of the process for selecting design options. The remaining sections parallel and describe the structure of the process and supply its training-related rationale. Appendix A contains worksheets to assist in recording options chosen.

GLOSSARY

adaptive format: A teaching method that requires the student to respond overtly throughout the instruction to indicate whether he understands, remembers, or can perform what he is being taught. Both the rate at which the instruction is given and the content of the instruction are adjusted to student needs on the basis of these reponses. Tutoring, branching programmed text, and most computer-assisted instruction use the adaptive format. (See **teaching format.**)

adaptive program: A device or machine that presents the subject matter, elicits an overt response from the student, senses the response, and selects the content of the next presentation on the basis of the response. Usually a computer. (See **teaching agent.**)

assumed inventory at start of course: The number of resource units already assigned to a course or able to be drawn from stock or purchased for the use of the course.

audio: A class of media that conveys only audible information—e.g., a phonograph. (See **media class.**)

motion visual: A class of media that conveys both audible information and visual information in motion—e.g., a videotape player. (See **media class.**)

audio still visual: A class of media that conveys both audible and visual information, the visual information being in the form of still pictures or print—e.g. a sound-slide set. (See **media class.**)

capacity (of a resource): The maximum number of students that can use or be instructed with a single unit of the resource during a given learning event. The capacity may be different for different learning events. (See **learning event, dedicated resource, shared resource.**)

category (of student): A subclass of the total student population defined on the basis of student ability, some other characteristic, or a combination of the two.

check practice: A type of learning event intended to check the student's mastery of the subject. The results do not directly affect his progress in scheduled instruction. (See **learning event type, test.**)

concurrent adaptability: The extent to which instruction is adapted to student needs in learning while the instruction is in progress.

common-element objective: An objective that is prerequisite to more than one training objective.

constructed response: A response the student must produce or construct himself. Examples are written or typed answers, drawings, and spoken words or phrases. (See **selected response.**)

content diversification: The planned instruction of different categories of students in different subject matter content. MODIA handles this by having students skip entire objectives or parts of objectives. (See **diversification.**)

courseware: Instructional materials prepared for particular learning events and media systems—e.g., a textbook; includes software as a subcategory. (See **software.**)

critique: A learning event following a test during which the instructor discusses the test with the class or individual student. (See **learning event, test.**)

dedicated resource: A resource that may be used in only one section of one learning event at a time. (See **learning event, section.**)

diversification: The provision before the course begins of different approaches to instruction to meet the needs of different categories of students.

entry group: A group of students newly arrived at the course. Does not include recycling students.

entry interval: The time between arrivals of entry groups.

evaluator: A person assigned to rate a student's performance on a check practice or test or to discuss student performance during a critique.

failure: Elimination of a student from the course because of unacceptable performance on a test. (See **test.**)

group discussion: A type of learning event during which a small group of students engages in an interactive discussion of the subject. (See **learning event type.**)

grouping: The separation of students into two or more divisions that are instructed separately. The groups can change their makeup during the course. (See **tracking.**)

guided practice: A type of learning event in which the student receives feedback on his performance as he performs the skill he is learning. (See **learning event type.**)

homework: An assignment for home study. (See **learning event type.**)

Instructional System Development (ISD): "A systematic procedure for assuring application of instructional technology to course planning and development.[1] The five steps of ISD are treated in detail in the five volumes of the *Handbook for Designers of Instructional Systems.*[2]

learning event: A portion of the subject matter that will be taught to a particular category of student in a particular way. May be equivalent to an objective or may be one of a sequence of several activities for teaching an objective. It is also described in terms of the kinds of training resources needed to teach it and the time it will take. (See **learning event type.**)

learning event type: The general instructional function of a learning event in a sequence of events for teaching a particular course objective. Includes presentation/demonstration, guided practice, unguided practice, group discussion, check practice, homework, review, test, and critique.

media class: A group of media systems that represent information in the same general way. Media classes include audio, still visual, motion visual, audio still visual, audio motion visual, and type.

media system: A particular configuration of hardware and media for transmission and display of information. Information may be produced live or recorded.

method diversification: The planned instruction of different categories of students in different ways, either by varying classroom practice (e.g., lecture or self study) or by varying the amount of instruction given, or both. (See **diversification.**)

MODCOM: The *MOD*IA *CO*st *M*odel, one of MODIA's computerized components.

MODIA team: A group of people who have been trained and are expert in the use of MODIA.

[1] *Instructional System Development*, Department of the Air Force, AFM 50-2, 31 July 1975, p. 1-1.

[2] *Handbook for Designers of Instructional Systems*, Department of the Air Force, AFP 50-58, 15 July 1973.

monitor: A person who supervises a learning event but does not actively teach it.

motion visual: A class of media that presents information by means of moving pictorial images. (See **media class.**)

objective: A portion of the subject matter. May be a general topic, a specific statement of content (e.g., the nomenclature for parts of a pressure regulator), a criterion-referenced statement of a behavioral objective, or even a division of course time (e.g., first class period).

presentation/demonstration: A type of learning event that presents the facts or concepts the student will be expected to learn or introduces him to the skill he will be expected to master. (See **learning event type.**)

process only (in relation to subject matter type): Student mastery of the skill must be assessed during his performance of the skill. The end result of his performance is no indication of his mastery. (See **subject matter type, product only, product and process.**)

product and process (in relation to subject matter type): Student mastery of the skill can be assessed on the basis of the product of his performance, the process of his performance, or both. (See **subject matter type, process only, product only.**)

product only (in relation to subject matter type): Student mastery of the skill can be assessed only from the product of his performance. (See **subject matter type, process only, process and product.**)

recitation format: A teaching method that requires the student to respond overtly throughout the instruction to indicate whether he understands, remembers, or can perform what he is being taught. (See **teaching format.**)

recycle: The repetition of a portion of the preceding instruction by a student who has performed poorly on a test; washback. (See **test.**)

recycle point: The point to which a recycling student must go back.

resource assignment policy: The combination of learning events by which a given resource will be differentiated or assigned to the course. These assignments can be by the whole course, blocks of sequential learning events, all learning events of a given subject matter type or learning event type, by student track, by individual learning events, various combinations of the foregoing, and none.

Resource Utilization Model (RUM): A simulation of the course operation that includes generation of requirements for training resources by student progress through a course. One of MODIA's computerized components.

response-paced program: A device or machine that presents the subject matter, elicits an overt response from the student, senses the response, and proceeds to the next presentation if the response is correct. Usually a teaching machine. (See **teaching agent.**)

response-paced format: A teaching method that requires the student to respond overtly throughout the instruction to indicate whether he understands, remembers, or can perform what he is being taught. The rate at which the instruction is given is adjusted to student needs on the basis of these responses. (See **teaching format.**)

review: A type of learning event that precedes and is intended to prepare a student for an upcoming test. (See **learning event type, test.**)

section: A single occurrence of a learning event. A number of students (between the minimum and maximum section size) are provided with the training re-

sources required (usually including a single teaching agent) for the section and take the learning event simultaneously. (See **learning event, teaching agent.**)

selected response: The student responds by selecting from a set of prepared responses. Typical examples are multiple choice, true-false, and matching questions. (See **constructed response.**)

shared resource: A resource that for a given learning event may be used simultaneously by students who are in different sections of the learning event or are in sections of other learning events. (See **learning event, section.**)

simple format: A teaching method in which the subject matter is merely presented or demonstrated to the student or the student is directed to perform. (See **teaching format.**)

software: A computer, or otherwise automated, program built to produce or control courseware. (See **courseware.**)

special resource: A resource (facilities, equipment, or material) specific to the subject matter—that is, that would be useful only in teaching a subject very similar to the subject of the course.

still visual: A class of media that conveys visual information in the form of still pictures or print. (See **media class.**)

subject matter expert: A person who understands the subject matter of the course and either knows the student population and the teaching methods that are best for them, or is familiar with school policy, or knows what resources are likely to be available to the course, or has the foregoing knowledge in any combination.

subject matter type: A category of course content that reflects its relative difficulty, whether it concerns skills (as opposed to knowledge), whether it has unusual requirements for resources, and the type of student response that is appropriate for judging mastery of the content.

teaching agent: The person or thing that interacts directly with the student to instruct him. Includes instructors, learners, response-paced programs, and adaptive programs.

teaching format: The method of instruction described in terms of the extent to which it is explicitly structured to involve the student and adapt to his needs while it is going on. Includes simple, recitation, response-paced, adaptive, and group interaction formats.

team (or interactive) skill: A skill that is normally performed in an interactive group or team on the job.

test: A type of learning event intended to evaluate student mastery of preceding instruction. The only type of learning event that can cause students to recycle or be eliminated from the course. (See **learning event type, check practice.**)

total resource capacity: The total number of students a resource type with fixed capacity can accommodate at one time; the product of the number of units of the resource available to the course and the capacity of a single unit of the resource.

tracking: The separation of students into two or more divisions that are instructed separately throughout the course—e.g., a fast track. (See **grouping.**)

type: A class of media that presents one or several alphanumeric characters at a time. Usually a teletype or other computer terminal. (See **media class.**)

unguided practice: A type of learning event in which the student is merely directed to practice or perform the skill he is learning. (See **learning event type.**)

User Interface (UI): An interactive computer program that builds the details of preliminary training course design on the basis of step-by-step input from the user. One of the computer-based components of MODIA.

CONTENTS

I. INTRODUCTION

THE PROBLEM

The Air Force is heavily involved in training; in fact, in peacetime almost all Air Force activities can be thought of as training of one kind or another. But the most visible and highly structured of these activities is the training conducted by Air Training Command (ATC)—Basic Military Training, Flying Training, and Technical Training. This is a multibillion dollar enterprise requiring the support and involvement of over 12 percent of Air Force personnel.

The largest single component of ATC is devoted to formal Technical Training, which prepares Air Force personnel for jobs ranging from aircraft maintenance to personnel administration. In 1976, some 150,000 persons—over a quarter of the force—will graduate from formal courses given in established technical schools.[1] The operating cost of this activity will be over $600 million; 9 percent of Air Force personnel will be engaged in such training at any particular time. Because of its large student load, formal Technical Training offers rich opportunities for realizing large dollar savings even though savings are small in terms of the individual student.

Many opportunities to improve the management of training resources arise in the normal course of events. There are currently some 300,000 different course hours in the curriculum, of which over a third are substantially revised or newly prepared annually. Changes in force composition, introduction of new weapon systems, and changes in operating policies of other commands all affect the subject matter of training and can have direct effects on requirements for training equipment and indirect effects on training operations. Shifts in training-related characteristics of the student population (such as general academic ability or previous experience related to the subject matter of the course) may require changes in teaching method or shifts in subject matter emphasis. Changes in school policy toward classroom management may encourage the replacement of familiar methods with new teaching materials or techniques. Finally, variations in requirements for the output of graduates obviously and strongly affect the availability of and requirements for training resources. Clearly, the design and redesign of courses is an important task that could lead to substantial improvements in training.

The current Air Force approach to course design, termed "Instructional System Development"[2] (ISD), is outlined in AFM 50-2.[3] ISD is a systematic procedure for relating the content and conduct of training to needs in the field. This procedure consists of five steps:

1. Analyze system requirements—that is, determine what tasks should be performed in the job.
2. Define education or training requirements—that is, determine how and where performance of these tasks will be learned.

[1] Derived from Office of Assistant Secretary of Defense (1976) pp. I-10 and B-9.

[2] Words and phrases defined in the glossary are in quotation marks the first few times they appear.

[3] Department of the Air Force (1975).

3. Develop the objectives and tests for instruction.
4. Plan, develop, and internally validate instruction.
5. Conduct instruction and evaluate its effectiveness both internally and in the field.

In carrying out these steps, training developers are guided by the general principles stated in AFM 50-2, tempered by their own judgment and past experience and by existing school policies and procedures.[4] Such expertise is requisite to skillful application of ISD, but course planners have lacked clerical assistance in a key area. Specifically, they have had no way to examine the requirements for training resources implicit in a particular course design. Instead, to estimate resource requirements, they have had to use planning factors (e.g., the average student-to-instructor ratio) based on past school experience. As a result, resource requirements have entered the design process only in a gross, subjective fashion or after course design was completed. The demands for bookkeeping and computation attendant on constructing and costing a course design has meant that only rarely has more than one design been considered during planning.

PURPOSE OF MODIA

MODIA was developed to help the Air Force manage resources for formal training by systematically and explicitly relating quantitative requirements for training resources to the details of course design and course operation during the planning stage. *Course design* includes the content and sequencing of subject matter and tests; teaching methods and the roles of instructors and other training personnel; the assignment of media, training equipment, and facilities; the characteristics of the trainees; and policies for the management of student progress. *Course operation* describes how all of these elements work together to affect student progress through the course and the resulting requirements for and use of training resources. There were two objectives in developing MODIA for designing courses at this level: (1) to help course developers consider approaches not incorporated in available planning factors, and (2) to relate resource use to the details of course design so that course developers will be encouraged to consider *alternative* designs. As the acronym implies, the consideration of alternatives is MODIA's primary objective.

MODIA is *not* a prescription for training, nor is it an optimizing model; rather, it is neutral with regard to the training effectiveness of a course design in terms of student learning or with regard to the desirability of a course design in terms of training policy. Instead, through an interactive, iterative process it encourages planners to consider, for example:

- The implications of the subject matter for requirements for training resources and teaching strategy;
- Characteristics of students that affect learning and instruction;
- The effects of course management policies and teaching strategy on learning and on the use of training resources; and
- How changes in one element of course design will affect the others.

[4] Quantitative approaches to training development are partly incorporated at step 1, in establishing the tasks commonly performed in the field, and at steps 4 and 5, in internal validation and field evaluation.

MODIA has been designed primarily for the use of the five ATC technical schools, which account for over 90 percent of the student load in technical courses. Each school has several departments, each dealing with a major subject area, and each department has several branches that are responsible for training in a related group of courses. MODIA is directed to the course level, because a student usually takes only one course at one school to qualify for his initial job assignment.

The most fruitful applications of MODIA will probably be in step 4 of ISD—in the planning and development of instruction. However, like ISD itself, MODIA can be applied at any of several stages of planning. For example, MODIA does not require that all objectives and tests be stated in criterion-referenced terms or even that all be identified before it can give insight into course development. As with the steps in ISD, among which feedback and interaction should refine and improve the ultimate result,[5] MODIA should be applied at different levels of generality to help guide the definition of training requirements and the development of objectives and tests. For example, MODIA may show that with a given student load there is not enough training equipment for each student to have sufficient practice on it. This might suggest that some of the equipment-oriented objectives could be redirected toward less expensive mockups, computer simulation, or other acceptable substitutes. Thus, MODIA has numerous slots for descriptive data that do not all have to be filled accurately before results can be useful. Moreover, MODIA can be an aid for planning only a portion of a course (e.g., a block or single module of instruction) or for planning up to four courses that use the same training resources simultaneously.

PHYSICAL DESCRIPTION OF MODIA

People are the most important component of MODIA. As with any tool, MODIA's product is only as good as its users can make it. Because of their importance, personnel roles and requirements in MODIA are discussed separately below.

Because the bulk of MODIA resides in computer programs, users may in a very short time generate a blueprint for instruction and estimates of the resources needed to produce and operate the resulting training course. More important, computerization encourages users to design and compare alternative plans before any particular plan is developed and put into operation, often a long and expensive process. Once a baseline course design has been constructed, alternatives can be generated in a matter of hours or minutes, depending on the degree to which they depart from the baseline and the richness of the baseline design.

MODIA has four components: This description of options for course design, the user Interface (UI), the Resource Utilization Model (RUM), and the Cost Model (MODCOM). Figure 1 shows the interactions between the user and these components. Note that MODIA has two main points for entering data—the UI and MODCOM—rather than automatically translating RUM output into course cost. This is because decisions concerning costing procedures and policies are often contingent on course operation. The additional entry point also permits planners to refine the design for preferred course operation before undertaking a complete cost analysis.

The separation of entry points has a further advantage; it permits MODCOM

[5] Department of the Air Force (1975), pp. 1-2.

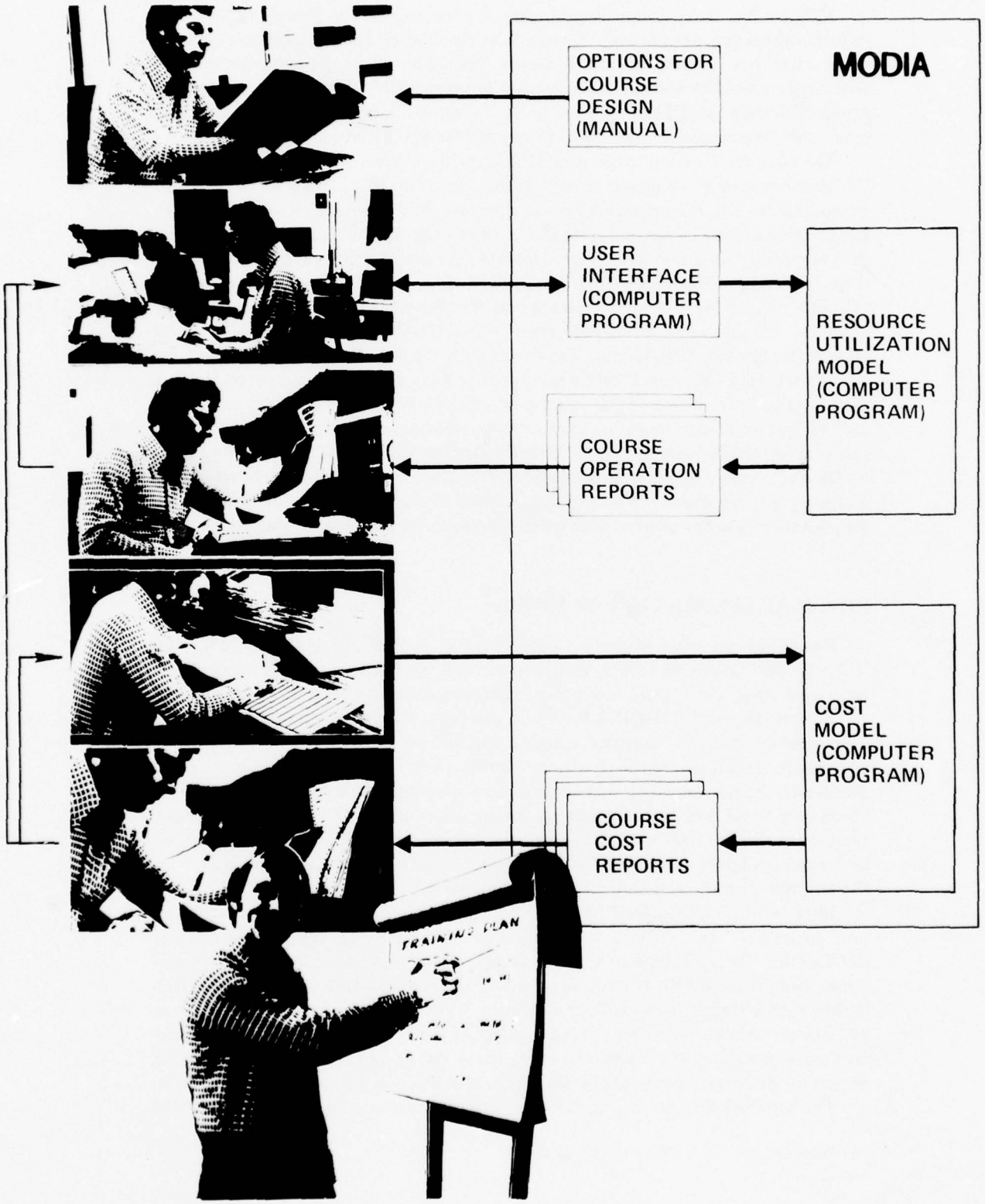

Fig. 1—Interactions between the user and MODIA components

to capture most of the information that is unique to ATC course planning, so that the UI and RUM are useful for planning training in a much wider range of applications. Thus, the UI and RUM can give insights for planning parts of courses, rather than full courses, or courses given in the Air Force Academy, the Air University, or other Air Force agencies. Conversely, ATC can use MODCOM independently of the UI and RUM to analyze course cost without requiring access to the considerably larger resources (computer capacity and MODIA analysts) required to support the UI and RUM.

The *Options for Course Design* provide an overview of the data and information the UI will ask for, the range of choices available at each entry point, and the pros and cons of each choice as they affect course operation, cost, or instructional effectiveness.

The UI is an interactive computer program; that is, the user enters data step by step in response to questions from the computer. The choice of question the computer asks at a given point is influenced by preceding responses from the user, hence the term "interactive." Also, at many intermediate points, the computer processes the set of answers given to that point and displays the results to guide further decisionmaking or to allow the user to recycle through the process if he is dissatisfied with the results at that point. In this way the UI produces a course description in computer-compatible data that interrelates course content, teaching strategy, student characteristics, and resource assignments.

MODIA inputs these data automatically to the RUM, which simulates the way in which student progress through the course generates requirements for training resources. The RUM is a "batch-process" program: It receives all of the inputs in a single batch, not step by step as in an interactive program. It also produces its outputs in a single batch. The outputs are detailed reports on course operation, including student flow patterns and waiting times as well as resource demand and use.

Planners will rarely be satisfied with the results of the first complete operation of the UI and RUM and will repeat the process several times before they prepare the input required for MODCOM. They may, however, need to compare rough, order-of-magnitude cost estimates to help them select from among the preliminary course designs.

MODCOM estimates the five-year investment and operating cost associated with a given course design. It is also a batch process program, but its inputs are provided by the planner. He can take some inputs, such as resource requirements, from RUM output, but he must draw on other sources for such items as equipment cost. He may also want to override cost and manning factors stored in the program. MODCOM provides options as to which costs should be included and how they should be computed, and supplies outputs in both functional and budgetary formats.

Since MODCOM requires some input that is not a direct consequence of RUM output, planners may wish to exercise MODCOM several times without revising the initial input to the UI. Or the course cost reports may highlight a feature of course operation that is unwarrantedly expensive, indicating additional operation of the UI and RUM. Since subsequent passes rarely entail complete redesign of the course, they often take only a small fraction of the time and attention required for creation of the first case.

When the planners are satisfied with both the course operation and course cost reports for a specific course design, they have at hand the bulk of the elements for a training plan and need only synchronize the plan with other planning activities at the school to put it in final form.

PERSONNEL

Two groups of people should be involved in any application of MODIA in planning—those who are expert in using MODIA ("the MODIA team") and those who have knowledge and experience in the areas of subject matter and planning particular to the course being developed (the "subject matter experts"). Figure 2 shows the configuration currently being used at the Keesler School of Applied Aerospace Sciences.

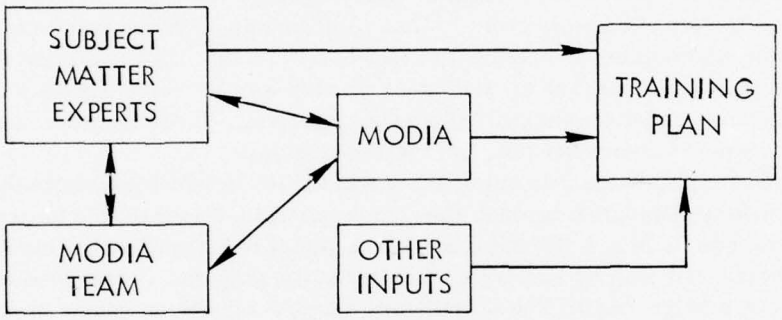

Fig. 2—Configuration currently in use at Keesler School of Applied Aerospace Science

Members of the MODIA team need not (and probably should not) have extensive experience with computers. By background and bent they should be problem solvers first, computer experts second. They need to be familiar with course planning and school operations, so that they can draw out the subject matter experts' best judgment on what constitutes effective instruction and help them distinguish between what is usually done (for convenience or by tradition) from what is needed. They should also have a feeling for how far school policies can be adjusted, if it would be desirable to do so, and be able to act as liaison among different organizational entities within the school whose interests may clash within a given training course design.

Members of the MODIA team need initial training in the use of the system and need to apply the system frequently enough to maintain their expertise. They should be fully aware of MODIA's features and operation, particularly of the alternatives it encompasses; should have a good feel for the effects of different choices of input on MODIA outputs; and should be able to guide the subject matter experts in choosing the most efficient alternatives.

The subject matter experts are people who normally plan and develop courses. They need an understanding not only of the subject of the course but of the student

population and the teaching methods that work best for them. They should be familiar with school policy and should know what resources are likely to be available to the course and what they will cost. All of this information need not reside in a single person (nor does it in the current development process). Perhaps most important, the subject matter experts need to be flexible—able to interact with the MODIA team so that the special capabilities of both groups can be fully applied.

PURPOSE OF THIS REPORT

This report provides a comprehensive introduction to MODIA by describing options for training course design. Options are specified in MODIA in a step-by-step process managed by the UI. The result of this process is a set of computer-compatible data from which MODIA derives a description of the course operation.

The report prepares and assists planners in making better use of MODIA by providing:

- An overview of the data and information that the UI will ask for;
- A general understanding of the logical relationships among the entries into the UI;
- A general understanding of the relevance of UI entries to the training course plan;
- The range of choices that may be made at each entry point;
- The pros and cons of each choice as they affect the instructional effectiveness or cost of the training course.

In sum, the report parallels the structure of the UI and supplies its training-related rationale.

Members of "MODIA teams," people who have been trained and are expert in the use of MODIA, should be thoroughly familiar with this report. The "subject matter experts" who work with the MODIA team in planning a specific training course should read the report to familiarize themselves with the information they will need to supply and with the options available.

MODIA may be used to simulate an existing course or one that has already been planned in detail, which requires direct translation of course features into the MODIA format. This report assists in making such a translation by describing the general structure of the UI process of course description. It also suggests alternative descriptions that may lead to improved course operation.

Another use of MODIA is to generate a course design from knowledge of the subject matter and trainee population. This report is of greatest assistance in the latter situation because it helps planners derive a course design from basic principles.

Each section of the report is designated by a combination of letters and numbers in bold-face type in the right-hand margin. When the UI calls for a decision, it displays the designator of the section where the training effects of that decision are discussed. This allows the user to find a needed reference after he has started operating the UI program. The user will find it helpful to keep the report at the terminal for reference.

THE WORKSHEETS

Appendix A contains worksheets to help keep track of options selected. These will be particularly helpful in laying out initial decisions, such as the description of course content and plans for course management. Planners can also record on the worksheets the sets of alternatives they would like to examine. In a few instances the UI does not keep track of information that will be useful in making later decisions; this information should be recorded on the worksheet provided.

Preparing the worksheets is an intermediate step between reading this report and operating the UI. The worksheets can save time at the terminal; they are particularly helpful when it is more difficult to give a decision full consideration at the terminal than at one's desk. During later phases of operation of the UI program, however, it is difficult to keep track of all of the ramifications of the decisions entered earlier. Since the UI does this automatically, the information it displays at the terminal becomes the best worksheet. Therefore, only one worksheet is provided for later stages in the program.

OVERVIEW OF THE DECISION PROCESS

The process of course design is described here briefly. The description uses several terms whose meanings are tailored to MODIA and are defined in the glossary. Since these terms are also used frequently throughout the report, the reader should refer to the glossary to facilitate understanding of the discussion here and in subsequent sections.

Result of the Decision Process

The end result of the decision process is a description of how the course is to be taught. This description takes the form shown in part on Fig. 3. The reader should not expect to grasp all of the implications of Fig. 3 until he has familiarized himself with the remainder of the report. Because Fig. 3 incorporates most of the fundamental concepts used in the decision process, it will help the reader keep these concepts and the relationships among them in mind. It may be useful to remove Fig. 3 and use it as a bookmark.

To describe the course, the planner lists a sequence of "objectives," which represent the course content. He breaks each objective into one or more "subject matter types," which reflect the relative difficulty of the content, whether it concerns skills (as opposed to knowledge) and whether there are unusual requirements for resources. For teaching each type of subject matter, the planner assigns one or more "learning events," which are instructional activities for teaching an objective. To each learning event he assigns a "teaching method" by specifying the instructional purpose of the learning event ("learning event type"), the way the instruction is structured to involve and respond to the student ("teaching format"), and the person or thing that does the teaching ("teaching agent"). Finally, he specifies the number of students that can take the learning event at one time and the amount of time the learning event requires. He also assigns resources to the learning events—instructors, classrooms, media, or equipment—and describes the availability and ca-

Sequence of Objectives[b]	Subject Matter Types[c]	Learning Events[a]					
		Learning Event Types[d]	Teaching Format[e]	Teaching Agent[f]	Time (minutes)	Number of Students	Resources
Objective 1	Easy facts and concepts	Presentation	Simple	Instructor	60	8	Instructor Classroom Overhead Projector
	Simple skills	Unguided practice	Recitation	Learner	120	8	Instructor Classroom Workbooks
		Homework	Response-paced	Learner	60	1	Workbooks
Objective 2	Difficult facts and concepts	Presentation	Adaptive	Instructor	120	8	Instructor Classroom Overhead Projector
		Group discussion	Group interaction	Instructor	30	8	Instructor Classroom
Objective 3	Task performance on equipment	Demonstration	Recitation	Instructor	120	8	Instructor Assistant Instructor Laboratory Training equipment Technical Orders
		Guided practice	Response-paced	Instructor	30	4	Instructor Assistant Instructor Laboratory Training Equipment Technical Orders

[a] *Learning event:* A portion of the subject matter that will be taught to a particular category of student in a particular way. It is also described in terms of the kinds of training resources needed to teach it and the time it will take.

[b] *Objective:* A portion of the subject matter. May be a general topic, a specific statement of content (e.g., the nomenclature for parts of a pressure regulator), a criterion-referenced statement of a behavioral objective, or even a division of course time (e.g., first class period).

[c] *Subject matter type:* A category of course content that reflects its relative difficulty, whether it concerns skill (as opposed to knowledge), whether it has unusual requirements for resources, and the type of student response that is appropriate for judging mastery of the content.

[d] *Learning event type:* The general instructional function of a learning event in a sequence of events for teaching a particular course objective. Includes presentation/demonstration, guided practice, unguided practice, group discussion, check practice, homework, review, test, and critique.

[e] *Teaching format:* The method of instruction described in terms of the extent to which it is explicitly structured to involve the student and adapt to his needs while it is going on. Includes simple, recitation, response-paced, adaptive, and group interaction.

[f] *Teaching agent:* The person or thing that interacts directly with the student to instruct him. Includes instructors, learners, response-paced programs, and adaptive programs.

Fig. 3—Schematic of course description

pacity of each resource. Specifying the number of students entering the course and how often they enter completes the course description.

The planner may describe other features of the course not illustrated on the figure, such as points at which major tests are given and whether students may be eliminated from the course or washed back on the basis of test results. He may also design a course that teaches different course content to different types of students or that teaches the same course content in different ways.

It is very improbable that the planner will be entirely satisfied with his first course design, if only because he will have been unsure about the effects of some of his decisions and will have been using the UI and RUM to try them for size. Therefore, he will want to rerun the UI and RUM, using insights from previous runs. Throughout the report are suggestions about using the iteration capability to obtain a more desirable course design.

Steps in the Decision Process

The above description gives a general understanding of where the decision process described in the rest of the report is headed. The steps in that process do not follow the same sequence as the description because the UI builds the course description in a logical order. For example, decisions about the placement of tests (if there will be tests) precede the specification of teaching method for individual learning events. Thus, early steps in the process deal with general features of the course—objectives, tests, if and how students will be categorized. In intermediate steps, the planner fleshes out these features by specifying teaching method, further defining test points, and assigning resources. In the last steps he defines resource characteristics and completes the description of the learning events by assigning the time and the number of students allowed for each. Flow charts of the decision process help the reader keep track of where he is at each step.

Need for Familiarity with MODIA Terminology

The MODIA decision process cannot be equated with other processes for course design for two reasons. First, it is the only process that translates course content and teaching method into quantitative measures of resource use. Second, common teaching terminology is not applicable without modification because meanings are not sufficiently precise. For example, one course designer might write his criterion objectives in such a way that he feels they are equivalent to learning events, but another might want his criterion objectives to contain several subject matter types and learning events. In addition, MODIA is a flexible system; it does not lock the user into a narrow set of options. For flexibility there is a price—the system is complex. For all of these reasons, the reader is again urged to refer frequently to Fig. 3, the glossary, and the flow charts as he works through the remainder of the report.

NOTES

II. DESCRIBE OBJECTIVES

This section discusses considerations pertinent to identifying and sequencing "objectives," portions of the subject matter. An objective may be a general topic, a specific statement of content (e.g., the nomenclature for parts of a pressure regulator), a criterion-referenced statement of a behavioral objective, or even a division of course time (e.g., first class period). Because MODIA does not require that training content be expressed in any particular way, examples of statements of objectives or content given in this section are purposely diverse in format. Since content may later be added to the basic list to meet the needs of special students, the list of training content may not be established in final form until decisions in Sec. V have been made.

This section also discusses the assignment of subject matter types to training content. Figure 4 relates the decisions discussed in this section to the overall decision process.

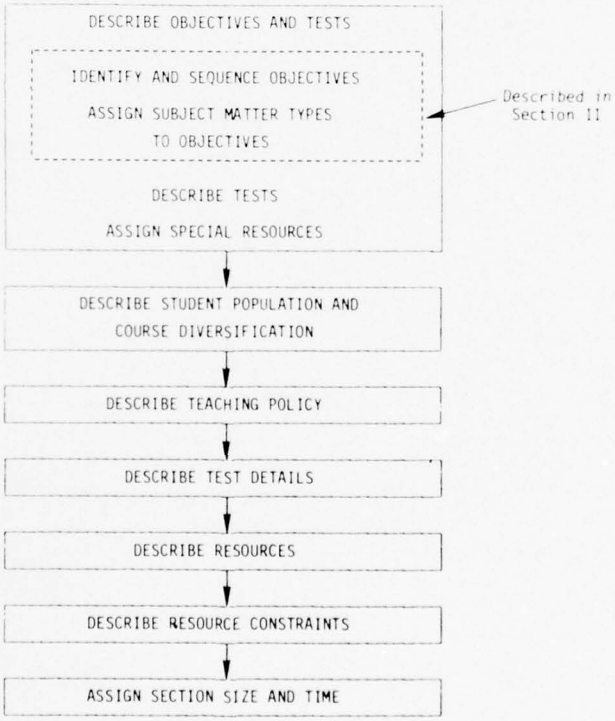

Fig. 4—Relation of decisions described in Sec. II to overall decision process

IDENTIFY TRAINING OBJECTIVES

Since a major purpose of MODIA is to assist in planning the use of training resources, translation of training content into training activities and resulting resource requirements is of major importance. Thus, the criterion for deciding whether a particular portion of content should guide course planning is that *training resources will be used explicitly to teach this content.*

At early stages in planning, course content may be stated in very general terms because the specifics of the course are not really known. However, if the third step in ISD (to identify objectives and tests)[1] has been completed, some objectives may already be stated in more detail than will be useful in MODIA, because ISD requires the planner to equate course content to evaluation of trainees' mastery of that content. Some objectives subject to separate test questions may merely be different outcomes of the same training activity, whereas the consequences of many activities that take appreciable time and other training resources may never be evaluated by tests. For example, the objectives may not include initial activities for orienting new trainees to school and classroom procedures so that an orientation session needs to be added to complete the course plan. Conversely, an objective will not guide planning if training resources will not be applied explicitly so that students will master it. For example, several behavioral objectives may be taught by a single activity that should not be subdivided, such as when students learn many features of both the purpose and operation of a piece of equipment during a demonstration. Or students may learn that their specialty is of particular military or economic importance and may gain a heightened appreciation for the value of the skills they are learning. But if this is expected simply as desirable fallout from other training activities, it should not be identified as an objective in MODIA. Table 1 provides an illustration of a list of behavioral objectives derived in ISD. (The table also includes mnemonic codes to simplify future references to these objectives; similar codes are entered in the UI.)

All separable training activities should be designated as objectives if the course is being planned in great detail. It is probably preferable at the outset to consider too many rather than too few objectives. Before operating the UI, however, the planner should condense the list of objectives as much as possible. This will simplify the operation of the UI, reduce the time required, and minimize the possibility of error. It will also decrease the cost of operation of the RUM. Excessive detail imposes unnecessary labor and discourages iterative operation of MODIA.[2] The best time to combine objectives is after subject matter types have been assigned to them.

For preliminary planning, where only the general content of the course is known, topics can be stated in terms that encompass several types of training activities. Planners can account for variations in resource use implied by these different activities by assigning different subject matter types to the topics, as described in II.C.5.

[1] Department of the Air Force (1973), Vol. III.

[2] Another reason for combining objectives occurs in certain situations involving use of limited resources, described in Sec. IX.A.

Table 1

EXAMPLE OF A LIST OF BEHAVIORAL OBJECTIVES

Statement of Objective	Code
1. Given a list of applicable test equipment, match the function with the equipment.	TESTEQP1
2. Given a list of test equipment, select the test equipment that is maintained by organizational/intermediate maintainance.	TESTEQP2
3. Given a list of malfunctions common to various pieces of test equipment, match the malfunction to the appropriate piece of test equipment.	TESTEQP3
4. Given TO 31R4-2URN5-2, select the purpose and technical characteristic of each major unit in the AN/URN-5.	URN5CHAR1
5. Given a schematic diagram of the power distribution and control circuits, trace the AC through the unit.	URN5SCHEM1
6. Using TO 31R4-2URN5-36, perform routines 1.1 and 1.2.	SERVROUT1
7. Given a schematic diagram of the cabinet power supply, select the output voltages.	URN5SCHEM2
8. Given a schematic diagram, analyze the T-357/URN-5 transmitter.	URN5SCHEM3
9. Given a schematic diagram, analyze the C-1107/URN-5 transmitter control unit.	URN5SCHEM4
10. Given a schematic diagram, analyze the MD-174/URN-5 modulator.	URN5SCHEM5
11. Using TO 31R4-2URN5-36 and supplemental information, perform servicing routine 2.1.	SERVROUT2.1
12. Using TO 31R4-2URN5-36 and supplemental information, perform servicing routine 2.2.	SERVROUT2.2
13. Using TO 31R4-2URN5-36, perform servicing routine 2.4	SERVROUT2.4
14. Using TO 31R4-2URN5-36, perform servicing routine 2.7.	SERVROUT2.7
15. Without reference to the Technical Order, select the eight types of resource material, found in the Technical Order, that can be used in troubleshooting.	TBSHPRIN1
16. Given a troubleshooting situation, select the basic measurement principles that would best locate the malfunction.	TBSHPRIN2
17. Given a hypothetical troubleshooting situation, designate the basic trouble-shooting principle that would locate the malfunction.	TBSHPRIN3
18. Provided with an inoperative AN/URN-5 in a shop situation, isolate and repair selected malfunctions using systems troubleshooting techniques.	TBSHURN5
19. Given AFM 55-8, identify the responsibilities of maintenance personnel, as they pertain to flight check.	FLTCHK1
20. Given AFM 55-8, identify the five types of flight check.	FLTCHK2
21. Using to 31R4-2URN5-11, select the six steps required to install AN/URN-5.	INSTALL

DETERMINE THE SEQUENCE IN WHICH OBJECTIVES WILL BE TAUGHT[3] II.B

A course planner establishes a sequence in which the separate course objectives, or topics, will be taught to insure that trainees are properly prepared for instruction, to simplify keeping track of student progress, and to make it easier to insure that training resources are available when needed. There are few hard-and-fast rules for establishing sequence, although the structure of the subject matter may dictate that some objectives should be mastered before others, especially when the later objectives make use of skills or knowledge mastered earlier.

Even in such highly structured subjects as mathematics, subject matter does not completely dictate sequence, and other factors should be considered: the degree of difficulty students will have in mastering each objective, the continuity of subject matter, the need to insure retention of critical subject matter, the need to stimulate trainee interest, and the effects of sequence on course management. The planner must balance these considerations, some of which may conflict with others, to produce a well-sequenced course. MODIA can assist in this process by demonstrating the effects of different sequences on student flow and resource use.

Sequence Required by Subject Matter II.B.1

The first step is to identify sequences required by the subject matter. Subject matter has a required sequence if a trainee must be taught other skills or knowledge before he can master a particular objective. For example, to add numbers on a calculator, he must know how to enter them and how to read the display. However, some cautions in the determination of *necessary* prerequisites should be observed. Almost no subjects except mathematics and logic are so highly structured that the bulk of the objectives have a required order. Second, many, if not most, skills or knowledge *assumed* to be required before a particular objective can be mastered are not. Even in mathematics, it is usually necessary to verify empirically whether selected skills or knowledge *must* precede a given objective. Moreover, there may be several equally good ways to sequence prerequisite objectives.

It is best to begin with a detailed analysis of the most complex knowledge or skill used in the task to determine what the student has to know and be able to do to master it.[4] Prerequisite objectives can deal with skills as well as with knowledge. For example, before a trainee can measure the inside diameter of a small cylindrical part he must know how to adjust and read a micrometer.

"Common-element objectives" are those that teach skills or knowledge that are components of several objectives. It makes sense to teach common-element objectives early in the course. It is a mistake, however, to teach all of them in a group, because this may damage trainee motivation, as is discussed later under *Stimulating Trainee Interest*, Sec. II.B.4.

Subject matter can appear to impose a different sequence from what has been discussed when a task or skill consists of a sequence of steps, each of whose outputs is input for the next step. Remove-inspect-repair-replace tasks, for example, always contain some sequences of this type. It may be natural to teach such sequences in

[3] A number of the concepts discussed here were drawn from Glaser (1965), pp. 787-789.

[4] This process is described in Chapter 3 of the *Task Analysis* volume of the Air Force *Handbook for Designers of Instructional Systems* referred to earlier and will not be discussed further here.

the order in which they would occur on the job, but some evidence indicates that this method is not always the most effective; see the discussion under *Stimulating Trainee Interest*.

II.B.2 Difficulty

Next, arrange objectives in order of increasing difficulty. Subject matter difficulty depends on the characteristics of the student as well as on the subject matter itself. Probably the most important student characteristic affecting difficulty is his familiarity with the subject matter. Therefore, planners should be aware of the abilities of students similar to those who will take the course, as well as of the subject matter. Familiarity largely depends on the language used in the technical specialty (technical words, phrases, and jargon) and whatever parallels there are in everyday life to the equipment, principles, and procedures used in the specialty. For example, most students are familiar with the procedures in tuning a color television set and therefore would quickly grasp the principles and procedures for tuning a radar display. It is better to teach objectives using familiar words and involving familiar equipment, principles, and procedures before those that require specialized terms or unfamiliar equipment, concepts, and procedures.

Another crucial characteristic is the level of proficiency in basic skills that the subject matter requires. (By "basic skills" is meant those skills that the average student population is expected to possess, such as the ability to speak and listen, write and read, calculate, control and execute body movements, sense stimuli, use common tools, and interact with others.) An objective that requires unusual proficiency in a basic skill will be more difficult than one that does not, other things being equal. A familiar example is the requirement that the student follow instructions given in a Technical Order, which is often written in complex technical jargon.

Generally speaking, complex subject matter is more difficult to learn than simple subject matter. Complex subject matter requires the student to master such skills as rule using, problem solving, and pattern recognition, which require the integration of several sub-skills, perceptions, or knowledge. Some of the differences between simple and complex behaviors are described in the *Handbook for Designers of Instructional Systems*.[5] Keep in mind, however, that complex objectives that have many familiar aspects can be easier to master than some simple objectives that have few familiar aspects.

Other subject matter characteristics that contribute to difficulty can often be alleviated by careful development of instructional activities. For example, tasks that take a long time to complete can sometimes be broken into sub-objectives that lead to the ultimate goal, or highly abstract or general subject matter can be made more comprehensible if it is illustrated by concrete examples. Other suggestions for handling such problems are given in the reference just cited.

II.B.3 Enhance Continuity

It is a good idea to group together objectives dealing with the same general subject or topic. Two reasons are to assist in reinforcing learning and to facilitate

[5] Department of the Air Force (1973), Vol. IV.

generalization and discrimination. Each of these will be illustrated briefly by example.

If a trainee must learn a great deal of unrelated material between the time he learns the nomenclature for a particular piece of equipment and the time he must use the Technical Order (TO) to go through the checkout procedure (or whatever is the first task he performs on the equipment), he may well have forgotten the appropriate nomenclature or get it mixed up with other nomenclature learned in the interim. However, having to use the nomenclature in reading the TO immediately after he has learned it reinforces his learning by giving him a chance to use it and by repeating it at the same time. Thus, prerequisite objectives should be taught immediately before objectives for which they are prerequisites or as close to them as possible. Apply this rule only to bona fide prerequisites to avoid unnecessary rigidity in sequencing.

Grouping together objectives dealing with similar subject matter can facilitate generalization by providing the student with different examples of the same general principle. For example, the same sequence of basic steps should be followed in checking any Line Replaceable Unit (LRU) on an automatic test station for advanced avionics—i.e., fill in the preliminary information on the 349 form, locate the required information in the TO, connect the LRU to the test station, call up the first test sequence from the computer, etc.

The details of these steps will be different for different LRUs. For example, the Work Unit Codes will differ, as will the location of information in the TO. Having the student check several different LRUs on the test station in close succession will demonstrate not only the common features of the processes but the differences in detail as well. This will help him discriminate among the processes.

Arrange the Sequence to Stimulate Trainee Interest II.B.4

Avoid designing a course that has long stretches of similar activities that become boring to the trainee. This may happen, for example, if common-element objectives such as theory, safety practices, and security procedures are all taught together in the classroom first because they are prerequisite to subsequent trainee performance. It is much better to teach such skills or knowledge as part of the tasks in which they are used, rather than separately, even if it requires breaking them into small parts or repeating them to do so. This injects variety into trainee activity and increases trainee interest. It also increases trainee interest by making the usefulness of what is being learned more obvious and thereby more likely to be learned and remembered. It is even possible that objectives that seem to be difficult will become less so when students see their applicability. Finally, it is possible that by determining which aspects of each common element objective are essential for each task, the course planner can eliminate unnecessary material.

Another common practice is to defer training on the highest performance equipment until the end of the course because it is usually the most complex. But such equipment is often the most exciting to the trainee. Therefore, an alternative is to put training on simpler tasks involving high-performance equipment early in the course.

If a task is lengthy or complex enough to be broken into subtasks, and if the output of one subtask is input to the next, sequencing the tasks in the order in which

they will be performed is not always the best way to stimulate trainee interest and enhance learning. In fact, it may sometimes be more effective to teach the last step first![6] The final step in the task provides powerful motivation and focus for the trainee because it reaches the objective. For example, students learning computer programming will be more highly motivated if they first learn to manipulate an existing program rather than beginning by learning the programming language.

II.B.5 Repetition to Insure Retention

The use of programmed learning, criterion objectives, and other techniques that tend to modularize instruction may have caused instructional designers to lose sight of the need for repetition of crucial subject matter to insure that trainees will remember it long enough to use it. The subject matter of common-element objectives is probably repeated sufficiently often that it needs no special consideration. Other subject matter may not be. Two of the most frequently used tactics to insure retention are repetition of instruction on the objective at later points in the course and telling the student that the objective is subject to test on later examinations. The latter is probably the most efficient tactic for all objectives that have to do with knowledge and skills that can be tested with paper and pencil. Since it is more expensive to repeat tests and instruction on objectives that require the student to use expensive training facilities or equipment, it may be necessary to designate for repetition only the objectives of this type that are of special importance.

II.B.6 Effects on Course Management

The sequence in which objectives are taught obviously affects student progress through the course and, thereby, resource use. Poorly designed sequences can, for example, result in overlapping requirements for scarce resources that are underutilized at other times. The output of the RUM will alert the planner to such circumstances. At this stage, he should concentrate on constructing a sequence that is instructionally effective.

In courses where resources are insufficient to accommodate all students simultaneously, instructors commonly schedule smaller groups of students through alternative sequences of instructional activities that generate demands for the scarce resource at different times, thus preventing bottlenecks. These alternative sequences can be simulated explicitly in MODIA, using one of the diversification options. For example, a sequence might be:

1. Study task procedures
2. Perform task
3. Study task procedures

where one group of students goes through activities 1 and 2, skipping 3, and the other goes through activities 2 and 3, skipping 1. This is "content diversification," described in Sec. VI.B.2. Alternative sequences can also be simulated implicitly by characterizing resources as described in Sec. IX.A.

[6] The original work in this area is reported in Gilbert (1962).

ASSIGN SUBJECT MATTER TYPES TO OBJECTIVES II.C

Next, one or more types of subject matter are assigned to each objective; recall that the UI assigns the same teaching method to every objective with the same subject type. (Hence objectives that will be taught differently should be assigned different subject matter types.) This feature has two purposes. First, it relieves the user of having to specify teaching method separately for every objective; rather, he specifies teaching method only for each subject matter type. Second, the subject matter types relate to resource use and teaching method and provide guidance in designing a course from basic principles. These implications are traced through in considerable detail in the remainder of this report.

If MODIA is being used to simulate an existing course or one that has been planned in detail, subject matter types should be assigned primarily with the aim of facilitating simulation. This process is illustrated by example in Sec. II.C.5.

The MODIA subject matter types are listed in Table 2. Note that a primary distinction is between subject matter that does and does not require students to use "special resources." Examples of special resources are specially equipped laboratories or workshops, trainers, simulators, and actual pieces of equipment. Instructors, classrooms, media, workbooks, auditoriums, and learning centers are *not* special resources.

Table 2

MODIA Subject Matter Types

Type	Description
1	Easy facts and concepts
2	Difficult facts and concepts
3	Simple classroom skills ("selected response")
4	Simple classroom skills ("constructed response")
5	Complex classroom skills ("selected response")
6	Complex classroom skills ("constructed response")
7	Team skills with special resources
8	Individual skills with special resources ("product only")
9	Individual skills with special resources ("process only")
10	Individual skills with special resources ("product and process")

Types 1 and 2 II.C.1

These subject matter types include facts, concepts, and principles to be known or understood. Students are not learning skills and can master the objective without manipulating or performing. Students are not required to use special equipment or to perform in special facilities.

Statements of objectives derived during ISD always require student performance to demonstrate mastery. However, this does not preclude such an objective from being a type 1 or 2 *learning* objective, since it is the *learning*, not the *demonstration of mastery*, that guides classification. The bulk of cognitive learning, for example, proceeds covertly and is not immediately manifested by observable behavior.

Type 1 differs from type 2 only in relative difficulty.

Examples: Given eight selected statements, identify information as classified, unclassified, or of possible intelligence value.

Identify the AIM-9/B, AIM-4/C, AIM-7, and AGM-65 missiles. (The student does not have to work with the missiles to recognize them.)

Describe the removal/installation procedures of the F-4E nose gun system. (The student can describe the procedure without being able to perform it.)

II.C.2 Types 3-6

These subject matter types include *skills* that can be learned and performed in a conventional classroom. Students are not required to use special equipment or to perform in special facilities but they are learning skills.

Example: Given five electronically related equations, solve at least four for any unknown value.

II.C.2.a Types 3 and 4

These are fairly simple classroom skills such as pronouncing or spelling unfamiliar words, making simple calculations, plotting points on a graph, drawing symbols, and reading numerical tables.[7] They can be taught through fairly routine, repetitive, or automatic drill and do not require the student to interrelate several steps or concepts.

Example: Draw the schematic symbols for a fixed, tapped, and variable resistor.

Type 3 is distinguished from type 4 on the basis of the way in which a student's ability to perform the skill can be evaluated or diagnosed. A student's mastery of classroom skills can be assessed by having him make either "selected responses" or "constructed responses."

A selected response is a response that the student selects in some way from a set of possible responses that have already been prepared. Examples are questions with multiple-choice or true-false answers and questions asking a trainee to match pairs of related phrases. In contrast to selected response, a constructed response is one that the student must produce or construct himself. Examples are written or typed answers, drawings, and spoken words or phrases.

Many instructional designers prefer that student responses be selected rather than constructed, because selected responses are more quickly checked and checking requires little or no judgment. However, it is impractical to try to determine student mastery of some skills by calling for selected responses. Many psychomotor skills fall into this category.

MODIA distinguishes between selected and constructed responses because in general only humans can feasibly judge the adequacy of a constructed response. Teaching machines or computers are not useful as "teaching agents" where such judgment is required.

[7] Such skills are discussed in Department of the Air Force (1973), Vol. IV, pp. 3-1 through 3-15.

Type 3 skills permit selected response. Put simple skills that *can* be assessed by selected response in this category whether or not they are regularly so assessed.

> *Example:* Given five electronically related equations, solve at least four for any unknown value. (This is the same example given on p.20. The trainee's skill can be assessed by having him select answers from among several possible answers.)

Type 4 skills require constructed response.

> *Example:* Draw the schematic symbols for a fixed, tapped, and variable resistor. (This is the second example given on p. 20.)

Types 5 and 6 II.C.2.b

These are fairly complex classroom skills that require the student to interrelate several steps, concepts, or skills. They correspond to rule using and problem solving.[8]

> *Example:* On a basic map of the United States, depict the weather situation yesterday at 1400 by drawing isotherms for every 10 degrees, shading areas of precipitation (indicate rain or snow), and indicating cold, warm, stationary, and occluded fronts in standard symbols.

Type 5 skills permit selected response.

> *Example:* Given a formula and an oscilloscope representation of a carrier modulated waveform showing E maximum and E minimum, compute the percent of amplitude modulation. (This skill can be evaluated by asking the student to choose the percentage from a set of percentages.)

Type 6 skills require constructed response.

> *Example:* On a basic map of the United States, depict the weather situation yesterday at 1400 by drawing isotherms for every 10 degrees, shading areas of precipitation (indicate rain or snow), and indicating cold, warm, stationary, and occluded fronts in standard symbols. (The trainee's ability to identify features on a weather map can be assessed by selected response, but his ability to draw a weather map cannot.)

Type 7 II.C.3

Type 7 is a team (or interactive) skill requiring students to use special resources.

> *Example:* As a load team member, inspect, prepare, install, functional check, boresight, and remove the gun pod on the LT-41 trainer IAW TO 1F-4C-2-18 and TO 1F-4C-33-1-2.

An important feature of a team skill is that it prescribes the size of the performing group. A skill that is commonly taught in an interactive group primarily for convenience or to improve the effectiveness of instruction should not be classified as

[8] See Department of the Air Force (1973), Vol. IV, pp. 3-15, 3-16.

an interactive skill. *Only* those skills that are normally performed in an interactive group or team *on the job* should be so designated.

II.C.4 Types 8-10

These are individual skills requiring students to use special resources.

> *Examples:* Given a 4 × 5 press camera, an exposure meter and film, the student will take five photographs, four of which show proper exposure and acceptable composition.
>
> Disassemble and assemble the M61A1 automatic gun IAW TO 11W1-12-4-32.

Note: Frequently classrooms are furnished or equipped with special resources for training in particular skills. For example, classrooms for teaching typing usually contain typewriters; classrooms for teaching maintenance of small equipment are often furnished with workbenches, equipment to be maintained, and test equipment. Objectives requiring student performance in such classrooms as these are subject matter type 8, 9, or 10, unless the student would normally have access to similar furnishings or equipment outside of class hours and away from the school premises. For example, students learning to use the slide rule might be expected to have their own slide rules. If such is the case, an objective could be type 3.

Skills in subject matter types 8-10 can be put in one of three classes: only process is important, only product is important, or both process and product are important. If only process is important, student skill must be assessed *during* the performance (or by observation of a recording of the performance). If only product is important, student skill can be assessed from the product alone, and monitors or recorders may not be needed during the performance. If both process and product are important, assessment may be made on the basis of the product alone or the total performance or the process alone.

In general, process is important if any of the following criteria is satisfied:

- The *only* objective of the performance is the process of performance.
- The student must follow special procedures to avoid harming himself, others, or the facilities or equipment (safety precautions).
- The student can experience undesirable emotional reactions during the performance, such as fear, impatience, or anxiety.
- The sequence of steps in the performance is important in itself, as when a particular maintenance procedure has been specified by regulation.

II.C.4.a Type 8

These are individual skills in which only the product of performance is important. If the process of performance is not important, then only the product is important.

> *Example:* Given a 4 × 5 press camera, an exposure meter and film, take five photographs, four of which show proper exposure and acceptable composition. (This is the first example above.)

Type 9 II.C.4.b

These are individual skills in which *only* the process of performance is important.

> *Example*: Inspect percussion and electrically primed ammunition IAW TO 11A13-10-7 and 11A13-4-7. (The trainee must be able to follow the procedures specified in the TO.)

Type 10 II.C.4.c

These are individual skills in which *both* the product and the process of performance are important.

> *Example*: Disassemble and assemble the M61A1 automatic gun IAW TO 11W1-12-4-32. (This is the second example on p.22. Process is important because of the need to conform to the procedure specified in the TO and because of the need to observe safety precautions.)

Steps in Assigning Subject Matter Types II.C.5

First the assignment of subject matter types will be illustrated for a course being designed from basic principles, then to simulate an existing course.

To clarify the assignment of subject matter types to objectives the types will be discussed from the more general level of categorization to the more specific. The first comprises four broad categorizations:

Types 1 and 2: Facts and concepts.
Types 3 – 6 : Classroom skills.
Type 7: Team skills requiring the student to use special resources.
Types 8 – 10: Individual skills requiring the student to use special resources.

The essential criterion for deciding which of these four groups should be assigned to each objective is: What *must* the student do to master this objective?

Note that the categories imply the use (or non-use) of special training resources and thus the concreteness of the learning experience. This is why it is important that the assignment made here reflect the ultimate course objectives; in particular, all items designated in the Specialty Training Standard as only subject knowledge or only task knowledge can be classified as type 1 or 2. For example, the objectives of Table 1 would be classified as follows:

Types 1 and 2: 1, 2, 3, 4, 15, 16, 17, 19, 20, 21
Types 3 – 6: 5, 7, 8, 9, 10
Type 7: 6, 11, 12, 13, 14, 18 (all performed in teams of two)
Types 8 – 10: none

More than one of the four broad categories listed above may be appropriate for a single objective if several different methods will be used in teaching it. This often happens when a skill is taught, because there are almost always special facts and concepts the trainee must learn to help him perform the skill. For example, he must

know the nomenclature applicable to the equipment he is to check out before he can follow the procedure prescribed in the TO. If the objectives have been developed as part of ISD, the knowledge that supports the skill being taught has probably already been identified as a separate objective. If this is the case, assign subject matter types 3-6, 7, or 8-10 to the objective as appropriate. The separate knowledge objective insures that the plan will include instruction in the required supporting knowledge, and the higher category of subject matter insures that the plan will include whatever special resources are needed to teach the skill.

If different objectives teaching facts and concepts should be taught differently, differentiate subject matter types 1 and 2 by difficulty or on any other basis that should be reflected in teaching method. Another possible basis for distinction would be to separate those objectives dealing primarily with facts (nomenclature, location of parts of equipment, procedures in routine maintenance) from those dealing with concepts or principles that require the trainee to relate several facts (the whys and wherefores of equipment operation). Other bases on which to make the distinction could be a requirement for unusually high performance in a basic skill, such as reading; a need to emphasize particularly important topics, such as safety practices; or a need to teach transitory topics, such as the way the class will be conducted, differently from the teaching of more stable topics. If different objectives teaching facts and concepts will be taught the same way, classify all such objectives as either type 1 or type 2.

If desired, distinguish between simple and complex classroom skills (subject matter types 3-6). Unlike types 1 and 2 objectives, types 3-6 objectives should be classified as simple or complex, because guidance in training method can be more closely keyed to this distinction. As before, however, any desired basis may be chosen for distinguishing between types 3 and 4 and types 5 and 6 objectives or no distinction at all may be made.

Finally, distinguish objectives on the basis of the type of student response required; that is, distinguish between types 3 and 4 and types 5 and 6 on the basis of whether mastery may be assessed by selected response, and among 8, 9, and 10 on the basis of whether the product only, the process only, or both the process and product of student performance are important. Allowing the statement of the criterion objective to dictate these choices automatically may unduly restrict the choice of teaching agent, as discussed in Sec. IV.D.3.e.

A final assignment of subject matter types to the example of Table 1 is illustrated in Table 3.

II.C.6 Combining Objectives

Recall that the list of objectives for entry into the UI should be as concise as possible. (See discussion in Sec. II.A.) Adjacent objectives concerning the same topic that have the same subject matter type may be combined to reduce the amount of input required. In the example of Table 1, the second set of SERVROUT objectives might be combined, for example. Further, adjacent objectives concerning the same topic may be combined, whether or not the subject matter types are the same, since more than one subject matter type may be entered for each objective. Thus all three TESTEQP objectives could be combined. Do not combine objectives, however, if a separate training activity might be inserted between them. For example, if the

Table 3

Example of Assigning Subject Matter Types to Objectives

	Objective	Code	Subject Matter Type	Aggregated Objective	Subject Matter Type
1.	Given a list of applicable test equipment, match the function with the equipment.	TESTEQP1	1	TESTEQP	1 2
2.	Given a list of test equipment, select the test equipment that is maintained by organizational/intermediate maintenance.	TESTEQP2	1		
3.	Given a list of malfunctions common to various pieces of test equipment, match the malfunction to the appropriate piece of test equipment.	TESTEQP3	2		
4.	Given TO 31R4-2URN5-2, select the purpose and technical characteristic of each major unit in the AN/URN-5.	URN5CHAR1	2	URN5CHAR	2 6
5.	Given a schematic diagram of the power distribution and control circuits, trace the AC through the unit.	URN5SCHEM1	6		
6.	Using TO 31R4-2URN5-36, perform routines 1.1 and 1.2	SERVROUT1	7	SERVROUT1	7
7.	Given a schematic diagram of the cabinet power supply, select the output voltages.	URN5SCHEM2	6	URN5SCHEM	6
8.	Given a schematic diagram, analyze the *T-357/URN-5 transmitter.*	URN5SCHEM3	6		
9.	Given a schematic diagram, analyze the C-1107/URN-5 transmitter control unit.	URN5SCHEM4	6		
10.	Given a schematic diagram, analyze the MD-174/URN-5 modulator.	URN5SCHEM5	6		
11.	Using TO 31R4-2URN5-36 and supplemental information, perform servicing routine 2.1.	SERVROUT2.1	7	SERVROUT2	7
12.	Using TO 31R4-2URN5-36 and supplemental information, perform servicing routine 2.2.	SERVROUT2.2	7		
13.	Using TO 31R4-2URN5-36, perform servicing routine 2.4.	SERVROUT2.4	7		
14.	Using TO 31R4-2URN5-36, perform servicing routine 2.7.	SERVROUT2.7	7		
15.	Without reference to the Technical Order, select the eight types of resource material, found in the Technical Order, that can be used in troubleshooting.	TBSHPRIN1	1	TBSHPRIN	1 2
16.	Given a troubleshooting situation, select the basic measurement principles that would best locate the malfunction.	TBSHPRIN2	1		
17.	Given a hypothetical troubleshooting situation, designate the basic troubleshooting principle that would locate the malfunction.	TBSHPRIN3	2		
18.	Provided with an inoperative AN/URN-5 in a shop situation, isolate and repair selected malfunctions using systems troubleshooting techniques.	TBSHURN5	7	TBSHURN5	7
19.	Given AFM 55-8, identify the responsibilities of maintenance personnel, as they pertain to flight check.	FLTCHK1	1	FLTCHK	1
20.	Given AFM 55-8, identify the five types of flight check.	FLTCHK2	1		
21.	Using TO 31R4-2URN5-11, select the six steps required to install an AN/URN-5.	INSTALL	1	INSTALL	1

trainee must demonstrate mastery of each SERVOUT procedure in turn, they should not be combined. Other possible combinations of objectives are illustrated Table 3.

Simulating an Existing Course

Table 4 lists the codes of Table 1 together with activities (quizzes, homework, performance checks) that might take place at the end of the day in an existing lock-step course. The table also shows an assignment of subject matter types to simulate this course and a suggested combination of objectives to simplify input.

Table 4

ASSIGNING SUBJECT MATTER TYPES TO SIMULATE AN EXISTING LOCK-STEP COURSE

Objective	Code	Teaching Method	Subject Matter Type	Aggregated Objective	Subject Matter Type
1	TESTEQP1	Discussion/Demonstration	2	Day 1	2
2	TESTEQP2	Discussion/Demonstration	2		6
3	TESTEQP3	Discussion/Demonstration	2		1
4	URN5CHAR1	Discussion/Demonstration	2		4
5	URN5SCHEM1	Demonstration/Performance	6		
		Quiz	1		
		Homework	4		
6	SERVROUT1	On-equipment Performance	7	Day 2	7
7	URN5SCHEM2	Demonstration/Performance	6		6
8	URN5SCHEM3	Demonstration/Performance	6		1
9	URN5SCHEM4	Demonstration/Performance	6		4
10	URN5SCHEM5	Demonstration/Performance	6		
		Quiz	1		
		Homework	4		
11	SERVROUT2.1	On-equipment Performance	7	Day 3	7
12	SERVROUT2.2	On-equipment Performance	7		9
13	SERVROUT2.4	On-equipment Performance	7		
14	SERVROUT2.7	On-equipment Performance	7		
		Progress Check	9		
15	TBSHPRIN1	Discussion/Demonstration	2	Day 4	2
16	TBSHPRIN2	Discussion/Demonstration	2		7
17	TBSHPRIN3	Discussion/Demonstration	2		9
18	TBSHURN5	On-equipment Performance	7		
		Progress Check	9		
19	FLTCHK1	Discussion/Demonstration	2	Day 5	2
20	FLTCHK2	Discussion/Demonstration	2		
21	INSTALL	Discussion/Demonstration	2		

NOTES

III. PLACEMENT OF TESTS

Since tests and objectives are so closely related, it is frequently helpful in specifying the objectives of a course to decide how student mastery of the objectives will be tested. In fact, ISD encourages the planner to specify test content when he specifies course content. As soon as objectives have been sequenced, tests can be entered in the sequence.

If the content of the course is known in only a rough way, it is difficult to make well-informed decisions about the placement of tests, and they should probably be omitted. If topics have been well-defined and sequenced, however, points at which tests will be inserted can be chosen. Tests can affect the course design and the resources, including course time, required for the tests themselves. This is particularly important for performance tests that require students to use special, perhaps costly resources and to be observed by one or more skilled raters.

Tests can also affect the way students progress through the course, causing some students to be eliminated from the course, others to "recycle" through preceding course material (washback), others to take special remedial instruction, and still others to skip some subsequent material (proficiency advance). Tests provide an administrative tool for adjusting instructional resources to student needs and abilities; hence, this type of test is of particular importance in MODIA. This section discusses considerations about the placement and description of tests and test-related activities. Figure 5 shows the relation of the decisions described here to the overall decision process.

III.A TESTS AS FLOW REGULATORS

Tests that affect the way students progress through the course can have strong effects on course structure and resource requirements. This is particularly true of tests given at the end of a major section of the course such as a block. In fact, students frequently pass from one administrative division of the course to another when they pass an end-of-block test. Sometimes important tests are inserted within a block, particularly if it is a long one with difficult subject matter.

Tests over smaller sections of course content can also affect student progress. For example, a student may be required to repeat the instruction during the regular training day if he fails a criterion check. This causes him to fall behind his classmates and to take more of the instructor's time and attention and more of other instructional resources, such as classroom space or training equipment. Similarly, another student who is allowed to skip sections of the course on the basis of his test performance takes fewer instructional resources than the average.

An intermediate situation can arise that is of marginal importance for planning—namely, when a student who performs poorly on a test is given remedial instruction outside of class hours or for home study. Such assignments have no direct effect on the student's progress through regular instruction, although they impose an additional burden on his out-of-class time and may increase the load on the instructor and instructional facilities. Since out-of-class remedial instruction is already

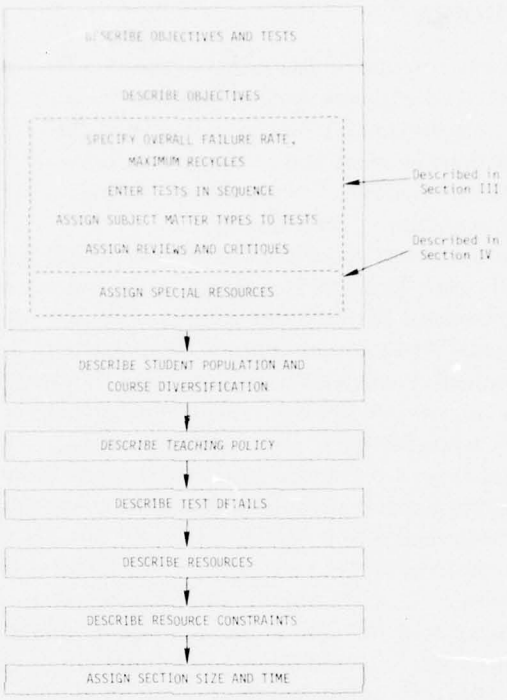

Fig. 5—Relation of decisions described in Secs. III and IV to overall decision process

included in the regular out-of-class duties of an instructor, however, it should not be included in MODIA.

TESTS AS TEACHING DEVICES III.B

Tests can be an integral part of the instruction. By determining whether a student has mastered the subject, they can permit or block his further progress, as discussed above. They can also reinforce preceding instruction by causing the student to review it in preparation for the test. And they can be used as diagnostic tools to determine how much the student already knows about the subject, what his aptitudes are, or in what particulars the instruction is or is not meeting student needs. Information from diagnostic tests (pre-tests) is used in placing students in courses as well as in tailoring instruction to the needs of individual students.

Frequent testing can be particularly helpful for the student who is poorly motivated to learn the subject. However, *too* frequent testing can slow down the instruction and lead to boredom with test taking. There is a point at which the frequency of testing is optimum, but to determine precisely where it is requires intimate familarity with the subject matter and student population.

III.C TESTS IN MODIA

After he has entered subject matter types for the training objectives, the user identifies tests that regulate student progress through the course. All tests whose results can cause students to be eliminated from the course or to recycle a portion of the course must be identified at this point. Tests that determine the content of subsequent instruction for individual students may also be entered here, although MODIA does not simulate this directly.

In planning the test schedule, the planner will find it helpful to consider what each test will cover. This provides direction for assignment of subject matter types and special resources to particular tests and for later decisions.

The material a test covers depends on its purpose. For example, a test can be used to assess mastery of objectives taught since the last test. Or, as discussed earlier (II.B.5), tests can be used to force review of crucial objectives taught earlier in the course. (Such tests are sometimes termed "criterion rechecks.")[1] Objectives with subject matter types 1-6 are especially amenable to retest; it may be unacceptably expensive to retest many of those with higher subject matter types.

Ideally, tests should be based on objectives, but it is possible for a test to cover none of the objectives taught in the course in a direct way. For example, a test may require the student to synthesize the course materials to solve a special problem. In this case, ability to synthesize is being tested as much as mastery of objectives. Diagnostic pretests, often used to assign students to particular tracks or groups, may also be only indirectly related to the precise course objectives.

III.D ELIMINATION FROM THE COURSE

Unfortunately, there is almost always some non-zero percentage of trainees who cannot (or will not) master a given training course. This percentage depends on the difficulty of the course material, the ability of the students, and their motivation. Some examples of subject types, aptitude prerequisites, and elimination rates are shown in Table 5.

Students are sometimes eliminated from a course because of sickness, disciplinary problems, or other nonacademic reasons. MODIA does not simulate elimination from the course anywhere but after tests. Therefore, nonacademic eliminations should be included with academic eliminations if they are to be considered in course planning.

III.E RECYCLES THROUGH COURSE CONTENT

Students who do poorly on an examination may be required to washback and take the examination again, rather than be eliminated from the course. Recycling is a convenient device for adjusting the instruction to student needs. It helps the instructor to stay within the course elimination rate, which may be administratively necessary, without spending long hours after class giving remedial instruction, and it gives the poorer student breathing space for mastering difficult parts of the course,

[1] Air Training Command (1974).

Table 5

EXAMPLES OF TECHNICAL COURSES, APTITUDE PREREQUISITES, AND ELIMINATION RATES

Course Number	Title	Prerequisite AQE[a]	Elimination Rate
3ABR63130	Fuels Specialist	G40	04
3ABR39130C	Maintenance Analysis Specialist (Motor Vehicle)	G60	15
3ABR42132	Aircraft Pneudraulic Repairman	M40	03
3ABR44330G-002	Missile Mechanic (WS-133)	M50	10
3ABR29333	Radio Operator (voice)	A60	07
3ABR20731	Morse Systems Operator	A60	30
3ABR30534B-002	Electronic Computer Systems Repairman (Display Equipment 465L)	E80	06
3ABR30332	AC and W Radar Repairman	E80	23

[a]Score on a subsection of the Airman's Qualifying Examination (AQE). Subsections are General (G), Mechanical (M), Administrative (A), and Electronic (E).

without requiring the preparation of additional course materials. A recycling student may join the class that entered after his, to simplify administrative adjustments all along the line. The disadvantage is that recycling over a large portion of the course can incur large costs in terms of additional instructional resources (especially student time) required. In fact, remedial instruction is probably much more efficient than across-the-board recycling.

SKIPPING AHEAD III.F

Students who do very well on a test may be permitted to proficiency advance. This can provide additional motivation for the able student and release him from uninteresting instruction, and it relieves some of the pressures on training resources. Like recycling, skipping is simple to administer and requires no additional preparation of materials.

MODIA cannot simulate proficiency advance in the same way as it simulates recycles and failures—i.e., by sending an individual student back over course material or dropping him from the course. MODIA can approximate the effects of proficiency advances, however, if the planner designates beforehand objectives or learning events to be skipped, along with the categories of students who would skip them. This is a type of content diversification and is treated more fully in VI.B.2.

OTHER TEST-RELATED ACTIVITIES III.G

Tests can generate other instructional activities—namely, reviews and critiques. A review prepares the student to take the test by having him go over important points on which he may be tested. A review is also a unique opportunity to help

the student see the course as a whole by relating all of the things he has learned to that point. Tests covering especially difficult material, a large amount of material, or material from earlier parts of the course that the student may have forgotten are good candidates for reviews.

Reviews are assumed always to precede the test; they may be given during scheduled instruction or assigned for home study. If a review for a particular test will never be conducted during regular class instruction but may be assigned for home study, the planner should treat it as a homework learning event, not a review. Reviews requiring the student to use special resources should always be conducted during scheduled instruction.

A critique is a session following the test during which the instructor discusses the test with the class or individual student. Critiques enhance the instructional function of the test and increase the student's sense of involvement with the instruction. In line with ATC policy, all students taking a test are assumed to attend the subsequent critique, regardless of their performance on the test.[2]

III.H ASSIGNING SUBJECT MATTER TYPES TO TESTS AND REVIEWS

The type of subject matter for tests and reviews is related to but not necessarily the same as the subject matter of the objectives covered. For example, instruction for the objective of safety wiring aircraft parts may include a motivational unit on the reasons for using safety wiring, which is category 1 subject matter, but the student may be tested only on his ability to do safety wiring, which is category 8 subject matter. Conversely, the student may be required merely to know the procedures for installing a particular item of equipment (category 1 subject matter), although he may have the opportunity to perform such an installation during class (perhaps category 10 subject matter). The test on that objective could legitimately be classed as category 1 in that case.

A less defensible practice, but one that is often forced on the course designer because of scarcity of training resources, is where student mastery of task performance is tested only with a written test of task knowledge. This test would be category 1 or 2 subject matter for an objective that was one of categories 7-10. Some compromises of this type may be necessary and may not be too damaging to training effectiveness if minimal motor or sensory skills are required for task performance or sufficient samples are taken of student ability to perform critical tasks. Probably the best approach is to plan initially for a complete schedule of performance testing of critical tasks, obtain MODIA's estimate of the effects on requirements for training resources, and successively reduce the schedule, if necessary, until estimated resource requirements reach a tolerable level.

Assignment of more than one category of subject matter to a test permits the specification of different testing methods at a single test point. For example, a test containing categories 2 and 10 might be administered by a written ("measurement") test and a performance test ("progress check"), during which an evaluator observes the student's performance and rates it with a checklist.

[2] Unless they have already been designated for skipping the critique as described in Sec. VI.B.2.

Somewhat different considerations affect the assignment of subject matter types to reviews, since they can be an integral part of instruction and may be conducted differently to meet different student needs. For better students, for example, a review might be just a mental rehearsal of the performance, recalling its critical aspects to the student. Such a session would be subject matter type 1 or 2 and would reduce requirements for training resources without losing all the benefits of the review. Poorer students might require both the mental rehearsal and actual practice, which would result in assignment of subject matter types 1 or 2 and 8, 9, or 10 to the same review. To permit maximum flexibility in later decisions, it is advisable to assign several appropriate subject matter types to each review. With content diversification, portions of the review then can be deleted for students who will not need them.

A test or review may contain as many of the ten categories of subject matter as desired; these will generally correspond to the subject matter categories of the objectives they cover. As with objectives, subject matter types should be assigned in the order in which they will occur. Since MODIA expands a test or review containing several categories of subject matter into an equal number of learning events, if the part of a test or review that deals with a given type of subject matter will be very short, it is advisable to combine such subject matter types with similar subject matter types to simplify planning. The most important consideration is to separate subject matter types that require significantly different use of training resources for test or review.

NOTES

IV. ASSIGN SPECIAL RESOURCES TO OBJECTIVES, TESTS, AND REVIEWS

Figure 5, Sec. III.A, shows the relation of this step to the overall decision process. For courses that are undergoing revision, lists of special resources are entered in the Plan of Instruction as training equipment. If steps 1-3 of ISD have been applied to the course, special resources will have been entered on the Task Description Worksheet under *Activity Support Elements*. If the course is new, MODIA can help determine what mix of real equipment, trainers, trainers designed to teach less than the full range of skills, or simulators is most desirable.

Often hundreds of items of hardware are required to conduct a course, but it is undesirable to enter each separately into the UI. Only those that are costly or in short supply, or that should be explicitly treated in planning for some other reason, should be considered at this point, to save unnecessary work for both the user and the computer.

The full set of resources that will be needed should later be entered in MODCOM so that complete costs can be assessed. To reduce the number of separate inputs to MODCOM, resource identifications should represent a set or group of hardware items whenever possible. Thus, entries to the UI should represent the aggregations that ultimately will be costed.

This concept is most easily conveyed by the example in Table 6. If several learning events require essentially the same package of equipment with but minor differences, then the basic package should be identified as one hardware type and the supplementary equipment as separate types. If an additional unit of a particular hardware type is required, then the prescribed quantity of each item within the set will be required.

In general, instructional media should not be considered special resources, as noted earlier. Media are considered in detail at later stages in the design process.

Table 6

EXAMPLE OF COMBINING RESOURCES

	Contents	
Name of Hardware Set	Item Description	Units Required per Set
Darkroom Equipment	Enlarger	1
	Darkroom sets (trays, clips, containers, etc.)	1
Tool Kit	Tool chest	1
	Drill	1
	Flat-tip screwdriver set	1
	Phillips screwdriver set	1
	Open-end box wrench set	1

NOTES

V. DESCRIBE STUDENT POPULATION AND COURSE "DIVERSIFICATION" V

The population of trainees expected to take the course and the extent to which different approaches are planned for different types of trainees have major effects on course design. The total number of students to be trained, the number entering the course at one time, general strategies for course diversification, and the trainee characteristics on which diversification will be based set the stage for later specification of details of these effects. This section presents considerations for making these preliminary decisions. Their relation to the overall decision process is shown in Fig. 6.

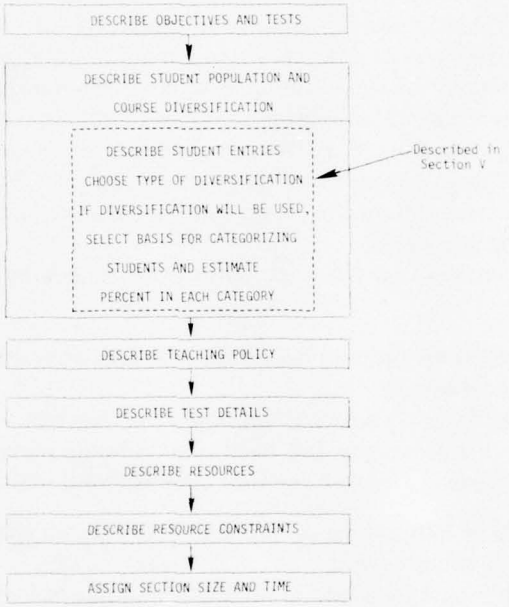

Fig. 6—Relation of decisions described in Sec. V to overall decision process

SUPPLY OF STUDENTS V.A

In Technical Training, the total number of students who must graduate from a course in a given period of time is determined by the Training Program Requirement. Courses in which a large number of students are trained, often continuously, can usually make better use of training resources if they are designed differently from those that are given infrequently to small numbers of students. Between these extremes are courses for which it is difficult to guess which design will make the best use of training resources. One of MODIA's most useful features is that planners can

rapidly estimate the sensitivity of requirements for training resources to variations in the total number of students to be trained. Thus, although the first design described for the UI should treat the most likely number of students to be trained, reasonable variations on this number should also be analyzed to establish the ability of the course plan to accommodate to variations in student loads.

Although the total number of trainees is of primary importance, the way in which they will enter the course also has significant effects on the use of training resources. Student entry is affected both by the way in which students are supplied to the course from outside activities—such as Basic Military Training, another technical course, or an operating command—and by the way in which the course itself is conducted. Another course feeding this one may, for example, graduate either about 20 students every two weeks or between 5 and 25 students on an average of every two weeks. If student time between the two courses is not to be wasted, each of these situations would imply a different procedure for entering students into this course.

Other factors should also be considered. One is the way the course itself will be conducted—primarily whether it will be taught by lock-step or will permit some variability in progress of individual students. Lock-step instruction requires students to progress at the same rate in groups of fixed size; other methods of instruction may allow students to progress at varying individual rates.[1] Training methods that encourage variable *group* flow are probably more useful for courses devoted largely to teaching team skills (subject matter category 7), but this tactic is similar to lock-step instruction insofar as it requires students to form groups of fixed size before training can begin.

MODIA contains the following options for describing student arrivals at the course:

1. Fixed group size and fixed time between arrivals (includes "groups" of a single student);
2. Variable group size and variable time between arrivals;
3. Variable group size and fixed time between arrivals;
4. Fixed group size and variable time between arrivals.

As in the case of total students, the ability to explore the effects of variations in student arrival options and
ariations within options is one of MODIA's significant features.

Option 1. Planners might like to try varying both the group size and the arrival interval while maintaining the same total number of student entries over a fixed period. Suppose that 12 students enter the course every 30 hours (which is a week in most technical courses). If 24 students entered every 60 hours or 6 students every 15 hours, the same total entry rate would be maintained but the use of training resources might be very different.

Option 2. This is like a combination of Options 3 and 4,[2] but planners know only the average size of the entry group and the average time between arrivals. The

[1] Self-pacing is an example of variable individual progress, but other teaching methods can also have this effect.

[2] Numbering of the options corresponds to the numbering used in the description of the RUM in Gallegos (forthcoming).

option simulates greater variability in student arrival patterns than Option 3 or 4 as well as variability in both parameters at once.

Option 3. Planners estimate both the average size of the arrival group and how far from the average the maximum and minimum are (the spread). For example, an arrival group might usually contain about 10 students, but sometimes as few as 3 or as many as 17 students might be available for the course. In this case, the average size would be 10 and the maximum group size spread would be 7 ($10 - 3 = 7$ and $17 - 10 = 7$).

The average in the above example lies halfway between the maximum and the minimum. If such is not the case, one or more of the numbers should be adjusted. For example, suppose that the average size of the arrival group is 10, the minimum is 2, and the maximum is 12. Halfway between 2 and 12 is 7, not 10. [$(12 + 2)/2 = 14/2 = 7$.] If 7 is entered as the average group size, MODIA will usually produce entry groups of around 7 students; only occasionally will they be as large as 10. Probably a better tactic in this case is to adjust the spread, choosing 8 if the effects of exceptionally large and small arrival groups are of concern or 2 if only the effects of moderately large and small arrival groups are of concern. A spread of 5 would, of course, compromise between the two extremes.

In Option 3, planners can juggle average arrival group size and time between arrivals in the same way as in Option 1, but different combinations will not generally result in the same total entry rate because of the variability in entry group size. Option 3 is an excellent choice for simulating how instructional methods that require grouping affect the time trainees must wait before entering the course when they arrive in groups of variable sizes.

Option 4. To characterize the interval between group arrivals, MODIA needs an estimate of the average time between them and of the spread of arrivals around this average. This allows planners to simulate the case where students arriving at the school at random wait until a class of specified size can be formed. It also allows planners to simulate a situation in which individual students arrive at the course at random by specifying a group size of 1 and an arrival interval as appropriate.

COURSE DIVERSIFICATION V.B

MODIA incorporates both "concurrent adaptability" and pre-planned adaptability (diversification) as techniques for tailoring instruction to student differences.[3] Concurrent adaptability refers to teaching methods that adapt the instruction to the apparent needs of the students during instruction. Recall that diversification refers to provision, before the course begins, of different approaches to instruction to meet needs of different categories of students. Both options can have significant effects on requirements for training resources.

Why Diversify? V.B.1

Diversification can improve the efficiency of instruction. For example, allowing

[3] An intermediate type of diversification is one in which the specification of instructional approach to be used in a given learning event is based on the student's performance during the preceding learning event. An example is Computer Managed Instruction. The current version of MODIA does not explicitly simulate this option.

students to bypass materials they already know decreases the resources needed for a given level of learning of a given body of subject matter. Requirements for resources can also be reduced if students can proceed through the course at their own rates. Or planners might want students who are deficient in reading skills to be taught orally rather than with print. But diversification will not improve the efficiency of instruction a great deal if the students are pretty much alike in most important respects.

The total number of trainees who will take the course is also important because diversification incurs a cost either for developing the materials required or for administering the different procedures for different students. If the total number of trainees who will be treated differently from the average is small (say less than 10), it may cost more to provide diversification than can be saved.

For MODIA to give planners estimates of the effects of diversification on student flow through the course and on requirements for training resources, planners must have some idea of the fraction of students that will be taught in each of the different ways. This will ensure that sufficient resources are allocated beforehand to carry out the chosen strategy.

Finally, the form of diversification selected will depend on the goals of the school. On the one hand, ATC wants graduates of a particular course all to have a given level of competence in the same skills and knowledge. Naturally, there will be variations among graduates, but the policy is to expend only those resources needed to bring all graduates to a certain point. With such a policy, diversification primarily improves the efficiency of use of school-furnished instructional resources. On the other hand, in certain subject areas the school may wish to encourage trainees to become as competent as they can within a given length of time or within other resource constraints. Under this policy, diversification can also improve the development and application of the students' capabilities, probably the most significant of all instructional resources. For example, a student who has shown exceptional talent in photography might be given special assignments to photograph base activities for the local paper, and his instructor might take time to guide him in this activity. Although such an approach is not now part of official ATC policy, it is included in MODIA for greater flexibility.

V.B.2 Content Diversification

MODIA provides content diversification as an option so that not every student will have to be instructed in every aspect of every objective. A familiar example of content diversification is the proficiency advance, discussed in III.F. Other reasons for skipping or adding objectives are:

1. Helping poorly prepared students make up for deficiencies in fundamental skills or knowledge that the average student normally has before he enters the course.
2. Allowing better prepared students to skip portions of the course that they knew before they entered training or have picked up without explicit instruction.
3. Encouraging more capable students to go beyond minimum mastery.
4. Allowing less capable students to skip difficult skills or knowledge not essential to initial job performance.

If the planner chooses 2 or 4 from this list, he will need to designate objectives in the basic list that can be skipped by particular types of students. If the planner chooses 1 or 3 it may be necessary to add objectives for other types of students to the basic list.

Method Diversification V.B.3

There are two ways for diversifying teaching method for students with different characteristics: teaching the same learning events in different ways or teaching an objective by means of a different series of learning events. As an example of the first tactic, students who read well may use a programmed text for a learning event, whereas those who have difficulty in reading may participate in a recitation on the subject.

Some of the reasons for skipping or adding learning events *within* objectives are that better students may need less orientation, review, or guided practice than the average student; poorer students may need more; or unmotivated students may need more frequent testing than the average.[4]

Procedures for Facilitating Diversification V.B.4

Either "tracking" or "grouping" facilitates diversification by putting together students who will be instructed similarly. But even if students in different tracks are taught the same course materials by the same methods, tracking in itself will result in diversification because a student's peers have a pronounced effect on his learning environment. The diversification can be enhanced, however, by providing different content or using different methods to teach the different tracks. For example, students in one track may work almost entirely with self-instructional materials, while in the parallel track they may study in conventional classrooms and spend additional hours in review and repetition of work already presented.

Tracking or grouping can also facilitate diversification of content in that a particular group or track of students might study a special set of objectives. As noted earlier, however, there should be sufficient commonality of objectives among the tracks or groups that all of the students can be considered to be taking essentially the same course.

Recall that in MODIA "grouping" refers to separating students into divisions whose members can change from one type of subject matter to the next. Grouping can permit greater diversification than tracking because the grouping strategy can be tailored to variations in subject matter difficulty or other features of the course. In addition, tracking locks students into invariant divisions, which can have undesirable psychological effects. Grouping, however, puts greater demands than tracking on course administration.

Tracking precludes grouping, since tracks are invariant throughout the course. Grouping does not preclude tracking, but since tracking is easier to prescribe, tracking should be chosen if it will be used.

If planners wish to consider the effects of using different sets of resources to teach different groups or tracks of students the same objective, they should choose

[4] Tutoring, programmed learning, self-pacing, and most programs for Computer Assisted Instruction are methods for concurrent adaptability; they will be considered later.

diversification of method. For example, if materials for self-pacing will be used by better students but a regular instructor will work with average students, separate groups or tracks should be indicated for those learning events to allow MODIA to compute the student load on each set of resources.

V.C CHARACTERIZING THE STUDENT POPULATION

Planners choose tracking, content diversification, or method diversification if they believe the trainees will profit from these approaches. They must also describe the student population in terms of the percentage of students having diverse characteristics. In effect, this establishes categories of students for whom diverse approaches can be planned. For example, if content diversification has been chosen and if the student population has been broken into two categories, students in one of the categories will skip content intended only for students in the other, but students in both categories may study common content. Further examples of the use of categories of students are given shortly.

The first step is to establish the basis for categorizing students. MODIA provides three options:

1. Ability (up to four categories).
2. Some other characteristic (two categories only).
3. Both ability and another characteristic (four categories only).

Ability is defined as the competencies required to learn the subject. It is very difficult to measure ability directly, but it may be approximated in several ways. In academic subjects, IQ tests approximate ability, although paper-and-pencil tests of aptitude in the subject area are generally better measures for predicting trainees' success in learning. Such tests measure how well the trainee has already learned skills and knowledge fundamental to the subject. Often the subtests on the Airman's Qualifying Examination are useful measures of academic ability. In nonacademic courses, measures of visual, motor, or other types of skills may be better surrogates for ability. For example, dentistry requires finger dexterity and the ability to do small-scale work by touch.

Other characteristics than ability may also be important. One of the most obvious is that the students' previous experience in areas closely related to course work may be widely different. For example, many trainees can whiz through basic electronics because they have already studied it in high school; others are highly adept in the equipment-oriented portions of electronics courses because they have worked in TV repair or run ham radio stations. Some other characteristics for which diversification might be desirable are age and sex. Older trainees may be less responsive than younger to methods that present the instructor as the source of all wisdom and may be more motivated to pursue idiosyncratic interests. Or males may need to learn different skills from females and in different contexts, particularly in subjects dealing with interpersonal relationships or personal services.

Ability

The student population may be broken into as many as four categories on the basis of ability, as shown below:

Number of Categories	Type of Category
2	S F
3	S A F
4	S S' F' F

where the following designators apply:

A Average
S Slow
F Fast
S' Slower than average
F' Faster than average.

The designators are intended as mnemonic devices only and do not indicate the average rate with which each group will progress. Rate is determined by later input from the user. As suggested, however, ability is assumed to increase across the spectrum from S to F. After the groups are chosen, the user must estimate the percentage of students expected to be in each group. The user has wide flexibility in manipulating these percentages and rates of progress. For example, by assigning 75 percent of the students to the S group and later estimating that this group will progress at an average rate, the user in effect makes the group represent average students.

Other Characteristics

If some characteristic other than ability will be the basis for breaking the student population into categories, only dichotomous categories may be specified. For example, if age is important, a break point should be chosen below which students will be classified as "young" and above which students will be classified as "non-young" (that is, old). In some cases, such as sex, a natural break point already exists. The user assigns a mnemonic code to the characteristic chosen (such as E.E.TNG to designate students with previous training in electrical engineering).

Both Ability and Another Characteristic

If the categories are broken down by a combination of ability and another characteristic, the four categories shown below will be formed:

Category ID

1 Slower students without the characteristic.

2 Slower students with the characteristic.

3 Faster students without the characteristic.

4 Faster students with the characteristic.

As in the case where ability is the only basis for categorization, either the slower or the faster group can be thought of as including the average students.

Note that although up to four categories of ability and two categories of another

characteristic may be chosen, at most four (not eight) categories may be designated combining both ability and another characteristic. This limitation comes about primarily because it seemed unlikely that the proportion of students who would be in each of eight categories could be estimated beforehand accurately enough to be meaningful and to minimize computer requirements.

Planners might want to consider *fewer* than four categories based on both ability and another characteristic. For example, it might be worthwhile to diversify course content in the same way for all faster students but in different ways for slower students who do and do not have E.E. training. MODIA permits this by allowing planners to specify the same content diversification strategy for both the faster students without E.E. training and the faster students with E.E. training.

NOTES

VI. DESCRIBE TEACHING POLICY

The foregoing decisions provide the framework within which planners now specify in detail the way the course is to be taught. The relation of the steps described in this section to the overall decision process is shown in Fig. 7.

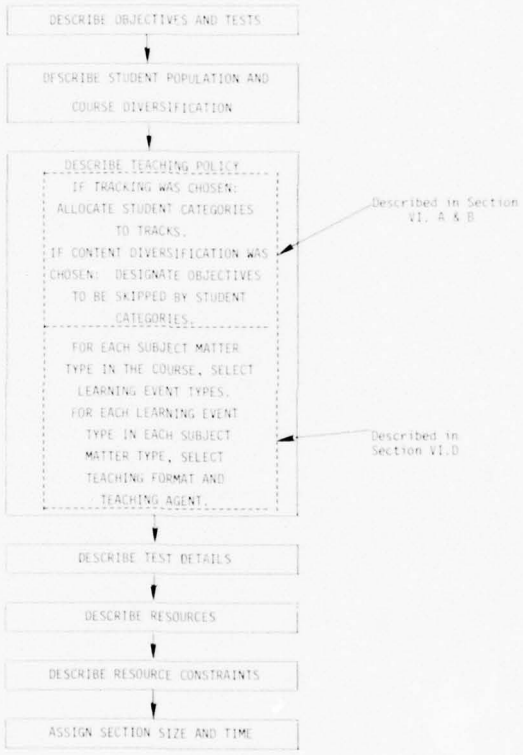

Fig. 7—Relation of decisions described in Sec. VI to overall decision process

VI.A LENGTH OF TRAINING SHIFT

First, the UI asks for the length of the training shift in terms of the average number of minutes students are expected to spend in scheduled classroom instruction, excluding home study, and the number of minutes in home study. The UI uses these numbers to determine the number of training days in the course and to help the planner check the ratio of hours to be spent in home study to hours to be spent in class.

DIVERSIFICATION VI.B

If tracking, content diversification, or method diversification have been indicated, some details of their application to the course are specified next. Otherwise, the user defines instructional policy for each type of subject matter or combination of types. Even if diversification is not contemplated, it is advisable for the planner to read the next few paragraphs carefully to understand the options available. Recall also that concurrent adaptation (variable pacing, for example) can be provided whether or not method diversification has been chosen, as is illustrated later.

Tracking VI.B.1

First, the user indicates which categories of students are in which tracks. At this point, it is a good idea to check the percentages of students in each category against the expected entry group size to make sure that each track will contain enough students to be worth the effort of producing the required materials and managing the track. For example, it might be wasteful to plan a track for 10 percent of the students if only 10 students were expected every month. In this case, these students might better be grouped with others who had sufficiently similar characteristics to be taught in the same way.

Suppose, for example, that the percentages of students in each category are:

Category ID	Student Type	Percent Total
1	Slow Non-E.E.TNG	28
2	Slow E.E.TNG	12
3	Fast Non-E.E.TNG	42
4	Fast E.E.TNG	18

If 100 students will enter the course every month, it might be reasonable to plan four tracks, one for each category of student. The smallest track, slow E.E.TNG, would then contain an average of 12 students, certainly enough to justify a track tailored to their abilities. If only 10 students enter the course every month, the smallest track would usually be empty, and the effort that went into designing it would largely be wasted.

Content Diversification VI.B.2

Planners specify content diversification by choosing the objectives, tests, reviews, and critiques that each category of students will skip. Most students will skip objectives that are added[1] for the needs of special students, such as those intended to remediate entrance deficiencies or to stimulate particularly able students. Only a few students will skip other objectives, such as those that some students already know or that are too difficult (and not essential) for other students.

Students may skip an entire objective or only part of it, if it includes more than one type of subject matter. The latter choice might be made if, for example, students

[1] As mentioned previously, training objectives cannot be added after the basic list has been entered in the UI. Therefore, it is particularly important to have a thorough understanding of the options for course diversification and have thought through the desirability of adding objectives to the basic course list before sitting down to the UI terminal. Worksheets are provided to help keep track of these decisions.

who have previous experience with the subject need only to be reminded of essential steps in the performance of a procedure (subject matter type 1 or 2) but do not need to practice it (subject matter types 8-10).

A given category of students can skip a test, with its associated review and critique, as well as an objective. In fact, if a test covers only preceding skipped objectives, it should probably also be skipped. If, however, it includes objectives that the given category of students will be held responsible for, there would be reason for them to take it. Guidance in making these decisions will come from the list of tests and the objectives they cover (Worksheet II).

Students may also skip portions of the review (or the critique) associated with a particular test. Poorer students are more likely to benefit from structured reviews; better students may prefer minimally directed or no review. If a review will be given only for home study for a particular category of student, those students will skip the scheduled review.

It is also useful to refer to the schedule of tests in making these decisions, particularly with respect to objectives added for remediation of entrance deficiencies and those that can be skipped because they have already been mastered or are too easy (proficiency advance). Frequently, it is only after a test has been given that an instructor will have enough information on which to base such decisions. Hence, objectives designated for remediation or proficiency advance often follow the appropriate test.

Even if two or more categories of students *will be combined in a single track*, subject matter content can still be diversified for these students. Thus, content diversification can parallel tracking or can take place within tracks, as desired. To parallel tracking, simply specify the same skips for each category of students within a given track.

VI.B.3 Method Diversification

Teaching method is diversified by subject matter type. Figure 8 shows the decision process for method diversification. If planners wish to diversify teaching method for a particular type of subject matter and will use tracking, they specify the teaching method for this subject matter type for each track. For example, the same methods may be specified for teaching less difficult subject matter to every track, but different methods for each track may be specified for more difficult subject matter. However, the expense of providing training resources for subject matter categories 7-10 may dominate considerations of teaching method for these categories.

If tracking will not be used, planners first decide how the categories of students previously identified will be grouped. This is done in the same way as tracks are defined, explained in VI.B.1, and illustrated fully in Appendix C. Once the groups have been established, they specify the teaching method for this subject matter type for each group.

VI.C SAME POLICY OPTIONS

To allow planners to design a highly diversified course, MODIA must incorporate a large number of decision points. In many cases, however, planners may wish

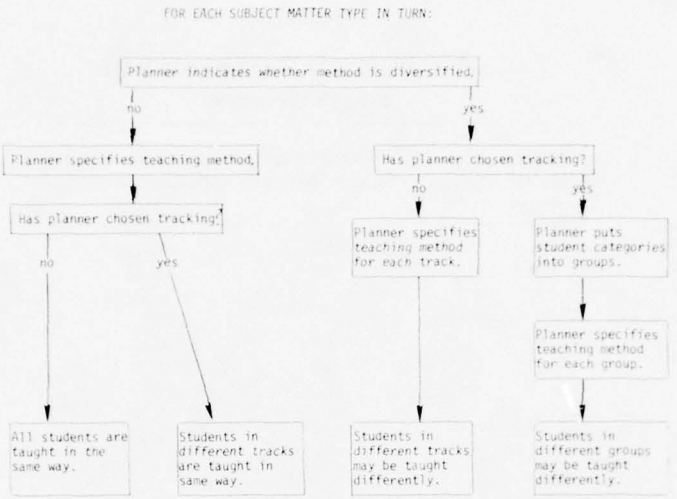

Fig. 8—Decision process for method diversification

to shorten this process. For example, if only a few learning events have a particular subject matter type, it may be wasteful to design an entirely different approach for teaching those events. Thus, MODIA allows the user to specify that he wants the same policy to be followed in teaching a particular type of subject matter as he has already established for another type.[2]

The "Same Policy" option should be used with caution because it can lead the user inadvertently to apply a teaching method to a type of subject matter for which he feels that method is inappropriate. For example, teaching methods for type 1 subject matter will not include guided practice of skills, which is often used for teaching type 9 subject matter. The least risky correspondences are shown in Table 7. These are presented in descending order because the UI asks for teaching method to be specified in ascending order of subject matter type. Because of the possibility of entrapment by the "Same Policy" option, the UI immediately displays the results of its application so that the user can see whether it makes sense. If not, he can forgo use of the option.

SPECIFY TEACHING METHOD VI.D

Planners specify teaching method by defining six characteristics: learning event type, teaching format, teaching agent, section size, average time, and time variability. The definition of each characteristic is repeated below to provide a context for the ensuing discussion. The full implications of the first three are treated next. Full treatment of the last three must be deferred, however, because for a given learning

[2] *Wherever this would not lead to a logical inconsistency.* For example, a "response-paced program" cannot be a teaching agent for subject matter type 4. The UI will not permit the planner to make such an error.

Table 7

MOST APPROPRIATE CHOICES FOR SAME POLICY OPTIONS

Subject Matter Type	Most Similar Subject Matter Type	Somewhat Similar Subject Matter Type
10	9,7	6,4
9	7	6,4
8	—	4,6
7	—	4,6
6	4	5,3
5	3	2,1
4	1,2	3
3	—	1,2
2	1	—
1	—	—

event, learning events immediately preceding and following have strong influence on the features of time, time variability, and section size.

Learning Event Type: The general instructional function of a learning event in a sequence of events for teaching a particular course objective.

Teaching Format: The method of instruction described in terms of the extent to which it is explicitly structured to involve the student and adapt to his needs while it is going on.

Teaching Agent: The person or thing that interacts directly with the student to instruct him.

Section Size: The maximum and minimum numbers of students in the section instructed, generally by a single teaching agent.

Average Time and Time Variability: The time required for a learning event and the extent to which it may be varied.

The correspondence of some commonly used teaching methods to various combinations of the first four parameters is shown in Table 8. The ensuing discussion clarifies these relationships.

VI.D.1 Learning Event Type

An objective may be taught by means of a sequence of learning events, each of which has a slightly different function and may require a different use of training resources. MODIA includes the types of events listed below.

Presentation/Demonstration: This presents the facts or concepts the student will be expected to learn or introduces him to the skill he will be expected to master.

Table 8

TRANSLATION OF COMMON TEACHING METHODS INTO MODIA PARAMETERS

Teaching Method	Subject Matter Type	Learning Event Type	Teaching Format	Teaching Agent	Section Size
lecture, lecture/discussion, demonstration, demonstration/discussion	all	presentation/demonstration	simple	instructor	> 1
group recitation, class recitation	all; 3-10	presentation, review; guided practice	recitation	instructor	> 1
performance, practice	all; 3-10	presentation review; guided practice, unguided practice	simple, recitation	instructor	> 1
group-paced instruction	all; 3-10	presentation, review; guided practice	simple, recitation response-paced	instructor	> 1
group programmed instruction	all; 3-10	presentation, review; guided practice	response-paced	instructor	> 1
small-group instruction	all; 3-10	presentation, review; guided practice, unguided practice	simple, recitation, adaptive[a]	instructor	> 1
seminar, group discussion	all	group discussion, review critique	group interaction	instructor	> 1
tutorial	1,2; 3-6, 8-10	presentation, review; presentation, guided practice, review	adaptive	instructor	1
independent study	1-6 8-10; 3-6, 8-10	presentation, homework, review, check practice; guided practice, unguided practice	all[b]	learner	1
problem solving	5,6, 8-10	guided practice, unguided practice, homework, review, check practice	simple, response-paced[b] adaptive[b]	learner	1
home study, assignment	all	homework	all	learner	1
linear programmed instruction	1-6, 8-10; 3-6, 8-10	presentation, homework, review; guided practice	response-paced	learner	1
branching programmed instruction	1-6, 8-10; 3-6, 8-10	presentation, homework, review; guided practice	adaptive	learner	1
self-pacing	1-6, 8-10 3-6, 8-10	presentation, homework, review, check practice; guided practice, unguided practice	all[b]	learner	1
individualized instruction	1-6, 8-10; 3-6 8-10	presentation, homework, review, check practice; guided practice, unguided practice	all[b]	learner	1
teaching machine (learner-controlled)	1-6, 8-10; 3-6, 8-10	presentation, homework,[c] review; guided practice	response-paced	learner	1
teaching machine (machine-controlled)	all,[d] 3,5,8[c]	presentation, homework,[c] review; guided practice	response-paced	response-paced program	1
CAI (Computer Assisted Instruction)	all,[d] 3,5,8[c]	presentation, homework,[c] review; guided practive	adaptive	adaptive program	1
CMI (Computer Managed Instruction)[e]	all	all	all	all	≥ 1
Peer tutoring[e]	all	all	all	student peer	≥ 1

[a]Except guided practice.

[b]Except unguided practice and check practice.

[c]Teaching machines and computer terminals for homework and subject matter type 8 guided practice not available in MODIA.

[d]Teaching machines and computer terminals used only for presentation in subject matter types 1,6,7-10.

[e]CMI and some types of peer tutoring are not simulated in MODIA.

Guided Practice: During this type of learning event the student receives feedback on his performance as he performs the skill he is learning.

Unguided Practice: In this the student is simply directed to practice or perform the skill.

Check Practice: A learning event is of this type if it is intended to check the student's mastery of the subject but does not directly affect his progress in scheduled instruction. No guidance is provided during a check practice.

Group Discussion: A small group of students engages in an interactive discussion of the subject.

Review: Discussed in III.G.

Test: Discussed in III.C.

Critique: Discussed in III.G.

Homework: An assignment for home study.

Several of these correspond to the early, intermediate, and final stages of instruction discussed in Vol. IV of the Air Force *Handbook for Designers of Instructional Systems.*[3] The learning event types that may be designated for teaching each type of subject matter are displayed in Table 9.

Although MODIA provides planners with the opportunity to choose a variety of types of learning events to teach each objective, they may select only one type of event for each type of subject matter, if they so desire. This will reduce the number of decisions required but will limit opportunities for tailoring the course for efficient use of training resources. It is a good way to get a first rough cut at maximum resource requirements and is about the only approach that makes sense if the details of course content are poorly known. If this approach will be followed, it would be best to select the learning event types noted on Table 9 as most representative of instruction in each of the subject matter types.

VI.D.1.a Subject Matter Types 3-6

Because the richest set of learning event types is appropriate for subject matter types 3-6 (teaching classroom skills), considerations in selecting learning event types for this type of subject matter are discussed first. The selection of learning events for teaching other subject matter is then discussed by exception.

A sequence of learning events for teaching a classroom skill might be:

Presentation/Demonstration
Guided Practice of Skills
Unguided Practice of Skills
Group Discussion
Check Practice
Homework

[3] Department of the Air Force (1973), Vol IV.

Table 9

PERMISSIBLE TYPES OF LEARNING EVENTS FOR EACH SUBJECT MATTER TYPE

Subject Matter	Presentation/ Demonstration	Guided Practice	Unguided Practice	Group Discussion	Check Practice	Review	Test	Critique	Homework	
1	X[a]			X	X	X	X	X	X	
2	X[a]			X	X	X	X		X	
3	X	X[a]	X	X	X	X	X		X	
4	X	X[a]	X	X	X	X	X		X	
5	X	X[a]	X	X	X	X	X		X	
6	X	X[a]	X	X	X	X	X		X	
7	X	X[a]		X	X	X	X		X	(Demo. only)
8	X	X[a]	X	X	X	X	X		X	" "
9	X	X[a]	X	X	X	X	X		X	" "
10	X	X[a]	X	X	X	X	X		X	" "

[a]Event types most typical of instruction in subject matter type indicated

Presentation/Demonstration. In the above sequence, the first learning event introduces the student to the skill he will be expected to master. This introduction might include a discussion of the role of the skill in the job for which he is being trained and points of major difficulty in performing the skill. It could also include a demonstration of the skill, accompanied by a discussion of such points. The important feature of the presentation/demonstration is that it is an introductory learning event during which the student does *not* actually perform the skill he will be learning. VI.D.1.a(1)

The presentation/demonstration may or may not elicit active student interaction by posing questions at critical points or directing attention to special features of the performance. This depends on the format of the instruction, which is chosen later.

Presentation/demonstration learning events are more likely to be needed for teaching complex classroom skills (subject matter types 5 and 6) than for teaching simple classroom skills (subject matter types 3 and 4). Such learning events are also more likely to be needed for less able or less well-prepared students than for better or more advanced students.

Guided Practice of Skills. During the next learning event type in the sequence the student receives feedback on his performance as he performs the skill he is learning. A student can work independently if he is provided with a step-by-step model of what the results of his performance should be at each stage; that is, if a student is working independently, he is not necessarily in an unguided practice session. VI.D.1.a(2)

Guided practice of skills is more likely to be needed for teaching complex skills (categories 5 and 6) than for simple skills (categories 3 and 4). Less able or less well-prepared students may profit from learning events of the guided practice type for subject matter at both levels of difficulty, however.

Unguided Practice of Skills. In this the student is simply directed to practice or perform the skill. If there is feedback on the quality of his performance, it is VI.D.1.a(3)

provided after the practice session is finished. Unguided practice is often used to teach skills that require a large amount of repetitive drill for mastery, such as typing or sending Morse code, and is therefore particularly appropriate for subject matter in categories 3 and 4. Students may also need unguided practice after they have had a session of guided practice in skills in categories 5 and 6 if these are particularly difficult to learn. If guided practice events have been omitted for more able students, a session of unguided practice or check practice (either of which might be homework) should be included so that the students will have an opportunity to practice the skill.

VI.D.1.a(4) *Group Discussion.* In this type of learning event, a small group of students engages in an interactive discussion of the skill. Group discussions will normally follow learning events in which students' opportunities to interact with each other and with an instructor have been restricted, such as presentation/demonstration, unguided practice, or homework events.

Group discussions use a group interaction format, which is also especially suitable for review and critique learning events. To keep track of the purpose of such events, the "review" or "critique" designation is retained.

To insure that the discussion is productive in terms of learning, it is assumed that an instructor is always the teaching agent for the event. But to insure that every student actively participates in the discussion, group discussion learning events should be planned for groups of, say, 10 or fewer students.

Group discussions are useful for teaching almost any type of subject matter at almost any point in the instructional sequence. It is better, however, that they be conducted *after* the subject matter has been introduced by the first learning event in the instructional sequence[4] so that the students will have something to discuss.

Most students enjoy and profit from group discussions, but the instructor needs special skills. He must insure that the group does not stray from the subject, that the discussion does not rush ahead of any participant's understanding, that the discussion is not monopolized by the more aggressive students, and that each student is encouraged to contribute.

Sometimes the characteristics of the subject matter itself determine whether group discussions would be beneficial. Students may be embarrassed in discussions of elementary subjects (like reading and arithmetic) but participate enthusiastically in discussions of more complex subjects such as weather forecasting or electronic circuitry.

VI.D.1.a(5) *Check Practice.* A learning event is of this type if it is intended to check the student's mastery of the skill but does not directly affect his progress in scheduled instruction. Students who fail a check practice event may, however, be required to take additional remedial instruction outside of regular class hours or to do remedial homework assignments. (This is not simulated in the RUM.)

The check practice is a useful device for maintaining motivation to learn. It also helps the student focus on the essential features of the subject and thus provides closure. Because of this, check practice may be more effective than review before a formal test.

The format of both unguided practice and check practice learning events is assumed to be "simple" or "recitation" (defined later) because no guidance is pro-

[4] Which could be a homework learning event.

vided *during* practice and, hence, the instruction is not modified during practice on the basis of student performance.

Homework. Any type of learning event (except some in subject matter categories 7-10, group discussion, or critique) can be assigned for home study, thereby saving most of the training resources required for scheduled instruction. Although homework actually includes other types of learning events, homework events are not differentiated by function because they do not directly affect a student's progress in scheduled instruction. VI.D.1.a(6)

Two aspects of homework are important for planning: (1) the cost of preparation and provision of the workbooks, study guides, film strips, and the like that will be used for homework assignments; and (2) whether the amount of time a student must spend on homework unacceptably lengthens the training day. Both of these features are derived from inputs by the user (specifically, selection of teaching format and teaching agent and specification of the total proportion of training time that can be allocated to homework).

At this point it is important simply to note that homework can replace any or all presentation/demonstration types of learning events and any other type of learning event for subject matter categories below 7, except group discussion and critique because these require the teaching agent to be an instructor. The more learning events that can be done in homework, the fewer training resources, including student time in the classroom, will be required. Every instructor is aware, however, that students who are less able or poorly motivated may get little out of homework assignments. Thus, more learning event types will be chosen for replacement by homework for better students than for poorer students.

It may be useful to rate learning event types for their amenability to replacement by homework. Using only a criterion of the degree of interaction required with the teaching agent, events might be rated in the following order, beginning with those most replaceable:

Unguided Practice (subject matter types 3-6)
Presentation/Demonstration (all subject matter types)
Review (subject matter types 1-6)
Check Practice (subject matter types 1-6)
Guided Practice (subject matter types 3-6)

Of course, the order depends on the criteria used, which planners would select.

Care should be taken not to allocate so much instruction to homework that the total time budgeted for homework is overdrawn. The UI totals homework and non-homework time for comparison to avoid this error.

Review. Reviews are intended to prepare the student for an upcoming test and always precede it. They may be done in the classroom or for homework and may be directed by any appropriate teaching agent in any appropriate format. Reviews with subject matter types 3-6 are like guided practice or unguided practice sessions. VI.D.1.a(7)

Test. This type of learning event is similar to check practice, and the same options are available for it. As discussed earlier, it is called out separately because of its special role in regulating student progress. VI.D.1.a(8)

VI.D.1.a(9) *Critique.* In a critique the instructor goes over the test with the students; the format is group interaction, and the teaching agent is always the instructor.

As with the assignment of subject matter types, planners may choose any sequence of learning event types appropriate to the subject matter and repeat some, if desired. The sequence assigned is the sequence in which the student will progress through the learning events. Generally, presentation/demonstration, guided practice, unguided practice, and check practice would follow in that order.

Table 10 illustrates some of the many possible sequences of learning event types that may be chosen for teaching subject matter types 3-6. This example involves slow, average, and fast students. The homework events replace or supplement the events shown in the left column.

Table 10

AN EXAMPLE OF LEARNING EVENT TYPES FOR SUBJECT MATTER TYPES 3 – 6

Learning Event Type	Student Category		
	Slow	Average	Fast
Presentation/Demonstration	X	X	X
Guided Practice	X	X	X
Guided Practice	X		
Unguided Practice	X	Homework	Homework
Group Discussion		X	X
Review	X	X	
Review	Homework		
Check Practice	X		
Test	X	X	X
Critique	X	X	

VI.D.1.b **Subject Matter Types 1 and 2**

Refer to Table 9 for the learning event types that may be chosen for these subject matter types. Because they do not concern skills, learning event types having to do with practice of skills are inappropriate. This leaves us with presentation/demonstration, homework, check practice, and review learning events (in addition to group discussion, test, and critique, to which the foregoing discussion applies here).

VI.D.1.b(1) *Presentation/Demonstration.* This type of learning event presents facts and concepts to the student. However, this does not mean that the student must be passive; the presentation may include drill in recalling, memorizing, restating, and explaining the subject. This is accomplished by appropriate specification of format, discussed further below.

VI.D.1.b(2) *Check Practice.* This would be similar to the drill and practice aspects of the presentation/demonstration type of event, but probably shorter.

VI.D.1.b(3) *Homework.* Presentation/demonstration learning events are prime candidates for homework for subject matter types 1 and 2, particularly for the better students.

Review and check practice can also be given in homework—almost *all* instruction is this type of subject matter, if desired.

Review. This recaps material treated in presentation/demonstration or homework events. VI.D.1.b(4)

Subject Matter Type 7 VI.D.1.c

Refer to Table 9 for the learning event types that may be chosen for this subject matter type, which involves team skills requiring the use of special resources. Since it is not possible to practice team skills without guidance (at the least, guidance is provided by teammates), unguided practice is not appropriate here. Otherwise, all learning event types are applicable.

Presentation/Demonstration. The most usual way in which team skills are introduced is through a demonstration by one or several instructors, sometimes with the assistance of students, as needed. The instructor explains the features of the skill and points out critical steps as the demonstration proceeds. Often the better students are used as assistants; they may not have a chance to practice the skill again because of limited availability of the special resources required. Thus, better students may be engaged in what is essentially guided practice of a team skill while their peers are observing a presentation/demonstration. VI.D.1.c(1)

Alternatively, a *presentation/demonstration* of this type could be recorded on the appropriate communication medium and given as homework or in scheduled instruction. This is the only type of learning event that lends itself to homework in subject matter type 7.

Note that the presentation/demonstration described above does not necessarily teach the knowledge (facts and concepts) that support the performance of the team skill, especially if that has been called out as a separate objective.

Guided Practice of Skills. This is the type of learning event most commonly used for teaching team skills and would usually be provided to every category of student. VI.D.1.c(2)

Group Discussion. Group interaction will inevitably take place during the practice of the skill. Team self-critique might be made more effective, however, if a separate session is provided during which the team discusses its own performance. Performance might be recorded for this purpose, as is done in teaching sports. VI.D.1.c(3)

Check Practice. Because the use of special resources is required, check practice may rarely be used for team skills. Teams having difficulties may get so much benefit from this type of learning event, however, that the resources required are justified. VI.D.1.c(4)

Homework. Only presentation/demonstration is appropriate for homework in teaching team skills. VI.D.1.c(5)

Review. A review with subject matter type 7 is a guided practice session for the team. VI.D.1.c(6)

VI.D.1.d Subject Matter Types 8-10

This subject matter involves individual skills requiring the use of special resources; all types of learning events are appropriate. (Refer to Table 9.)

VI.D.1.d(1) *Presentation/Demonstration.* As in subject matter types 3-6, this type of learning event introduces the student to the skill he is expected to master. Even when only the product of performance is important, it is often helpful to begin the instructional sequence with a presentation/demonstration. The significant feature of such an event is that the student does not require direct access to the special resources needed to perform the skill for this event; the demonstration can be recorded for classroom instruction or homework.

VI.D.1.d.(2) *Guided Practice of Skills.* This type of learning event is particularly appropriate for teaching skills in which the process of performance is important (subject matter types 9 and 10) because it may be essential that each step in the process be carried out properly. If only the product of performance is important (subject matter type 8), it may be possible to infer the student's performance well enough from what he produces that guided practice sessions are not needed. Less able students profit most from guided practice, but if process is especially important, even better students may need it. The decision at this point probably hinges on whether and for whom to omit guided practice rather than where to include it.

VI.D.1.d(3) *Unguided Practice of Skills.* Unguided practice is often used to teach skills in which only the product of performance is important, because the student's performance does not have to be observed to be judged. It is particularly useful where simple, repetitive skills are being taught, such as soldering and safety wiring. However, as with subject matter categories 5 and 6, students may also need unguided practice after they have had a session of guided practice in skills that are particularly difficult to learn. Finally, if guided practice events have been omitted for more able students, a session of unguided practice or check practice should be included.

VI.D.1.d(4) *Group Discussion.* Group discussion of important points in performance can substitute effectively for review. If complicated performance, such as tracking a radar target, is being taught, it might be worthwhile to record student performance for critique in group discussion. Most students will probably benefit from group discussion of skills requiring special resources.

VI.D.1.d(5) *Check Practice.* This is a useful technique for stimulating self-critique and review. It provides additional practice as well, which poorer students may need.

VI.D.1.d(6) *Homework.* Only presentation/demonstration types of instruction are appropriate for homework in teaching individual skills requiring special resources.

VI.D.1.d(7) *Review.* A review with subject matter types 8-10 is like a guided practice or unguided practice session; it requires special resources.

VI.D.2 Teaching Format

The user assigns a teaching format to each learning event type for each subject matter type (and each student group or track). Recall that teaching format describes

the way in which the instruction is explicitly structured to involve the student and adapt to his needs *as it is going on*. For the purposes of planning, MODIA recognizes five fundamentally different formats: group interaction, simple, recitation, response-paced, and adaptive. These are shown in relation to learning event types in Table 11. A brief description of each follows:

Group Interaction: A group of students discusses the subject matter interactively.

Simple: The subject matter is presented or demonstrated to the student; the student is directed to perform.

Recitation: The student is required to respond overtly during the instruction to indicate whether he understands, remembers, or can perform what he is supposed to be learning. The teaching agent receives and processes the student's responses.

Response-paced: The recitation format is taken one step further in that the *rate* at which the instruction is given is matched to the rate at which student response indicates that the subject is being learned.

Adaptive: The response-paced format is taken one step further in that the *content* of the instruction is also adjusted to student needs on the basis of student responses.

Table 11

PERMISSIBLE TEACHING FORMATS FOR EACH LEARNING EVENT TYPE

Learning Event Type	Teaching Format				
	Group Interaction	Simple	Recitation	Response-paced	Adaptive
Presentation/ Demonstration		X	X	X	X
Guided Practice		X	X	X	X
Unguided Practice		X	X		
Group Discussion	X				
Check Practice		X	X		
Review	X	X	X	X	X
Test		X	X		
Critique	X				
Homework		X	X	X	X

Influence of Student Capability on Choice of Format VI.d.2.a

As implied by these descriptions, the interaction of the instruction with the student becomes more highly structured as we progress down the list from simple

to adaptive formats. Since less able or less well-prepared students generally need more assistance, for such students formats toward the adaptive end are more effective than are formats toward the simple end. Even for the average and above average student, the response-paced and adaptive formats can reduce the time required for learning. Therefore, although the more highly structured formats are considerably more expensive to prepare, their cost may be defrayed by other savings in courses that graduate large numbers of students.

Better students are often irritated by the step-by-step approach of adaptive or response-paced instruction that has been prepared for average or below-average learners. These problems can be avoided, by and large, if instructional materials are pitched to the bright students' level. In fact, they like to outguess imaginatively prepared response-paced or adaptive courseware (particularly the latter) and enjoy being led to explore subtle points. However, they can make do with even poorly prepared instruction in simple format, imposing whatever structure they need to learn the materials. Therefore, for low-load courses, the simple format may be the least costly choice for the better student.

VI.D.2.b Influence of Subject Matter Difficulty on Choice of Format

Subject matter is difficult or easy partly depending on student capability and preparation for the course. Therefore, the same arguments can be used to direct the choice of formats for various subject matter types; that is, for poorer students the simple and recitation formats are less appropriate for more difficult subject matter than they are for easier subject matter.

VI.D.2.c Group Interaction Format

The group interaction format applies to learning events of the group discussion, review, and critique types and, as mentioned before, is the only format appropriate for group discussion. The pros and cons of using group discussions for various types of subject matter and students (treated in VI.D.1.a(5), c(3), and d(4)) apply directly to the group interaction format.

The group interaction format is assumed to require an instructor as teaching agent to provide the necessary direction and substance to the discussion. It also requires the section size to be large enough for bona fide group interaction to take place (probably the minimum number of students in the group should be three) and small enough to insure that every student in the group participates actively in the discussion (probably the maximum number in the group should be ten). Of course, these numbers can be altered either way, but planners should be aware that doing so may damage the efficacy of the group interaction format. There will be some tradeoff between maximum section size and the length of the group interaction, as more students can be actively involved at some point in a longer discussion than in one that is shorter. The maximum of ten is most appropriate for a short discussion, say 15 minutes or less.

VI.D.2.d Simple Format

This is the format of the bulk of conventional instruction. Lectures, demonstrations, textbooks, training films, and slide presentations are almost always in this

format. It is, of course, possible for recitation, response-paced, or adaptive instruction to occur during instruction in simple format, but the materials, lecture notes, class organization, and so on are not explicitly structured for these purposes. MODIA needs to capture the cost of developing this structure, rather than to describe accurately what will take place in the classroom.

Teaching agents appropriate for the simple format are the learner and the instructor; there are no inherent limits on section size. The determination of whether the section is to consist of one student or 500 usually is based on the availability of teaching agents and the capacity of facilities, rather than on requirements of the simple format. Although the simple format is commonly associated with lock-step instruction, even this is not inherent in the method. Students may proceed at different rates and even on different paths through instruction in simple format, although other formats facilitate these types of variability, particularly for the less able student.

One reason the simple format is used is that it requires minimal preparation of courseware. Although a full-blown lesson plan is often provided, a good instructor can teach effectively by ad libbing from sketchy notes. This may be the best choice if the course is given rarely or to only a few students or is substantially changed so frequently that preparation of courseware is uneconomical.

Instruction in simple format is appropriate for any type of learning event except group discussion, guided practice, and most forms of unguided practice, check practice, and test. The last three generally are inherently in the recitation format with the exception of subject matter involving complex skills (types 5-7 and possibly 8-10). For practice and test in such skills it is often sufficient to give the student brief directions before he embarks on a fairly protracted session of independent performance. This would be a simple format event.

Less frequently, the simple format might be used to direct drill sessions in unguided practice in subject matter types 3 and 4 and, possibly, 8-10, if the student would be expected to provide his own drill stimuli. Having the student supply his own drill stimuli in unguided practice encourages the development of disciplined skills in independent study.

The simple format is often implicit in plans for review. In most cases, the instructor is expected to devise the content of the review session ad hoc. Some may merely repeat the preceding instruction, whereas others may use the opportunity to help the students understand what they have learned in the total context of the course. This suggests that review learning events can be as valuable and integral to the course as any other type and that preplanning their content and format may be desirable.

Recitation Format VI.D.2.e

Recall that the recitation format adds the feature that the student is required to respond overtly at some point in the instruction to indicate whether he understands or remembers what he is supposed to be learning; and the teaching agent receives and processes the students' responses in some way, even though no particular action is preplanned to result. Recitation is appropriate for all types of learning events except group discussions and critiques. It is the most frequently used format for unguided practice (particularly for drill in subject matter types 3 and 4 and

possibly 8-10), check practice, and test. An unguided practice, check practice, or test event in which stimuli are provided frequently, as in a written multiple-choice test, is in recitation format. Or, if the students' performance must frequently be observed directly by an instructor during this type of event, the format is equivalent to recitation.

The recitation format is very similar to the simple format in that there is no preplanned, explicit structure for adjusting the instruction on the basis of the student's responses. Recitation can also be presented in any medium. For example, if the instruction requires a film, questions or directions to the student can be inserted where appropriate, followed by a pause to give the student time to respond before the presentation proceeds.

The recitation format has no inherent implication of lock-step instruction.

VI.D.2.f **Response-paced Format**

This format attempts to match the rate of the instruction to the rate at which the students learn the subject. The requirement for integrating the right stimuli at the right time and with the right frequency to facilitate learning increases the cost of courseware development because development requires special skills and takes longer. Unlike the simple and recitation formats, the response-paced format always requires an investment in courseware development.[5]

Because a response-paced format facilitates adjustment of the rate of instruction to students' learning rates, it usually encourages the average student to progress more rapidly through the instruction than he would with simple or recitation formats. This comes about from two effects: (1) Conventional instruction is geared to the learning rate of the less able students (that is, even average students are usually held back in conventional instruction); and (2) being able to finish the instruction early motivates some students to work faster than they normally would. Therefore, if a large number of students will take the course, the added cost of courseware development may be offset by savings in student time and in other recurring requirements for instructional resources.

It is not necessary that the response-paced format result in savings of teaching time or even in variability of teaching time. Students who finish early could simply be allowed additional time to do as they please before starting the next learning event or could be kept with the rest of the class until the allotted time was up. The response-paced format could still be valuable in these circumstances because it stimulates poorer students to give more attention to learning. Whether a particular category of students needs this type of stimulation is a matter for the planners' judgment.

The response-paced format is appropriate for presentation/demonstration, guided practice, review, and homework. It is not appropriate for any type of learning event during which the student is not expected (or not allowed) to receive continuous feedback on his performance—i.e., for unguided practice, check practice, or test learning events. It is, of course, inappropriate for group discussion and critique.

In guided practice of team skills (subject matter type 7), the response-paced

[5] An exception might be made to this if instructors were especially trained to use the response-paced approach *ad hoc*. However, an instructor might tend to use an adaptive format in such a situation, rather than be constrained to the rigid structure of response-pacing.

format is probably indistinguishable from the recitation format. It is included as an option because it implies a management strategy that permits time variability, whereas the recitation format does not have this implication (although it does not preclude time variability).

When the times required for various learning events are estimated, they should include the effects of using the response-paced format. Section X presents representative numbers that may be used at that point. Additionally, only when the section size is one will each student proceed at his *own* rate. This is also discussed more fully in Sec. X.

Adaptive Format VI.D.2.g

The adaptive format adjusts the content as well as the pace of the instruction on the basis of student response. The most familiar examples of instruction in the adaptive format are tutoring, branching programmed instruction, and computer-assisted instruction. The adaptive format is inappropriate to the same types of learning events as the response-paced format—namely, unguided practice, check practice, and test—and for the same reasons.

The most frequent types of content adaptation in adaptive format are repetition or remediation in reaction to incorrect responses and skipping ahead in reaction to correct responses. Sometimes side discussions of subtle points of special interest or of possible misunderstanding are also included.

MODIA does not simulate alterations in an individual student's path within or between learning events in response to his performance during instruction.[6] Thus it will not be possible to use MODIA to predict, for example, the number of times a particular remedial unit would be called up in a particular learning event or, conversely, to trace the path of an individual student through a learning event of branching programmed instruction. (Recall the distinction between content diversification and concurrent adaptability, discussed in Sec. V.B. and V.B.2.) Instead, MODIA deals with those aspects of adaptive format that can have the strongest effects on the way the instructional system operates and its consequent requirements for training resources. These are: (1) teaching agent (discussed below in VI.D.3.d); (2) the time required for instruction; (3) section size; (4) courseware development cost; and (5) media system requirements.

The adaptive format has effects on the time required for instruction that are similar to those of the response-paced format. Time savings can be somewhat larger, however, because instruction can be even more efficient than in the response-paced format. (Some comparative examples are given in Sec. X.) Section size must be less than for other formats because the teaching agent must interact closely with every student. In most cases, the section size will be one. As might be expected, courseware development costs are relatively large.

The adaptive format can incur technological difficulties in the media area, particularly where audio-motion-visual media are required. A few media systems of these types can be used in the adaptive format, but they will be quite expensive for some time to come. Since audio-motion-visual media are rarely an absolute necessity for instruction, this limitation will usually not be significant.

[6] With the exception of recycling or failing after a test learning event. The skipping of a learning event because a student falls within a category for which it is a skipped event (content diversification) is entirely pre-planned and not subject to random variations within the model as are recycles and failures.

VI.D.3 Teaching Agents

The user assigns a teaching agent to each learning event type for each subject matter type (and each student group or track). Teaching agents are the persons or things that interact directly with the students to instruct them and may be instructors, learners, response-paced programs, or adaptive programs. A brief definition of each follows.

> *Instructor:* A person qualified to teach the course through training in the subject matter and in the techniques of instruction.
>
> *Learner:* A trainee; someone taking the course.
>
> *Response-paced program:* A device or machine that presents the subject matter, elicits an overt response from the student, senses the response, and proceeds with the presentation if the response is acceptable. A teaching machine with selected response.
>
> *Adaptive program:* A device or machine that presents the subject matter, elicits an overt response from the student, senses the response, and selects the content of the next presentation on the basis of the response. Usually a computer.

VI.D.3.a *Roles for the Instructor in MODIA.* A discussion of the roles of the instructor in MODIA helps clarify the concept of teaching agent. Most people who are closely associated with school operations, including those who regularly plan new courses of study, are accustomed to assuming that the instructor carries the primary responsibility for instruction; and, therefore, whenever he is in the classroom or laboratory he is the teacher. To capture the implications for planning of the many ways in which an instructor may perform this role, however, MODIA must distinguish among them in a consistent way. The term *teaching agent* emphasizes the difference between this concept and the more general concept of instructor or teacher.

An instructor can, of course, be a teaching agent and is often the best choice for this role. As a teaching agent he may:

- Direct and prompt group interaction.
- Present facts and concepts to be learned.
- Question selected students at appropriate points.
- Give directions for student practice.
- Provide drill stimuli.
- Give students feedback on the quality of their performance while they are performing.
- Pace students as they progress through material.
- Adapt the content of instruction to perceived student needs.

In the foregoing we have tried to emphasize that as *teaching agent the instructor must interact directly with most of the students most of the time during the learning event.*

To be good teaching agents, instructors must be able to communicate the subject matter effectively to the students and to respond to questions with perception and patience. Many students need to feel that the instructor is directly and personally

involved with their progress; the chance to ask questions during instruction gives evidence of this involvement. Students who are insecure may need personal attention and support and may feel lost or neglected if required to be their own teaching agents. In addition, working with an instructor may help students develop abilities in dealing with their superiors and peers.

Instructors may be the best choice for teaching agents if it is difficult to obtain high quality materials or the course is given so rarely or to so few students that preparing the needed material is not worthwhile. They are also favored if the course is frequently substantially revised and an adaptive program cannot be used. This point is expanded below.

MODIA provides other roles for the instructor in the classroom or laboratory besides teaching agent. In these roles, the instructor acts as a monitor. A monitor is a person who may:

- Oversee student activity to maintain order.
- Make sure that safety precautions are being followed.
- See to administrative details (such as making announcements and taking roll).
- Provide assistance when students need it.
- Proctor check practice and test learning events.

If students will spend the bulk of the learning event working on their own with programmed texts or other media, the students themselves are the teaching agents *because they control their own instruction through direct interaction* with the media, even though an instructor may be on hand to help out if and when needed. (The media are not the teaching agents because the media are passive. This point is expanded under the discussion of the learners as teaching agents.) In this case the instructor is a monitor, an important distinction for several reasons. First, as monitor, an instructor can supervise many more students than he can as teaching agent. In addition, he can be "shared" among learning events because his entire attention may not be needed for a single event. If he is proctoring an exam, he can supervise even more students, and the possibilities for sharing him among learning events are even larger. Finally, identifying the learner as teaching agent makes clear that media are needed to carry the burden of instruction.

Monitors do not always have to be instructors. For example, a monitor needed primarily to maintain order and see that safety practices are observed could be anyone familiar with the performance requirements of the course, even a recent course graduate. Such people can be considerably less expensive than full-fledged instructors.

Although an instructor who is shared among learning events should be identified as a monitor (if only to clarify resource use), MODIA does not preclude the sharing of instructors as teaching agents among learning events.

The Learner as Teaching Agent

VI.D.3.b

The concept of the learner as teaching agent also needs amplification. In this role, the learner directs and controls his own study, working independently of other learners or an instructor, although he is often under supervision of a responsible person. (When the learner is teaching agent, the section size is one or the size of a single interactive group (subject matter type 7).)

Self-directed study requires access to high quality courseware, as the learner must be given enough supporting information to guide himself. The courseware must give the learner directions for proceeding (simple format), present stimuli for drill or practice (recitation format), provide models of correct responses (response-paced format), or supply alternative paths through the material (adaptive format). In this sense, the courseware is acting as a teacher. Because the learner exercises the ultimate control in the process, it is more descriptive to identify the learner as teaching agent. This emphasizes the control aspects of the process. It also helps differentiate between a learner-controlled process supported by courseware and a machine-controlled process supported by similarly sophisticated courseware, as must be provided for response-paced or adaptive programs. Thus, linear programmed text is not a response-paced program because the student controls his own study when working with a programmed text.

For high-load courses, the least expensive choice for teaching agent is probably the learner, even though the courseware he uses must be carefully prepared and of high quality. Using learners as teaching agents in any format facilitates time variability and flexible use of facilities, as any number of students within the capacity of the facility can study the materials in a library, a study hall, or at home, taking only as long as needed to complete a lesson. This promotes maximum economy in use of instructional resources. It also encourages the preparation of high quality materials on which sufficient time should be expended, not only to capture the best teaching practice but to validate instructional effectiveness. The foregoing remarks also apply to response-paced and adaptive *programs as teaching agents.*

If many instructors parrot canned lesson plans or merely write them on the chalkboard, the course can be made much cheaper with no loss in effectiveness by simply passing out the lesson plans to the students and replacing the instructor with a monitor in a study hall. Good students will respond especially well to such an approach. Of course, rewriting the lesson plans as study guides would improve their effectiveness and enhance the flexibility with which they may be used.

VI.D.3.c Special Features of Response-paced Programs

Response-paced programs are appropriate only for the response-paced format and have the same fundamental advantages. The hardware cost of response-paced programs is usually not a dominant consideration, even when presented on an individual basis. Hardware is available for either the group or individual mode. Sections in the group mode can typically be larger than for an instructor, and it is even possible to reach several groups of students simultaneously at geographically separated points.

VI.D.3.d Special Features of Adaptive Programs

Adaptive programs are appropriate only for the adaptive format and have the same basic advantages. Because of the high initial cost of computer hardware and software, they are unlikely to be used unless the computer is already available with a language for preparing courseware. Languages for courseware preparation permit rapid revision, making adaptive programs attractive choices for courses that are frequently significantly revised.

Effects of Subject Matter Type on Choice of Teaching Agent

VI.D.3.e

Recall that a teaching format is assigned to each type of learning event selected for teaching a particular type of subject matter to a particular category of student. Therefore, the choice of teaching agent depends, among other things, on: the subject matter type, the category of student, the learning event type, and the teaching format. Table 12 shows the teaching agents appropriate for each type of subject matter and each teaching format.

Type of Response. Note that response-paced and adaptive programs may be used as teaching agents only for subject matter types 1, 2, 3, and 5, and for presentation/demonstration events in other subject matter types. These programs are extremely limited in their ability to process constructed responses. In fact, for simplicity it is assumed that they can teach only subject matter for which selected response is usable.

A student's knowledge and understanding of facts and concepts (subject matter types 1 and 2) are commonly evaluated through the use of questions calling for selected response, as evidenced by ATC's policy for the construction of measurement tests, which use the multiple-choice format. Thus, response-paced and adaptive programs are often appropriate choices for this type of subject matter. They are also appropriate choices for teaching subject matter types 3 and 5 but are inappropriate for 4 and 6, where student mastery of classroom skills (such as typing or writing)

Table 12

APPROPRIATE TEACHING AGENTS BY TEACHING FORMAT AND SUBJECT MATTER TYPE

Subject Matter Type	Teaching Format				
	Group	Simple	Recitation	Response-paced	Adaptive
1	I	L, I[a]	L, I[a]	L, I[a], RP	L, I[a], AP
2	↓	↓	↓	L, I, RP	L, I, AP
3	↓	↓	↓	L, I, RP	L, I, AP
4	↓	↓	↓	L, I, RP[b]	L, I, AP[b]
5	↓	↓	↓	L, I, RP	L, I, AP
6	↓	↓	↓	L, I, RP[b]	L, I, AP[b]
7	↓	↓	↓	↓	↓
8	↓	↓	↓	↓	↓
9	↓	↓	↓	↓	↓
10	↓	↓	↓	↓	↓

L = Learner.
I = Instructor.
RP = Response-paced program.
AP = Adaptive program.

[a]Except homework.

[b]Presentation/demonstration only.

cannot be evaluated by means of selected response. They may be used in presentation/demonstration events, however, since they would only be checking students' perception of the demonstration.

Student mastery of skills that make use of special resources (subject matter types 7-10) can be evaluated by selected response so infrequently that they are not worth including in MODIA.[7] Therefore MODIA never allows response-paced or adaptive programs as alternatives for teaching these types of subject matter (except, again, for presentation/demonstration events).

Subject Matter Difficulty. Generally speaking, learners would tend to be favored as teaching agents for easier or less complex subject matter types such as 1, 3, 4, and perhaps 8.

VI.D.3.f Effect of Teaching Format on Choice of Teaching Agent

Table 12 shows that teaching format has a strong effect on choice of teaching agent.

Group Interaction Format. In fact, only an instructor may be chosen as teaching agent in the group interaction format.

Simple Format. The most appropriate choices for teaching agent are between the instructor and the learner. Response-paced programs or adaptive programs will usually be unwarrantedly expensive for the simple format.

As teaching agent, an instructor's skill at one-way communication is of greatest importance in the simple format, whereas the learner needs skills of reading, listening, observing, or otherwise perceiving if he is teaching agent.

Recitation Format. As in the simple format, the most appropriate choices for teaching agent are between the instructor and the learner. When the teaching agent is the instructor, the recitation format for subject matter types 1 and 2 limits the section size to the number of students the instructor can see or hear clearly at one time. This is usually somewhere from 15 to 40, depending on the design of the classroom and other factors. For subject matter types 3-10, the limitation on section size will be determined by whichever is smaller—the number of students who can see and hear the instructor or the number the instructor can see and hear.

Response-paced Format. Here, the teaching agent presents the facts and concepts to be learned or demonstrates the skill to be mastered, presents stimuli for overt student response integrated with the instruction, perceives the response, and proceeds with the instruction only after an acceptable response has been made. The most likely choices are an instructor, the learner, or a response-paced program.

Learners who are well motivated can be very economical choices for teaching agents in the response-paced format. As mentioned earlier, academic ability is not too important for this format and may even be a hindrance if courseware is not especially prepared for the top students. In fact, using the learner as pacer can actually build study skills; it frees the fast learner to direct his attention to particularly difficult or interesting topics and allows the slow learner to take his time without fear of embarrassment. If students are immature or insufficiently motivated, however, they may take advantage of the situation to dally.

[7] It would be a simple matter to include this option in MODIA but would considerably increase the author's work, as four types of subject matter would be added, one for each of 7 through 10.

The advantage of using an instructor as teaching agent in the response-paced format is that he can speed up the learning of students whose motivations are deficient and can immediately spot points at which students are having difficulty. Some research indicates that use of an instructor as pacer for a small group of students decreases the average time required over self-pacing by as much as 25 percent.[8] This is not, however, a particularly congenial role for some instructors, as they must act to some extent as taskmasters and are greatly restricted in the amount of spontaneous interchange they can have with the class. In addition, section size must be limited to the number of students the instructor can see or hear well enough to know how the group is progressing.

It is very expensive for an instructor to pace individual students. If an individual approach is needed, it might be better to train the instructor to carry out a fully adaptive, tutorial format rather than to lock him into the constrained structure of response-pacing. It makes more sense for an instructor to pace a group of students with similar learning rates rather than pacing one student at a time. Generally at most three groupings are used.

Response-paced programs cannot become impatient with students or "feel" stifled by the format. The student cannot skip idly through the program but must interact with it frame by frame. A response-paced program cannot entirely overcome the effects of poor motivation, however, because the student can still dally in answering or can answer at random until he hits the right response.

Adaptive Format. In this format, the teaching agent presents the facts and concepts to be learned or demonstrates the skill to be mastered, presents stimuli for overt student response integrated with the instruction, perceives and assesses the response, and selects the next instructional step on that basis. The most appropriate choices for teaching agent are among the learner, instructor, and adaptive program; response-paced programs are too limited to be used. The teaching agent for adaptive format learning events must be a cut above the run-of-the-mill teaching agent.

Arguments favoring the choice of the learner are similar to those advanced for the response-paced format.

The average instructor needs special training to teach effectively in an adaptive format, even when dealing with students on an individual basis. Tutoring more than one student at a time requires unusual qualities of responsiveness, perception, and patience, as the instructor must deal with a variety of student personalities and needs. Probably no one can deal effectively with more than six students, and four is a more realistic number. A good tutor is the most effective teaching agent yet devised and may well be the best choice, especially in courses that are inherently expensive because of low student load or the nature of the subject matter. Medical education is a good example of the latter.

Adaptive programs require courseware of the same quality as or better than the courseware used by a learner as a teaching agent. This may be justified, however, if a large proportion of learners are insufficiently motivated or otherwise deficient in attitudes or study skills to be their own teaching agents. Because the adaptive program controls and can record the progress of the instruction, daydreaming, unwarranted skipping, random selection of answers, and other diversionary tactics can be spotted and minimized.

[8] Amarillo Technical Training Center (1964).

If the courseware is prepared by instructors highly qualified within the subject area, adaptive programs can be more diverse in their adaptability, more reliable, and more "patient" than an average instructor and less expensive in the long run than instructors trained to be equally effective.

VI.D.3.g Effects of Learning Event Type on Choice of Teaching Agent

Because the teaching agent plays different roles in the different types of learning events, these types affect the choice of teaching agent. The most obvious instances are the group discussion and critique, which, because they use the group interaction format, require an instructor as teaching agent, and homework, for which only the learner[9] may be teaching agent in this version of MODIA.

An instructor may be required for guided practice, review, check practice, and test events where the student's performance must be observed and judged by a trained person during the learning event. This is most likely to be true in subject matter types 9 and 10 and possibly 4 or 6.

There is an alternative—to record student performance for later evaluation (check practice and test) or for self-critique during guided practice. Self-critique is often a highly effective means of instruction. Means for recording performance would most likely be needed in subject matter types 9 and 10, in which the process of performance is important.

When an instructor is teaching agent for a guided practice event, it is particularly important that the section size be kept small enough for him to provide the necessary feedback to every student. The appropriate size will depend on the frequency with which stimuli are given and the mode of student performance required. If students can respond orally or by writing on the chalkboard, an instructor can keep tabs on the progress of a larger number than if other means of response must be used.

A case can also be made for choosing an instructor when students must observe safety precautions while using special resources, as in guided practice, review, check practice, and test events in subject matter types 7, 9, and 10; unguided practice in types 9 and 10; and possibly presentation/demonstration events in type 7. This case is somewhat weaker, however, because a monitor[10] can often supervise a larger section than can an instructor acting as teaching agent (or he can be shared among sections).

An instructor might be favored for conducting presentation/demonstration events in subject matter types 7, 9, and 10 because he will be needed as a safety monitor or for other reasons in a guided practice session immediately following the demonstration. It might seem most convenient to have the same instructor do the demonstration, but that is not always the most economical approach, particularly if the special resources are in short supply. In that event, it may be better to record

[9] Response-paced or adaptive programs would be useful for giving homework assignments in response-paced or adaptive formats to students who otherwise might let their work slide. The programs could be devised to keep a record of assignment completion for each individual student, thus further assuring that the assignments are done. Of course, this would mean that hardware, facilities, and possibly a monitor to safeguard the premises would be needed after class hours. Since the strategy would probably be chosen only if the hardware had been bought for regular classroom instruction, the cost of the course might be increased only by the cost of providing the monitor. Future versions of MODIA may include these options.

[10] Whether a monitor is needed and, if so, whether he must be a fully qualified instructor are determined later.

the demonstration so the resources would be available for student use. Recorded demonstrations can be taught by adaptive or response-paced programs or by the learner himself.

Another point favoring recorded demonstrations is that it is sometimes hard for many students to observe a demonstration given in person, particularly if small or partially hidden movements are involved, unless special aids are provided. This is less likely to be a problem for classroom skills than it is for skills using special resources, but it can still arise. Typing is a good example of such a skill in the classroom. If an instructor gives the demonstration, therefore, the number of students who can be in the section may be quite limited.

Learners are particularly good choices as teaching agents for guided practice in subject matter types 3 and 4. An instructor may be bored by having to give drill stimuli, and his capacity for processing information can be overloaded. As monitor he can spot-check the work of large numbers of students during the session to make sure that they are properly checking their own progress.

Response-paced or adaptive programs are also good choices for guided practice in subject matter types 3 and 5. The requirement for overt response helps motivate the student, and the program device relieves the instructor of tedious chores.

The learner is probably the best selection for unguided practice in subject matter types 3 through 6 and 8, both because this permits maximum flexibility in the use of instructional resources and because the intent of unguided practice is to develop skills of independent performance and study.

The learner is an especially appropriate choice for teaching agent for guided practice and unguided practice in subject matter type 8. In guided practice, he can check his work step by step against a model of what it should be. Pictures or other media, mockups, or actual equipment can depict the results of each step in performance. Most trainees are strongly motivated to master the skills with which subject matter types 8-10 are typically concerned. The student often has been itching to get his hands on the equipment from the beginning of the course and has no fear of appearing stupid because of academic deficiencies. It is advisable to capitalize on such motivation to the greatest extent possible.

In check practice and test events, the teaching agent is the giver of directions or the director of performance. Rating student performance and providing feedback to the student, though of primary importance in association with events of these types, is done after the fact.

As in unguided practice, the learner is probably the best choice for teaching agent for check practice and test events for subject matter types 1 through 6 and 8. Remember that even though school policy may require an instructor to supervise test learning events, only if he furnishes the test directions and questions directly to each student is he the teaching agent. If the event requires the learner to read and respond independently to written test materials under supervision of an instructor, the instructor is a monitor, not a teaching agent. Instead, the learner is the teaching agent. This is the most commonly used mode for check practice and test events for subject matter types 1 through 6 and is also frequently used for subject matter type 8, in which the student is simply directed to produce the appropriate product and is judged on the basis of its quality.

Since check practice and test events are always in the simple or recitation format, MODIA does not provide response-paced or adaptive programs as choices for

these events. If such devices are readily available, however, or will be used in most of the course, planners may want them to present test questions and record and perhaps score student reponses. Such use is particularly desirable for computer managed instruction or other special applications of computer-administered and computer-scored tests.[11] This element may be added to course design at later phases of the decision process—i.e., at VIII.A (Adjusting the Assignment of Special Resources) or at VIII.I (Changing the Assignment of Resources).

VI.D.3.h Summary on Choice of Teaching Agent

The foregoing discussion is summarized for the reader's convenience.

Instructors are favored when:

- Provision of high quality courseware is not justified (the student load is too low; the course is given too infrequently).
- Course content is frequently significantly revised and an adaptive program is not a feasible choice.
- The average instructor is a high quality teacher; he can communicate effectively and is patient and responsive to student needs.
- Feedback on student performance *must* be given by an instructor (guided practice and review events in subject matter types 7, 9, 10, and possibly 4, 6).
- Students must be closely supervised by a full-fledged instructor for safety reasons (guided practice, review, check practice and test events in subject matter types 7, 9, and possibly 10; unguided practice events in subject matter type 9 and possibly 10; possibly presentation/demonstration events in subject matter type 7).
- The subject matter is difficult or complex and the students are below average.
- The simple or recitation format is used and the students are below average.

Learners, response-paced programs, or adaptive programs are favored when:

- High quality courseware is available or its preparation can be justified economically—e.g., by large class size.
- It would be difficult for students to observe a demonstration done in person (presentation/demonstration events in subject matter types 4-10).
- The instructor would become bored with having to teach routine or repetitive skills (guided practice events in subject matter types 3, 4, and possibly 7-10).
- Special resources that are needed to teach skills are in short supply (presentation/demonstration events in subject matter types 7-10).

Learners are favored over response-paced or adaptive programs when:

- They are academically mature, well-motivated, and have mastered the basic skills of reading and listening.
- Check practice and test events are given in subject matter types 1-6 and 8.

[11] Brown (1974); Levien et al. (1972), pp. 69-73.

- An objective of the instruction is to develop study skills (homework; unguided practice in subject matter types 3-6, 8, and possibly 7, 9, 10; presentation/demonstration, guided practice in subject matter type 8).
- The subject matter is fairly easy or simple.

Response-paced or adaptive programs are favored when:

- Students are academically deficient or poorly motivated.
- Instructors are ineffective or impatient.
- Instructors are more expensive than the alternative hardware and courseware.
- Detailed information on student responses during instruction will be used to tailor instruction to individual student needs (adaptive programs).
- Course content is revised frequently and adaptive programs are readily available.

VII. DEFINE TEST DETAILS

VII

Test details cannot be defined until the number and types of learning events assigned to teach each objective have been established because these affect the likelihood that students will fail a test on that objective. Moreover, the sequence of learning events dictates the point to which students must go back when they have to repeat earlier parts of the course because of poor test performance. This section describes the decisions that follow the definition of the sequence of learning events for each student. Figure 9 shows the relation of steps described in this section to the overall decision process.

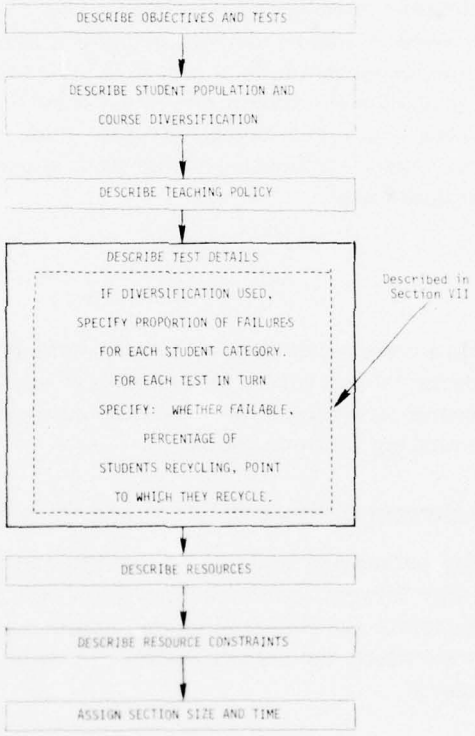

Fig. 9—Relation of decisions described in Sec. VII to overall decision process

FAILURES

VII.A

If planners expect some students to be eliminated from the course, they will need to identify tests at which such failures may occur. If diversification has been chosen, planners may also specify how failures are distributed among student categories.

VII.A.1 Proportion of Failures for Each Student Category

Probably a different rate of failure should be specified for different student categories. For example, most of the failures may occur in the lower ability categories of students; students with higher ability may fail only through lack of motivation. However, an objective of diversification could be to equalize the failure rate among student categories, in which case the same percentage of students would fail in each category.

VII.A.2 Designate Failable Tests

Planners may designate any or all tests (or none) as failable. The RUM allocates failures equally among failable tests for each category of students to produce the designated overall elimination rate. Tests should not be designated as points of failure if the material a test will cover is very easy or has been covered thoroughly in a variety of learning events, and all students may pass the test.

Clearly the sooner students who will ultimately fail can be screened out, the more instructional resources can be saved, so failable tests should appear early in the course, but enough of the subject matter must have been covered to provide a firm basis for a decision so that potentially good students will not be eliminated. Probably the first point of elimination should occur at least several weeks after the course has been under way.

VII.B RECYCLES

Students who do very poorly on a test but do not fail it may be required to repeat some of the material the test covers. Since details of recycling depend so heavily on the details of course structure, it may often be advisable to make most of these decisions while working at the terminal.

VII.B.1 Designate the Percent of Students Recycling from Each Test

The percentage of passing students that will be recycled after taking each test can be any number between (and including) 0 and 100. Like failure points, these numbers should reflect the difficulty of the subject matter the test covers, the thoroughness with which the subject matter is taught, and the abilities of the students who take it.

VII.B.2 Specify Recycle Point

Whenever the percentage of students that will recycle from a particular test is greater than 0, the material they repeat must be designated. This choice hinges on several considerations: the coverage of the test, administrative requirements, and details of the structure of the preceding instruction. In general, the repeated instruction should include all of the objectives covered by the test. If a recycling student must join a class that entered after his own, he must recycle to the point at which they enter—e.g., the beginning of the block or course. If lock-step instruction will not be used, however, students can often skip the introductory events at the beginning of the set of objectives to be repeated. In fully modularized courses, recycling students repeat only the module covered by the test.

NOTES

VIII. DESCRIBE RESOURCES

The next step in the process is to identify the types of resources[1] needed for teaching each learning event. This includes differentiation of the types of instructors if desired, assignment of monitors and evaluators where needed, specification of types of facilities, and, finally, identification of media hardware and courseware. Figure 10 shows the relation of steps described in this section to the overall decision process.

In early stages of planning when only a rough course design is being considered, most resources can be treated as generic types such as "instructor," "classroom," or "workshop." As the design is refined, however, the need for differentiated resources may become apparent; moreover, resource differentiation can provide additional opportunities for effecting cost savings. Finally, the more accurately the resources can be described, the more accurate will be the costs estimated by MODCOM.

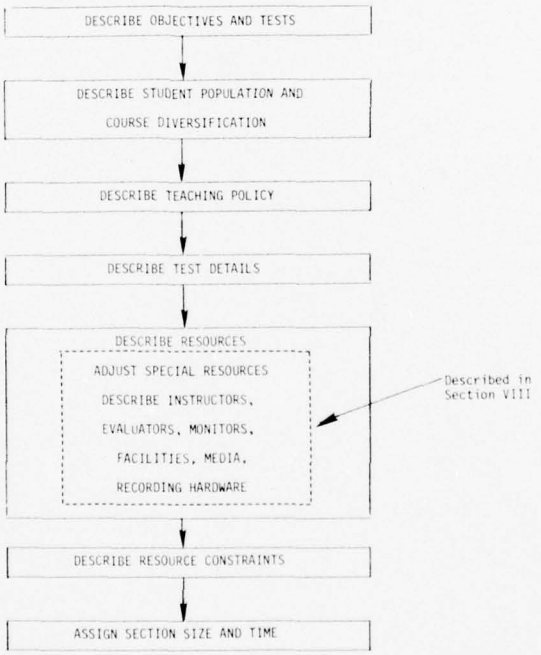

Fig. 10—Relation of decisions described in Sec. VIII to overall decision process

[1] The *number* of resources of each type required for a section is implicitly specified later when the resource capacity is identified.

ADJUST THE ASSIGNMENT OF SPECIAL RESOURCES VIII.A

Special resources required for objectives and tests in subject matter types 7-10 are identified early in the design process. In the course of specifying teaching method, some learning events of these subject matter types may have been designated for which the special resources are not needed, or some learning events may require the use of special resources that are not originally assigned. Therefore, MODIA gives planners a second opportunity to assign special resources. Adjustment of special resources for particular types of learning events is discussed below.

Presentation/Demonstration, Teaching Agent Is Instructor VIII.A.1

The usual practice is to expect the instructor to use whatever special resources the students will need in later learning events to demonstrate and discuss the skills they are going to learn. As pointed out earlier, however, this is not always the best use of resources, particularly those that are in such short supply that is is difficult to give every student enough hands-on experience to master the skills he should be learning. Therefore, even when the teaching agent is an instructor, it may be desirable to record the demonstration on film or whatever media are needed so that students will have as much on-equipment time as possible.

Presentation/Demonstration, Teaching Agent Not Instructor VIII.A.2

When the teaching agent is not an instructor, it is undesirable for students to use the special resources during an introductory learning event for two reasons. First, they may not have sufficient acquaintance with the resources to handle and observe them safely, and second, since media will be required to support and direct learning anyway, there is little reason not to record the demonstration on whatever media are needed.

Guided Practice, Unguided Practice, Review, Check Practice, Test VIII.A.3

A learning event of any of these types in subject matter types 7-10 usually requires the student to work with the special resources associated with the subject matter. In general, therefore, one would not delete any special resources assigned to these events.

Group Discussion, Critique VIII.A.4

Generally, special resources would not be required for this type of learning event, although discussion can often be more fruitful when students can illustrate their points by referring to the real thing. The choice will depend, as before, on whether this is the most productive use of special resources that are probably in short supply or whether surrogates in the form of models or pictures would be good enough for this type of instructional application.

Homework VIII.A.5

MODIA assumes that special resources are never required for homework learn-

ing events. Planners may make such allocations, if desired, but the RUM will not account for them in computing utilization.

VIII.A.6 Adding Special Resources

At this point, special resources that were omitted earlier may be added to any learning event. For example, special resources used for student practice in subject matter types 7-10 may also be useful for demonstration or discussion sessions in subject matter types 1-6.

VIII.B RESOURCE ASSIGNMENT POLICIES

Resources that are not subject-matter specific are next assigned to learning events. For example, planners may want to assign instructors who have been trained to teach particular blocks of the course to those blocks. This could be done by assigning Instructor I to Block I, Instructor II to Block II, and so on.

To relieve the user of as much work as possible, the UI allows assignments to be made for combinations of learning events rather than learning event by learning event. The learning event combinations provided are shown on Table 13. Assignments that are always available for every resource type are W (meaning that the same undifferentiated resource is assigned to the entire course) and LE (meaning that the resource is assigned and defined learning event by learning event).

Choosing the basis for resource assignment defines a set of learning events to which the resource type will be matched. For example, if subject matter types were chosen, planners could assign different types of instructors to teach learning events with different subject matter types. The result for the aggregated objectives listed in Table 13 could be as shown in Table 14, which indicates that recent course graduates could conduct classroom instruction and experienced instructors could conduct on-equipment instruction.

Note that the choice of subject matter type for resource assignment does not imply that a different type of resource must be assigned to teach *each* different type of subject matter. Rather it means that a different type of resource can be assigned to teach each of a set of one or more types of subject matter. Planners have complete freedom in specifying the way this assignment will be made.

After all resources have been assigned, planners may change the designation of resources or add or delete resources for individual learning events. This allows them to adjust resources for unusual learning events by exception, rather than having to make each decision learning event by learning event from the outset. Liberal use of this feature is strongly urged to decrease the number of inputs required.

VIII.C IDENTIFY INSTRUCTOR TYPES

For rough course design, instructors can probably best be considered as a single category. It is not unusual, however, for instructors to be differentiated even when they are associated with the same course, on the basis, for example, of their qualifications to teach different blocks of objectives. Such distinctions permit instructors to

Table 13

LEARNING EVENT COMBINATIONS FOR RESOURCE ASSIGNMENT

Code	Meaning
N	None
W	*Whole Course*
B	Block of sequential learning events
SM	Subject matter type
T	*Student track*
LET	Learning event type
SMLE	Subject matter type and learning event type
SMGT	Subject matter type and student group/track
SMLS	Subject matter type, learning event type, and student group/track
LE	Individual learning event

Table 14

IDENTIFYING INSTRUCTORS ON THE BASIS OF SUBJECT MATTER TYPE

Objective Code	*Subject* Matter Type	Type of Instructor
TESTEQP	1	Pipeline
	2	Pipeline
URN5CHAR	2	Pipeline
	6	Pipeline
SERVROUT	7	Field Experienced
URN5SCHEM	6	Pipeline
SERVROUT	7	Field Experienced
TBSHPRIN	1	Pipeline
	2	Pipeline
TBSHRUN5	7	Field Experienced
FLTCHK	1	Pipeline
INSTALL	1	Pipeline

specialize in different aspects of the subject matter, thereby shortening the time it takes to prepare them for teaching. A disadvantage of such specialization is that an instructor cannot teach outside his own block, which tends to reduce his usefulness. MODIA allows planners to make explicit considerations of the effects of such requirements on course design.

In addition to the whole course (W) and the individual learning event (LE), planners may differentiate among instructors on the basis of blocks of objectives (B), subject matter type (SM), student track (T), or combinations of subject matter and learning event types (SMLE), subject matter type and student group/track (SMGT) or subject matter type, learning event type, and student group/track (SMLS). The choice depends on the particular abilities of instructors that planners want to emphasize or for which they want to provide special training. For example, if they want instructors to specialize by blocks of related objectives, they would choose B.

ATC studies[2] have shown that men with field experience often make better instructors in the performance areas (subject matter types 7-10) than recent course graduates ("pipeline airmen"), who are somewhat better than field-experienced personnel in classroom instruction (subject matter types 1-6). In such cases, it would be reasonable to distinguish instructors by subject matter type (SM).

It is somewhat less usual to consider differentiating instructors by the combination of type of subject matter and type of learning event (SMLE), although this is frequently done in higher education when a noted scholar conducts lecture/demonstrations and a graduate student directs seminars and group discussions. Because of the special skills required to direct productive group discussion learning events, if many of these will be included it might be well to consider assigning a special instructor to them.

Other types of learning events that may require special expertise are check practice and test in subject matter types 7-10. Instructors need special training both to administer tests (act as teaching agents) and to rate student performance reliably and objectively; in fact, few instructors can do so.[3] It is particularly advisable to assign an instructor from another block or course in the same department or from the school evaluation section to administer test learning events, as the objectivity of a skilled observer not directly associated with the students is essential. Using an instructor to rate his own students through observation of their performance almost guarantees a biased result.

Another possibility is to distinguish instructors on the basis of student tracks (T). This is frequently done in public education when, for example, poorer students are given remedial instruction by a teacher specifically trained for this type of instruction. There is evidence that some instructors are better than others at teaching the slow students and that these same instructors may be ineffective in dealing with bright or even average students.[4] Although ATC has not tried to match instructors and students in the past, it would be a reasonable approach to handling a course in which tracking is used. A similar option is available if, instead of tracking, grouping has been chosen.

It is possible to differentiate instructors on the basis of the combination of subject matter type and learning event type (SMLE). It would probably be unwise, however, to identify a different type of instructor for *every* different combination because this could restrict any one type of instructor to so few learning events that his time would be badly underutilized. The same caution should be observed when one is using the combinations of subject matter type and student group/track (SMGT) or of subject matter type, learning event type, and student group/track (SMLS). (This latter combination permits planners to differentiate instructors on the basis of all three course characteristics by which teaching agents are assigned.)

There is a situation in which purely technical requirements within the RUM require differentiation of instructors, namely when an instructor will be "shared" among learning events that occur in several groups but cannot be shared among the *groups* of events. For example, one group of learning events may take place simultaneously within a single classroom and another group may take place within

[2] Chanute Technical School (1969).

[3] Fitzpatrick (1971), pp. 262-268.

[4] Summers (1975) p. 13.

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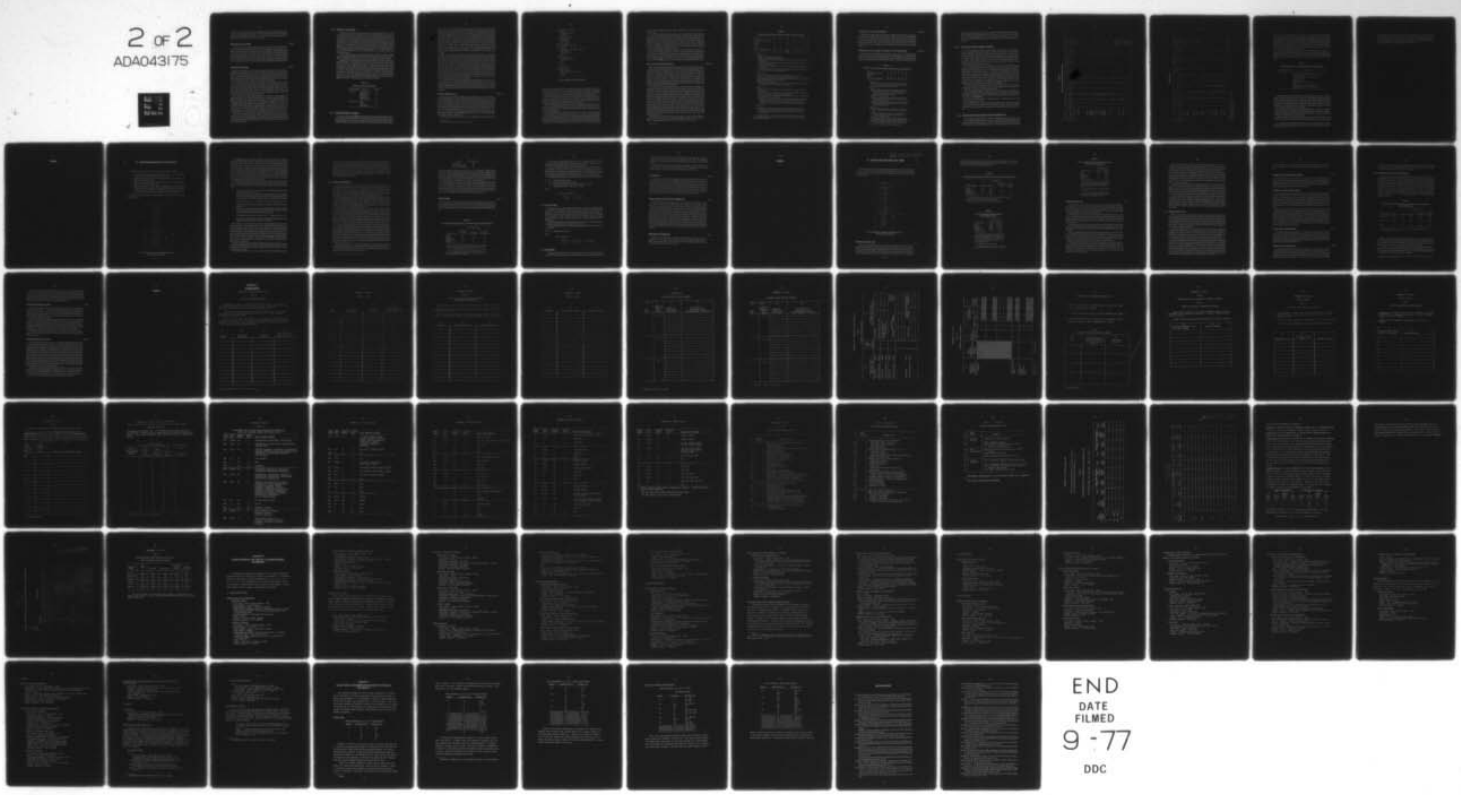

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another classroom. If the instructor responsible for the events within the first classroom cannot simultaneously conduct the events within the second, these instructors must be entered as different resources—e.g., inst1 and inst2. This same requirement, discussed again in Sec. X, applies to all resources.

IDENTIFY EVALUATORS VIII.D

Arguments have been presented above for using specially trained instructors when an instructor is the teaching agent for a check practice or test learning event. When an instructor is not the teaching agent, special abilities in test administration are no longer needed, of course. However, the task of reliably and objectively evaluating student performance in subject matter types 7-10 is even more demanding than test administration, and the possible need for specially trained evaluators remains. Therefore, planners may want to single out particularly important tests, or even some check practice events, for observation and rating by trained evaluators.

IDENTIFY MONITORS VIII.E

Monitors of student activity were discussed when the roles for the instructor in MODIA were described (VI.D.3.a.). A monitor supervises students to maintain order, answers occasional questions, takes care of administrative details, collects assignments, checks out materials, and makes sure that safety precautions are observed. Some schools have a blanket policy that a responsible person must always be on duty during scheduled classes, regardless of the mode of instruction.

The need for monitors and their qualifications often depend on the type of subject matter involved. For subject matter types 7-10, a monitor often has to be familiar with the safety requirements of the skills being taught so that he can insure that safety standards are being met. It is useful to distinguish such a person as a *safety* monitor because the role cannot be as readily filled by a clerk or advanced student as can the general type of monitor, who would perform the more routine duties listed above for subject matter types 1-6.

The same bases for identifying monitors can be chosen as are available for identifying instructors—namely B, SM, T, and the combinations SMLE, SMGT, and SMLS (in addition to W and LE). In addition, N (none) is available as a policy for assignment of monitors. Of these W, N, and SMLE are probably the most appropriate. SMLE allows safety monitors to be assigned only to subject matter types 7, 8, 9, and for 10 for guided practice, unguided practice, check practice, test, and review learning events—that is, events in which students must work with special resources. A general monitor should be all that is needed for learning events in which the teaching agent is not an instructor (even in subject matter types 7, 9, and 10).

The other combinations provide additional flexibility. For example, student track might be used if it is possible to relax requirements for student supervision in the case of more responsible students, or if some students (particularly those with no previous experience in handling the special resources required) would need more supervision than others.

VIII.F IDENTIFY FACILITIES

Facilities may be subject-matter specific, such as special laboratories (e.g., darkrooms or hangars) or more fungible, such as classrooms, auditoriums, carrel areas, learning centers, offices for tutorials, conference rooms for small group discussions, or facilities for test administration. In most cases existing facilities will be used, although they may be modified to facilitate particular modes of instruction. Therefore, planners may want to begin by matching the facilities at their disposal to likely learning events. Alternatively, they may skip the designation of facilities until the RUM has given a better idea of how students will tend to group and what types of facilities and furnishings would be most accommodating. An intermediate approach is to designate facilities in terms of student-spaces (e.g., a classroom space or a laboratory station).

As with hardware, facilities are most conveniently treated as packages complete with whatever furnishings will be needed. Some examples of packages are given in Table 15. MODIA can help determine the precise content of facility packages.

Combinations for assigning facilities may be B, SM, LET, and the combinations SMLE and SMLS (as well as W, LE, and N). Blocks of objectives (B) would be chosen if facilities are to be undifferentiated within a block of instruction. Choice of SM facilitates the familiar differentiation between classroom and laboratory instruction. Differentiation based on the combination of subject matter type and learning event type is most useful if widely varied teaching methods will be used as, for example, when unguided practice is performed in a carrel area, group discussions in conference rooms, and instruction by adaptive programs in a learning center. Similarly, when teaching method is diversified for student groups, the combination SMLS may also be a convenient policy for assigning facilities.

Table 15

EXAMPLE OF FACILITY PACKAGES

Facility Package	Contents	Number
Classroom	Instructor's desk	1
	Swivel chair	1
	Student desks	20
	Chalkboard	1
	Storage cabinet	1
	Floor space, sq. ft.	400
Tutoring Room	Table	1
	Chair	2
	Chalkboard	1
	Floor space, sq. ft.	40

VIII.G IDENTIFY MEDIA SYSTEMS

One of the tenets behind MODIA's design is that the selection of special "media systems" for instruction should be a consequence of policies concerned with instructional effectiveness, such as those dealing with course diversification and teaching method. Too often, course planning works in the reverse direction. Particular media

systems (such as a certain manufacturer's Super-8 movie system) are chosen, and the course is designed around them without explicit consideration of more fundamental decisions such as whether to use tracking or to assign unguided practice for home study. MODIA bends over backward to avoid this approach, not only because it is illogical but because it focuses attention on media systems, which are usually the least expensive components of an instructional system. Therefore, when planners first consider the media choices, they should identify only the general classes of media that will be needed. The "media classes" shown in Fig. 11 are derived from Bretz's work.[5] Within several of the media classes (such as AMV) are literally hundreds of existing systems (such as the Bell and Howell Autoload 16 mm projector, Kodak Supermatic 8 mm projector, Sony Videocassette Recorder, and Ampex Video Production Recorder (the last two requiring TV monitors for classroom use).

Media classes should be determined apart from the designation of teaching agent and section size because it is the combination of media class, teaching agent, and section size that delimits the systems that are practical. For example, suppose that pictures (still visual medium) are needed to show the student what he is learning. Assume in one case that the teaching agent is the learner and, hence, the section size is one. In a second case, the section size is still one but the teaching agent is an instructor. In a third case, the teaching agent is an instructor, and the section size is 15. For the specific system in the first case, an illustrated workbook might be chosen; in the second, a folder of 8-1/2 x 11 prints (the student looks at these while the instructor tutors him); the last might be a set of slides for a slide projector or a set of transparencies for an overhead projector. Since the best choice for section size may not be known until after the RUM has been operated, the choice of specific systems should be deferred for later iterations.

A discussion of the choice of media class precedes guidance for selection of specific systems on the basis of UI and RUM output. Courseware, the instructional materials prepared for a particular learning event and designated system, is defined for input to MODCOM and described in Hess and Kantar (forthcoming). Courseware is distinct from "software," special computer programs built to produce or control courseware.

Selection of Media Class

VIII.G.1

Audio-motion-visual (AMV) media include sound film, television, and videotape. They are all-inclusive in the sense that almost any message that can be conveyed in any other medium can also be conveyed by AMV media. Although they do not easily lend themselves to some forms of learner control, television and videotape cassettes are being used extensively for some courses for home study, particularly for presentation/demonstration and review learning events.[6] AMV media are, however, far less transportable than the still-visual (SV) media. Moreover, they are much more expensive from the beginning of the production process to display than other media. Therefore, although AMV media can work in any instructional application, they are often a poor choice.

Audio-still-visual (ASV) media lack only the capability of representing visual

[5] Bretz (1970, 1971).

[6] Commission on Non-traditional Study (1973), pp. 151-163.

Audio Motion Visual (AMV)
Television
Sound motion picture
Videotape
Audio Still Visual (ASV)
Sound filmstrip
Sound slide-set
Sound-on-slide
Motion Visual (MV)
Silent film (film cartridge)
Still Visual (SV)
Printed page (book, handout, picture set)
Chart, map
Slide, transparency
Chalkboard
Audio (A)
(Phonograph) record
Audiotape (cassette)
Radio
Type (T)
Teletype
Audio plus type (A&T)
Non-mediated Aids
Mockup, model
Object (equipment, part, specimen)
Trainer
Simulator

Fig. 11—Media classes and examples

images in motion, but they are much less expensive and have simpler hardware and production procedures. They also lend themselves much more readily to automated or learner control, which can be a significant advantage in instruction, and they reduce requirements for reading skills. Some ASV media are listed in Fig. 11.

Most of the applications of motion-visual (MV) media (of which silent film is the primary example) occur in instruction, particularly in film cartridges. These are useful aids to an instructor and can also be used in learner-directed study, particularly when supported by workbooks or other text materials.

The SV media include print, transparencies, and film strips. These are the most widely used of all media because they are cheap to produce and reproduce, there are very few messages they are incapable of communicating, and they are highly accessible and transportable.

Audio (A) media, which transmit only sound, are also very common. Included are the telephone, radio, audiotape (now usually in cartridges), and phonograph records. Audio media are heavily used in teaching foreign languages, public speaking, and music. Speech compressors may be used to speed audio presentation. The kind that is adjustable by the student provides a useful form of adaptation, allowing the student to cover material up to 2.5 times faster when it is easy or familiar, or

to slow it down to half normal speed when it is difficult or if he wants to take notes from the tape.[7]

The type (T) medium is infrequently used but it is included on this list because it is the commonest medium of communication by computer. Type can be only the alphanumeric characters found on the keyboard of the associated terminal; they usually produce only one character at a time. Even so, most messages *can* be communicated in type. If the course designer is considering any form of automated control of instruction, he should choose the type medium for as many learning events as possible because alphanumeric terminals are cheaper than those that can present the full gamut of visual information.

The class of medium required for instruction is heavily influenced by the teaching agent. If the teaching agent is the learner, the medium must carry the burden of instruction; an instructor as teaching agent needs media only to illustrate what would be inconvenient or impossible for him to produce in the classroom; response-paced or adaptive programs become very expensive if AMV or MV media must be used. Therefore MODIA asks that classes of media be identified by teaching agent.

The Learner Is the Teaching Agent VIII.G.1.a

Bretz has constructed criteria for determining which class of medium is required for a particular body of subject matter when the learner is the teaching agent, shown in Table 16. The choice should be based on *requirements*, not on what is conventionally used. For example, training films are often used to demonstrate a checkout procedure consisting of several steps, but unless the student must see a particular step (or set of steps) in motion to understand it, this is usually a poor medium for demonstrating the procedure. A well-written and well-illustrated pamphlet (SV medium) or a combination of sound and slide set for students who read poorly (ASV medium) would be a cheaper approach and probably more effective instructionally because students could study it as needed.

For many courses, the most obvious basis for choice of medium is probably the individual learning event (LE). This choice also requires the most work from the user, however, so several other options that might reasonably be selected are provided. For example, SV media (printed page and chalkboard plus conventional transparencies) are quite adequate for many courses, particularly if students are not deficient in reading skills. For such courses, it would make sense to assign SV to the whole course. Other possible combinations are block of learning events, subject matter type; learning event type; student track; and the combinations of subject matter and learning event type, subject matter and student group/track, or of subject matter type, learning event type, and student group/track. A particularly likely combination would be of subject matter type and learning event type. For example, unguided practice sessions are often directed by SV media, presentation/demonstration events for subject matter type 7 might require MV media or AMV media, but presentation/demonstration events for subject matter type 5 might well need only SV media.

If tracking or grouping will be used, planners may wish to provide different media for each track or group. The combination SMLS would be particularly appropriate if audio-supported media were to be provided for poor readers.

[7] Rippey (1975).

Table 16

Choosing Class of Medium when Teaching Agent Is Learner

Audial?[a]	Y	Y	Y	Y	N	N	N	N
Visuals (other than print)?[b]	Y	Y	N	N	Y	Y	N	N
Motion?[c]	Y	N	N	N	Y	N	N	N
Print?[d]	—	—	Y	N	—	—	Y	N
None?[e]	—	—	—	—	—	—	—	Y
Class of medium indicated	AMV	ASV	(A&T) or ASV	A	MV	SV	T	N

[a]Answer "Y" if:

- Specific sounds must be presented.
- Music or oral literature is being studied.
- Instruction merely in print would make the subject difficult for many students to understand.
- Simultaneous oral narration would be preferable to interrupting visual continuity with caption frames.
- The personal element (more readily conveyed by the spoken word than by print) is important.
- An objective of the instruction is to change feelings or attitudes, and the effective use of audial means would help achieve it.

[b]Answer "Y" if:

- Visual recognition or discrimination is an objective of the instruction.
- A process or procedure is to be presented or demonstrated.
- Two-dimensional relationships are important (physical placement, relative location).
- Three-dimensional structure is important.
- Visual art is being studied.
- The instruction involves concepts and relationships that would be clarified by graphic presentation (charts, graphs, diagrams, etc.).

[c]Answer "Y" if:

- Mastery of the instruction requires the recognition of the subject's manner of movement.
- Slow or fast motion is required to portray changes that ordinarily take place too rapidly or too slowly to be otherwise comprehensible.
- The concrete effects of hidden or abstract processes are to be shown and motion can make the processes perceptible.
- Animation of diagrams, graphs, or other symbolic representations is needed to demonstrate the effects of change, either in the symbols themselves (e.g., the movement of letters to teach reading) or in the idea they represent (e.g., animating an organizational chart to show a change in government structure).

[d]Answer "Y" if:

- Reading or writing is being taught, or a difficult technology is being introduced, and spoken words must be related to their counterparts in print.
- The learner is simply being directed to execute a procedure, perform a task, or drill himself.

[e]Probably rarely answered "Y" when the learner is the teaching agent. A possible choice for unguided practice and review events if brief directions given in preceding events would be sufficient.

An Instructor Is the Teaching Agent VIII.G.1.b

When the teaching agent is an instructor, media requirements are less because the instructor can fill in whatever commentary and directions are needed. Therefore an event that would otherwise require audio or still-visual to provide the commentary would no longer have this requirement. Some suggestions for choosing the medium when the teaching agent is an instructor are given in Table 17. The same combinations for resource allocation are available as when the teaching agent is the learner.

A Response-Paced or Adaptive Program Is the Teaching Agent VIII.G.1.c

The criteria given in Table 16 are relevant to cases in which a response-paced or adaptive program is the teaching agent. One major difference in directing choice is that it is desirable to eliminate, if possible, the use of AMV or MV media because of the current high cost of controlling such media by automated programs. Use of

Table 17

CHOOSING CLASS OF MEDIUM WHEN TEACHING AGENT IS INSTRUCTOR

Audial?[a]	Y	Y	N	N	N	N
Visual (including print)?[b]	Y	Y	N	Y	Y	N
Motion?[c]	Y	N	N	Y	N	N
None?[d]	—	—	—	—	—	Y
Class of medium indicated	AMV	ASV	A	MV	SV	N

[a]Answer "Y" if:
- Specific sounds must be recognized or discriminated that are expensive, inconvenient, or impossible to produce live.
- Music or oral literature is being studied.

[b]Answer "Y" if:
- Specific sights must be recognized or discriminated that are expensive, inconvenient, or impossible to produce live. (Refer to Table 16, note b, for examples of specific sights that may require visual media.)
- Visual art is being studied.
- The instruction involves concepts and relationships that would be clarified by graphic presentation (charts, graphs, diagrams, schematics, etc.).
- Reading or writing is being taught, or a difficult technology is being introduced, and spoken words must be related to their counterparts in print.

[c]Answer "Y" if:
- Specific movements must be recognized or discriminated that are expensive, inconvenient, or impossible to produce live.
- Slow or fast motion is required to portray changes that ordinarily take place too rapidly or too slowly to be otherwise comprehensible.
- The concrete effects of hidden or abstract processes are to be shown, and motion can make the process perceptible.
- Animation of diagrams, graphs, or other symbolic representations is needed to demonstrate the effects of change.

[d]Answer "Y" if the instructor needs no mediated aids.

videotape might significantly reduce this cost but would probably require engineering development. The other difference is that it is desirable to use the type medium wherever possible, particularly if the teaching agent is an adaptive program, because of the availability and economy of computer terminals with teletype-like functions.

VIII.G.2 SELECTING SPECIFIC MEDIA SYSTEMS

To assist planners in selecting media systems, the UI provides a summary of media use and the RUM recaps features of student participation in each learning event. To illustrate, a summary of media use from the UI is shown in the first nine columns of Table 18. Note that the summary is arranged by kind of medium, objective, subject matter type, and so on. The kinds of medium shown are prefixed by I., L., and P. to show whether instructors, learners, or automated programs are the teaching agents that use them. The ninth column associates the learning event numbers with the preceding information.

Planners complete the next three columns by entering the relevant data for each learning event listed in col. (9) from course operation reports provided by the RUM. This guides the completion of col. (13), in which specific media systems are designated. Worksheet VI and Tables B and C in Appendix A assist planners in this task. These tables associate class of medium, teaching format, and teaching agent with media systems. Media systems are described in Appendix B. For example, SV media that support instructors (I.SV) need accommodate a maximum of six students simultaneously and a maximum of two concurrent sections. Overhead projectors are appropriate for this application. A chalkboard, though less expensive, was rejected because the content it displays is less readily standardized.

The ASV media that support learners in home study (L.ASV) are prepared in a response-paced format. For this an ASV teaching machine was chosen that uses a combination of filmstrips and audiotape cassettes.

The L.SV media prepared in adaptive format are taken to be scrambled programmed texts. Other L.SV media in simple format are workbooks, tests, and Technical Orders. The numbers of copies of printed materials required can be determined automatically by MODCOM.

To display the P.SV media in adaptive format, a teaching machine using filmstrip cartridges was chosen.

Once specific media systems have been identified and assigned to learning events, they should be entered into the UI (with the exception of printed media) so that the RUM can compute the total number of items of hardware required and their use.

VIII.H HARDWARE FOR RECORDING STUDENT RESPONSE

If subsequent group discussions, reviews (with subject matter type other than 7-10), or critiques will focus on the students' performance during guided practice, unguided practice, check practice, or test, recordings of that performance can often be useful. In addition, if the teaching agent is not an instructor for check practice

Table 18

Example of Selecting Media Systems

Output from User Interface								Output from RUM			User Decision
Kind of Medium	Objective	Subject Matter	Group/ Track	L. E. Type	Teaching Format	Teaching Agent	Average Minutes	Maximum Section Size	Maximum No. of Concurrent Sections	Maximum No. of Students	Specific Media Systems
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)	(11)	(12)	(13)
I . SV	TEST EQP	1	1	P	R	I	90	5	1	5	Overhead Projector
	"	2	1	P	R	I	60	5	1	5	"
	URN5CHAR	2	1	P	R	I	120	5	1	5	"
	"	6	1	D	GI	I	30	9	5	2	5	"
	"	6	2	D	GI	I	24	38	3	1	3	"
	"	6	3	D	GI	I	24	64	3	1	3	"
	"	6	1	D	GI	I	30	14	5	2	5	"
	"	6	2	D	GI	I	24	43	3	1	3	"
	"	6	3	D	GI	I	24	69	3	1	3	"
	TBSHPRIN	1	1	P	R	I	30	17	4	1	4	"
	"	2	1	P	R	I	60	19	6	1	6	"
	FLTCHK	1	1	P	R	I	30	22	6	1	6	"
	INSTALL	1	1	P	R	I	30	24	6	1	6	"
	REVIEW 1	6	1	R	R	I	30	26	6	1	6	"
	"	6	3	R	GI	I	30	81	3	1	3	"
L . ASV	TESTEQP	1	1	H	RF	L	20	2	1	5	5	ASV T.M.[a]
	"	2	1	H	RF	L	20	4	1	5	5	"
	URN5CHAR	2	1	H	RF	L	20	6	1	5	5	"
	"	6	1	H	RF	L	60	10	1	5	5	"
	"	6	1	H	RF	L	60	15	1	5	4	"
	TBSHPRIN	1	1	H	RF	L	15	18	1	4	6	"
	"	2	1	H	RF	L	15	20	1	6	6	"
	FLTCHK	1	1	H	RF	L	15	23	1	6	6	"
	INSTALL	1	1	H	RF	L	15	25	1	6	6	"
L . SV	TESTEQP	1	2	H	AF	L	20	31	1	6	6	Programmed Text
	"	2	2	H	AF	L	20	33	1	6	6	"
	"	2	3	H	AF	L	20	59	1	3	3	"
	URN5CHAR	2	2	H	AF	L	20	35	1	6	6	"
	"	2	3	H	AF	L	20	61	1	5	5	"
	"	6	2	GP	AF	L	95	36	1	6	6	"
	"	6	2	H	S	L	60	39	1	3	3	Workbook
	"	6	3	GP	AF	L	95	62	1	5	5	Programmed Text
	"	6	3	H	S	L	60	65	1	3	3	Workbook
	SERVROUT	7	1	UP	S	L	30	11	5	1	5	Technical Order
	"	7	2	UP	S	L	30	40	5	1	5	"
	"	7	3	UP	S	L	30	66	5	1	5	"
	URN5CHAR	6	2	GP	AF	L	95	41	1	6	6	Programmed Text
	"	6	2	H	S	L	60	44	1	3	3	Workbook
	"	6	3	GP	AF	L	95	67	1	6	6	Programmed Text
	"	6	3	H	S	L	60	70	1	5	5	Workbook

Table 18 (CONT.)

Output from User Interface									Output from RUM			User Decision
Kind of Medium	Objective	Subject Matter	Group/ Track	L. E. Type	Teaching Format	Teaching Agent	Average Minutes	L. E. Number	Maximum Section Size	Maximum No. of Concurrent Sections	Maximum No. of Students	Specific Media Systems
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
L, SV (cont.)	SERVROUT	7	1	UP	S	L	90	16	4	2	6	Technical Order
	"	7	2	UP	S	L	90	45	6	1	6	"
	"	7	3	UP	S	L	90	71	6	1	6	"
	TBSHPRIN	1	2	H	AF	L	15	47	1	6	6	Programmed Text
	"	1	3	H	AF	L	15	73	1	6	6	"
	"	2	2	H	AF	L	15	49	1	6	6	"
	"	2	3	H	AF	L	15	75	1	6	6	"
	TBSHURN5	7	1	UP	S	L	90	21	5	2	6	Technical Order
	"	7	2	UP	S	L	90	50	6	1	6	"
	"	7	3	UP	S	L	90	76	6	1	6	"
	FLTCHK	1	2	H	AF	L	15	52	1	6	6	Programmed Text
	"	1	3	H	AF	L	15	78	1	6	6	"
	INSTALL	1	2	H	AF	L	15	54	1	6	6	"
	"	1	3	H	AF	L	15	80	1	6	6	"
	EXAM1	6	1	T	S	L	30	27	6	1	6	Test
	"	6	2	T	S	L	30	55	6	1	6	"
	"	6	3	T	S	L	30	82	1	1	1	"
	"	7	1	T	S	L	30	28	6	1	6	"
	"	7	2	T	S	L	30	56	6	2	6	"
	"	7	3	T	S	L	30	83	1	1	1	"
P, SV	TESTEQP	1	2	P	AF	AP	67	30	1	6	6	SV T, M.[b]
	"	2	2	P	AF	AP	45	32	1	6	6	"
	"	2	3	P	AF	AP	45	58	1	3	3	"
	URN5CHAR	2	2	P	AF	AP	89	34	1	6	6	"
	"	2	3	P	AF	AP	89	60	1	5	5	"
	TBSHPRIN	1	2	P	AF	AP	23	46	1	6	6	"
	"	1	3	P	AF	AP	23	72	1	6	6	"
	"	2	2	P	AF	AP	45	48	1	6	6	"
	"	2	3	P	AF	AP	45	74	1	6	6	"
	FLTCHK	1	2	P	AF	AP	23	51	1	6	6	"
	"	1	3	P	AF	AP	23	77	1	6	6	"
	INSTALL	1	2	P	AF	AP	23	53	1	6	6	"
	"	1	3	P	AF	AP	23	79	1	6	6	"
												Study References, Lesson Plans

[a] ASV Teaching Machine (filmstrip and audiotape cassette).

[b] SV Teaching Machine (filmstrip cassette).

or test events in subject matter types 7-10 and no evaluator has been assigned to these events, recording of student performance is mandatory for later evaluation. Recording hardware may be needed particularly for subject matter types 7, 9, and 10. In these cases, whatever recording hardware is needed should be assigned to the appropriate learning events. These will be both the events in which student performance will be recorded and those in which it will be discussed or critiqued. Specific systems can be identified at the outset, since their required capacity is obviously either one or the size of a performing team.

Table 19 is included to assist (but not to limit) planners in the selection of appropriate recording hardware. For subject matter types 1-6, paper and pencil are usually sufficient for recording student performance. Some exceptions might occur (especially in the teaching of languages) in which an audiotape recorder would be useful.

Table 19

COMMON HARDWARE FOR RECORDING STUDENT PERFORMANCE

Subject Matter Type	*Hardware*
1, 2, 3, 5	None (paper and pencil sufficient)
4, 6	None (paper and pencil or student product sufficient)
	Audiotape recorder
7, 9	Videotape recorder or sound movie camera
	Audiotape recorder
	Movie camera
8	None (student product sufficient)
	Camera
10	Videotape recorder or sound movie camera
	Audiotape recorder, possibly with camera
	Movie camera

For subject matter type 9, and probably also for subject matter type 7, only the process of student performance is of importance. This implies that student performance must be recorded in motion, so to speak, so that critical features of performance can be captured.[8] If both the visible and audible features of the performance are important, a videotape recorder may be the most convenient choice. If only the audible (or the visible) features are important, an audiotape recorder (or a movie camera) would be adequate and less expensive.

By definition, only the product of student performance is important in subject matter type 8. Hence the product itself would be adequate unless it were fragile or ephemeral or otherwise inconvenient to display. In that case, a camera could be used to capture essential features of the product.

Subject matter type 10 teaches performance in which both the process and product are important. Considerations for choice of hardware to record the process

[8] It is common practice to show critical features of performance by means of still pictures. However, these must be carefully planned beforehand and are often selected from a motion picture of the performance. It seems unreasonable to expect that instructors or students would be able to do this during a practice session.

of performance are the same as those for subject matter type 9. And, since any of the visual media used to record the process of performance can also be used to record student products, if desired, additional means would not be needed for this. However, if only audio tape is chosen for recording the process of performance, student products should be given some additional consideration.

NOTES

IX. DESCRIBE RESOURCE CONSTRAINTS

Planners describe each resource in terms of the following attributes:

- "The assumed inventory at the start of the course"—either on hand, in stock elsewhere, or procurable through a new buy.
- Its usual "capacity" in terms of the maximum number of students it can accommodate simultaneously.
- Whether the capacity varies (from the usual) and if so what the capacity is for each unusual learning event.
- Whether the resource can be "shared" simultaneously by more than one section or learning event, and if so whether all learning events (to which it has been assigned) can share it or only some can share it. If a resource cannot be shared, it is said to be "dedicated" to the learning event.

Figure 12 shows the relation of steps described in this section to the overall decision process.

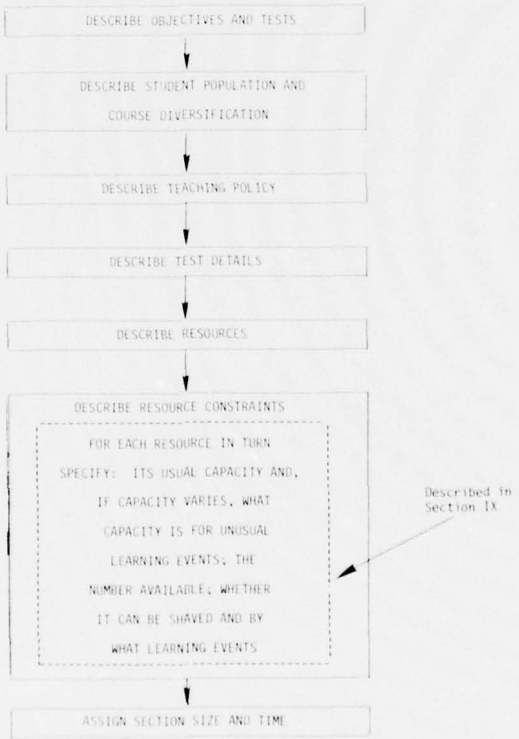

Fig. 12—Relation of decisions described in Sec. IX to overall decision process

One of MODIA's more important features is that it permits planners to address the questions both of the number of resources of each particular type that would be required to operate the course as specified and of how best to operate the course given that a limited number of a particular resource is available. The tendency of most school planners to design courses around existing training resources reflects a realistic appreciation of the difficulty of obtaining additional items. This approach, however, inhibits imaginative design, often unnecessarily; it is also an unjustified tactic in the design of entirely new courses. Therefore, in the initial design phases only those resource limitations that are inviolable should be allowed to limit the course design. Certainly limitations on fairly inexpensive items such as media systems should not direct the design from the outset.

The RUM outputs both the number of items used and the fraction of time they are used. Planners should check these fractions before settling on final course design, since some training resources cannot be used all of the time. Three cases may arise:

1. The fraction of time in use is less than the reasonable limit, in which case no adjustment needs to be made.
2. The fraction of time in use exceeds the reasonable limit, and the available quantity is unlimited or unknown, in which case the maximum number of items reported by the RUM should be inflated by the following multiple:

   (fraction of time in use) ÷ (reasonable limit of fraction of time in use)

   This quantity should then be input as the number available for the next iteration.
3. The fraction of time in use exceeds the reasonable limit, and the available quantity is limited. To simulate the full effect of such overutilization, the number should be deflated by the following multiple:

   (reasonable limit of fraction of time in use) ÷ (fraction of time in use)

   This quantity is the effective number available and should be input as the number available and another iteration performed.

The capacity of a resource is the *maximum* number of students that can use it simultaneously in a given learning event—that is, the RUM will never allow more than this number of students to use the resource. Thus, it is important to consider varying demands on the resource, such as those posed by recycling students, in specifying capacity. This number may be different for different learning events. It may be thought of in terms of the number of students a resource can accommodate or the number of student-sessions that can be conducted on a resource within a given time. As with resource availability, planners may use MODIA to help determine capacity if it is not limited *a priori*, as might be the case for new facilities such as study halls or auditoriums.

If a resource can be shared, students in different sections of a learning event or in different learning events can use it simultaneously. Shareable resources can be used much more flexibly than those that are dedicated to a single section of a single learning event at a time.

As noted earlier (VIII.C), if a resource cannot be shared simultaneously among

all sections of the learning events that share it but can be shared simultaneously among *some* sections of the learning events that share it, it should be designated as two or more resources. For example, an instructor in a study hall may simultaneously monitor all learning events in the study hall but be unable simultaneously to monitor learning events in the laboratory. Even though the same person could monitor the laboratory events at a different time, the instructor should be considered a different resource in the study hall and the laboratory (e.g., instructor—study hall; and instructor—laboratory).

IX.A SPECIAL RESOURCES

Usually the capacity of a special resource is fixed for the entire course or can be varied only within narrow limits. For example, a simulator might be able to accommodate at most two students, and a darkroom at most five. Sometimes, however, the use to which the resource is put affects its capacity. Perhaps as many as 15 students can watch a demonstration of loading bombs on an aircraft, but no more than four can practice loading bombs on one aircraft simultaneously.

Most special resources are worth considering in MODIA because they are expensive or in short supply for some other reason. Thus, the number available will often be known beforehand. Obviously it will be impossible for more students to use the resource simultaneously than the product of the total number available and the capacity of each. Therefore MODIA displays this product (the "total course capacity") later to guide the assignment of section size.

Some special resources, particularly special facilities, can be shared among learning events. Large pieces of equipment may also be shareable in special circumstances. A familiar example is for one group of students to observe a demonstration of a skill that is being practiced by another group. Another instance is when one group of students is studying the location and function of a subsystem of a larger system while another group studies a different subsystem on the same larger system. In this case, the larger system can be shared but the subsystems cannot, and it might be well to consider the subsystems and the larger system as separate resources.

The shareable feature can be used to simulate courses during which instructors (or a computer) normally schedule students through alternative sequences of training activities so that students will not have to wait to use a particular resource in limited supply, as described in Sec. II.B.6. To accomplish this: (1) combine into one event all of the learning events that give rise to the alternative sequences, (2) state the capacity of the resource in question in terms of the number of student-sessions that can be completed in the time available in the combined events, (3) make the resource shareable for this event.[1] (Be careful to follow the rule on differentiation of shareable resources that cannot simultaneously be shared among all events in which they are shared.)

For example, suppose that students will perform in teams of two on a piece of equipment of which only one is available. While one team is performing, one team is watching the performance and two others are studying the performance procedures. The basic sequence of learning events is:

[1] Step 3 is not necessary for strictly lock-step courses.

Activity	Time (minutes)
Perform task	30
Watch task performance	30
Study task performance	60

and the equipment would have a capacity of two. To avoid having to model the four alternative sequences explicitly, these learning events could be combined into a 120-minute event called, for example, learn task performance. The equipment would then have a capacity of eight student-sessions and be shared for this learning event. The disadvantage to this approach is that final figures on resource use will not reflect the time that most of the students are, in fact, waiting their turn.

Reasonable limits for use of special resources must be obtained from ATC. These limits should reflect the fact that more complex, less reliable hardware types will have lower maximum use; equipment used on multi-shift courses may also have lower maximums. However, most training days are only six hours long, allowing at least two hours for maintenance. Thus, a RUM output of zero idle time translates into a use of .75, which may be sufficient for normal maintenance.

INSTRUCTORS

IX.B

The capacity of an instructor can be quite variable, depending on the nature of the teaching activity. For example, an instructor may be ineffective in tutoring more than six slow students at one time but may effectively present basic information to several hundred students at once. Some of the possibilities are displayed on Table 20.

Table 20

SUGGESTED MAXIMUM CAPACITIES FOR INSTRUCTORS AS TEACHING AGENTS

	Subject Matter Types		
Teaching Format	1-6 (and Presentation in 7-10)	7 (except Presentation)	8-10 (except Presentation)
Simple	U[a]	—	—
Recitation	50	mT[b]	a[c]
Response-paced	20	T	b[c]
Adaptive	6	T	c[c]
Group interaction	10	10	10

[a]U: Undefined except as limited by facilities capacity or ability of students to see a demonstration in subject matter types 7-10.

[b]mT: An integral multiple of team size, where T is the team size.

[c]a, b, c: Nominal figures that reflect the instructor's ability to perceive and respond to the students' performance. Should be no greater than 50, 20, and 6 respectively.

The course plan should reflect these variations to capture the effects of variations in teaching methods. This can readily be accomplished if instructors are already highly differentiated with regard to teaching method.

It is usually advisable initially to let the RUM compute the number of instructors required. In courses where a very few people have the subject knowledge required, however (especially in courses dealing with advanced equipment or procedures), limitations on instructor availability may be an important constraint. Any events among which instructors are shared should occur in the same facility.

A reasonable limit for use of a classroom instructor can be calculated as follows:

Let: A = training days per month
B = classroom training hours per day
C = hours per month for leave, medical, training, and other organizational duties (historically, 32 hours)

Then:

$$\text{Classroom use for instructors} = \frac{(A \times B) - C}{(A \times B)} = \frac{(21.7 \times 6) - 32}{(21.7 \times 6)} = .754$$

IX.C EVALUATORS

The capacity of an evaluator depends on his ability to perceive and judge student performance in check practice and test events, and is similar to the instructor's capacity in the recitation format for subject matter types 8-10 (refer to Table 20). Evaluators may also conduct critiques in the group interaction format. Although these capacities are quite variable, evaluators are usually assigned to a small enough number of events that specifying them by learning event would not be burdensome.

Usually the RUM should initially compute the number of evaluators needed. Evaluators should usually not be shared among events.

A reasonable limit for use of evaluators and classroom monitors can be calculated as follows:

Let: D = working hours per day

Then:

$$\text{Monitor/evaluator use} = \frac{(A \times D) - C}{(A \times B)} = \frac{(21.7 \times 8) - 32}{(21.7 \times 6)} = 109\% \longrightarrow 100\%$$

IX.D MONITORS

Monitors for learning events with subject matter types 1-6 can have fairly large capacities. Usually, the capacity of a monitor for these events is limited more by the

facility in which the event takes place than by his own limitations. The capacity of monitors for subject matter types 7-10 is a different story. Here, the number of students that can be monitored in potentially dangerous learning events should be limited.

Again, the RUM should initially compute the number of monitors needed. Generally, monitors can be shared among events occurring in the same facility. As noted above, monitors can usually be used up to 100 percent of the time.

FACILITIES IX.E

Facilities usually have a fixed capacity and are available in limited numbers. In planning new courses, however, MODIA is useful for determining the capacity required for facilities. They can often be shared among learning events, but it is better not to share them among events in which the teaching agent is an instructor, because of the likelihood that one instructor's activities will disrupt the teaching in the other events. Events with subject matter types 7-10 are less likely to be able to share facilities unless the facilities are large laboratories, hangars, etc. Limits for the amount of time facilities may be used must be locally determined.

MEDIA TYPES AND SPECIFIC HARDWARE IX.F

The RUM should compute the quantities of media types needed and their capacity, unless it is already fixed. Media types are usually not be shareable among different events because each item of courseware is unique to a particular event.

The capacity and availability of specific media systems will usually be dictated by the output of early iterations of the course design, as discussed in Sec. VIII.G.2. Exceptions may arise in the case of media for response-paced or adaptive programs where the number of display units or terminals must be limited because of their cost and where their capacity is defined by existing hardware. Additionally, limited capacities and quantities should be entered on subsequent iterations to pin down more precisely the number and use of items of hardware (such as film projectors) required. As with special resources, alternative sequences using scarce media systems may be simulated by combining the basic sequence into a single event, making the system shareable for that event and expressing its capacity in terms of student-sessions.

RECORDING HARDWARE IX.G

The capacity of hardware for recording student performance is usually one (1); sometimes it is the size of the performing team. Availability should usually be determined from the output of early iterations. Usually recording hardware cannot be shared among different learning events.

NOTES

X. ASSIGN SECTION SIZE AND TIME X

Finally, planners specify maximum and minimum section size. Assignment of the time set aside for each learning event completes the description of learning events. Figure 13 shows the relation of steps described in this section to the overall decision process.

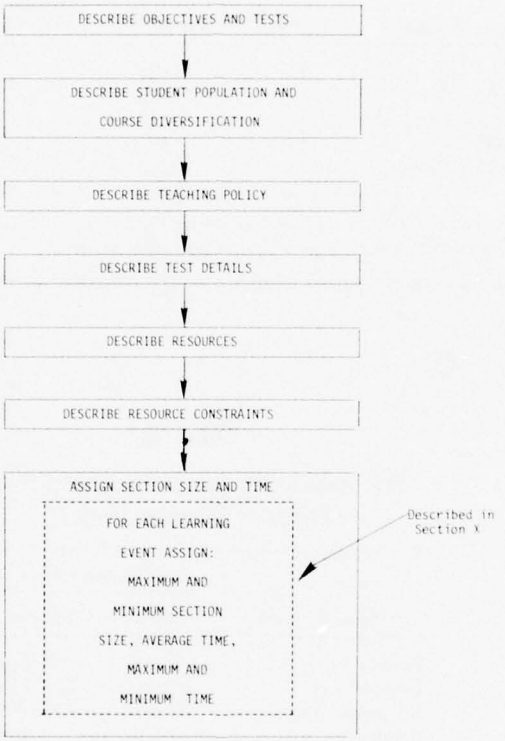

Fig. 13—Relation of decisions described in Sec. X to overall decision process

SPECIFY SECTION SIZE X.A

A section is a single occurrence of a learning event. Section size is specified by assigning a maximum and a minimum value to the number of students that may form a section. These numbers should reflect the combination of resource capacities and prior choices of teaching agent and teaching format as suggested in Tables 21, 22, and 23. Planners should not feel bound by these numbers, but they should be

aware that if they stray too far from them it may be impossible for designated teaching agents to fulfill the teaching formats specified. The tables are referred to frequently throughout the following discussion.

Table 21

SUGGESTED MINIMUM/MAXIMUM SECTION SIZES, SUBJECT MATTER TYPES 1-6

	Teaching Agent			
Teaching Format	Learner	Instructor	Response-Paced Program	Adaptive Program
Simple	1/1	1/U[a]	—	—
Recitation	1/1	1/50	—	—
Response-paced	1/1	1/20	1/50[b]	—
Adaptive	1/1	1/6	—	1/U
Group interaction	—	3/10	—	—

[a]U: Undefined (except as limited by facilities capacities or by hardware capacities for response-paced and adaptive programs).

[b]Nominal figure suggested by currently available hardware.

Table 22

SUGGESTED MINIMUM/MAXIMUM SIZES, SUBJECT MATTER TYPE 7[a]

	Teaching Agent	
Teaching Format	Learner	Instructor
Simple	nT/mT	(nT-1)/mT
Recitation	nT/mT	(nT-1)/mT
Response-paced	nT/mT	T-1/T
Adaptive	nT/mT	T-1/T
Group interaction	—	3/10

[a]All learning event types except presentation/demonstration, group discussion, and homework. These would be handled like subject matter types 1-6, except for demonstrations in which the instructor is teaching agent using students to assist in the demonstration.

[b]T: Number of students on team.

[c]n,m: Multiples of team size. Each is an integer greater than 0; m must be greater than or equal to n.

Table 23

SUGGESTED MINIMUM/MAXIMUM SECTION SIZES, SUBJECT MATTER TYPES 8-10[a]

	Teaching Agent	
Teaching Format	Learner	Instructor
Simple	1/1	1/U[b]
Recitation	1/1	1/m[c]
Response-paced	1/1	1/n[c]
Adaptive	1/1	1/o[c]
Group Interaction	—	3/10

[a]All learning event types except presentation/demonstration, group discussion, and homework. These would be handled like subject matter types 1-6.

[b]U = Undefined, except as limited by facilities capacities.

[c]m, n, o: Nominal figures that should reflect the instructor's ability to perceive and respond to the students' performance. See text.

Maximum Section Size X.A.1

As with capacity, the maximum section size is never exceeded in the RUM; e.g., if 11 students arrive at an event whose maximum size is 10, one student will either wait for the resources to be freed (if resources are limited) or start a new section. Thus, it is important to consider varying requirements, such as the accommodation of recycling students, when setting this maximum.

If the maximum section size is greater than one, all students will take the same time to complete the section. This is the average time assigned for the learning event in the next step in course design. Therefore, if planners want to assure that each student progresses through a learning event at his own rate, the maximum section size must be one.

For each learning event the maximum section size must always be greater than or equal to the minimum or no students will be able to complete the event. Thus, for group discussion and team performance the maximum should always be greater than one.

From the standpoint of resource use alone, maximum section size should be close to some multiple of the capacity of the set of resources assigned to the section, but less than their minimum total course capacity. However, as suggested by Tables 21-23, there are several instances in which section size should be limited to permit a designated teaching agent to carry out a chosen teaching format.

If the maximum section size is less than the entry group size, students may have to wait to enter learning events for which the availability of dedicated resources is limited. Of course, if so many students enter the course over such a short time that the total course capacities of the resources available for the learning event are continually exceeded, more and more students will have to wait for longer and longer times to enter the event.

Note that in Tables 21 and 23 in several instances maximum section size is undefined. In these cases, planners should be guided by the maximum capacity of whatever facilities, equipment, or other resources have been assigned to the learning events with the given combination of teaching agent and teaching format.

For subject matter type 7 (team skills, Table 22), the maximum section size for all types of learning events except presentation/demonstration, group discussion, and homework should be some multiple, m, of team size. For example, if students must perform the skill in teams of four, maximum section size could be 4, 8, 12, etc. If the learners are the teaching agent, however, the maximum section size should equal the team size, and m = 1.

As discussed earlier, when the teaching agent is an instructor in subject matter types 8-10, the maximum section sizes should be chosen to reflect the instructor's ability to perceive and respond to the student's performance (as noted in Table 23). The values of letters m, n, and o should be chosen to reflect this ability, with m being the largest and o the smallest of the three. Additionally, m, n, and o will usually be smaller than or the same as their counterparts on Table 21, namely, 50, 20, and 6.

As with assignment of resources, section size may be specified for combinations of learning events. Any combination may be used except N (none). The foregoing discussion suggests that the most reasonable combination might be subject matter type, learning event type, and student group/track (SMLS). If there is little diversification in teaching method or subject matter type, or if lock-step instruction is being planned, however, selection of W, B, or other more aggregated policies would be reasonable.

X.A.2 **Minimum Section Size**

The minimum section size must be one or more. If the minimum section size for a learning event is greater than one, each student arriving at that event must wait until the minimum has been reached. However, making the minimum section size for a learning event equal or very nearly equal to the capacity of the resources that will be used for that event insures that resources will be nearly fully utilized for that event. Never set this minimum larger than the minimum total course capacity of the resources assigned to the event.

If the minimum section size is greater than the entry group size for some learning event, students in one entry group may have to wait for other students to join them to fill up the section; such situations often arise in lock-step instruction. In addition, if the minimum section size is greater than one, a recycling student may have to wait to take the event until the next group of students comes along.

Table 22, which deals with maximum and minimum section sizes for the teaching of team skills, suggests that if an instructor is the teaching agent the minimum section size can be one less than some multiple of the team size. This is because the instructor can usually substitute for a team member if necessary. For example, if the team size is four, minimums might be 3, 7, 11, etc. Choice of 3/4 (for example) minimum/maximum section size permits more flexibility in flow than does choice of 4/4 and is therefore recommended. In general, it is advisable to make the minimum section size strictly smaller than (rather than equal to) the maximum to permit more flexibility in student flow and to accommodate stray students.

The remarks in X.A.1 concerning combinations of learning events for assignment of maximum section size apply to the assignment of minimum section size as well.

ASSIGN TIME TO LEARNING EVENTS X.B

The time required (or set aside) for a learning event is affected by several interacting factors: the subject matter of the learning event, the capability and motivation of the student to learn the subject matter, administrative arrangements affecting the allocation of time to the event, and the method by which the event is taught (teaching agent-teaching format combination).

Considerations About Subject Matter X.B.1

Three characteristics of the subject matter in an individual learning event affect the time required to teach it: the gross amount of material to be learned, its complexity, and its familiarity to the average student. These characteristics, discussed at some length in Sec. II.B.2., are roughly reflected in MODIA's subject matter types 1 through 6. In fact, if the assignment of subject matter types reflects subject matter difficulty (complexity, amount, unfamiliarity), fundamental considerations of the time required for a learning event may have already been built into the course design.

Subject matter types 7 through 10 are a different story, however; because these concern the teaching of skills requiring the use (often the manipulation) of special resources, there are usually physical limits to the speed with which the skills can be performed and learned. For example, in teaching students to develop film, time must be allowed for the developer and fixative to act. Thus an intimate knowledge of the performance in question is required to establish minimum times for performance, to which the time for student learning must then be added. These remarks are most applicable to learning events of the guided practice, unguided practice, check practice, review, and test types.

Considerations About Students X.B.2

One aspect of subject matter difficulty is its familiarity to the students; students' basic ability and motivation to learn are also of consequence in determining the time required for instruction. An objective for diversifying the course by grouping or tracking is to put slower or less motivated students in separate groups so that more able students will not be held back. These points have been discussed in Sec. V.B.1. and will not be expanded further here.

Administrative Arrangements X.B.3

Course administration can be greatly simplified if teaching sessions come in multiples of some basic class period. For example, most lock-step instruction in ATC is geared to the 60-minute period, which includes a 10-minute break for students and instructors. This eases problems of scheduling the use of facilities and training equipment and makes it possible for instructors to plan regular work schedules

geared to detailed lesson plans. If such an approach is to be used, the times required for learning events should be arranged to fit into the desired periods. If not, such considerations need not enter into time assignments.

X.B.4 Considerations About Teaching Method

Variations in teaching method will have little effect on time requirements if administrative arrangements are the overriding consideration. When requirements for lock step instruction are lifted, however, different combinations of teaching format and teaching agent will have different effects on time requirements. Although the research is far from definitive on this score, the relationships displayed on Table 24 are consistent with ATC research.[1] Some of the reasons for the differences in these numbers have been discussed in Secs. VI.D.2 and 3. An example illustrates the use of the table. Suppose that it takes a student 35 minutes to complete a unit of linear programmed text. It should take an instructor, using the adaptive format, $.45/.75 \times 35 = 21$ minutes (approximately) to teach the student the same material.

Table 24

RELATIONS AMONG TIMES REQUIRED FOR MASTERY USING DIFFERENT TEACHING METHODS[a]

		Teaching Agent			
Teaching Format	SV Media?	Learner	Instructor	Response-paced Program	Adaptive Program
Simple/Recitation	Yes	.85	N/A	N/A	N/A
	No	1.00	.70	N/A	N/A
Response-paced	Yes	.75	N/A	.65	N/A
	No	.90	.55	.75	N/A
Adaptive	Yes	.60	N/A	N/A	.50
	No	.75	.45	N/A	.65

[a]Apply primarily to subject matter types 1-6 and to presentation/demonstration events in subject matter types 7-10.

Planners should bear in mind that Table 24 represents research results tied to specific subject matter and student populations; therefore, they should feel no constraint to adhere strictly to the numbers given. However, there are good reasons to believe that the *relationships* among the numbers are reasonable.

Note that even for the combination of instructor with simple format, there is some time saving when lock-step instruction is not used. This because the time for lock-step instruction must be padded at nearly every step so that unforeseen hitches in instruction will not interfere with the schedule.

[1] Harris et al., 1972; Keesler Technical Training Center, 1972; Amarillo Technical Training Center, 1964; HQ Air Training Command, 1967.

SV media are singled out in Table 24 because they are so commonly used and because they usually save time over the use of other media. This is because reading is inherently faster than listening for the average reader. Planners will already have assigned some form of audio for poor readers unless reading of particular words and phrases (as in Technical Orders) is being taught. In that event, the time savings suggested on the table will not be realized for poor readers.

Assign Maximum Relative Time X.B.5

For those learning events in which students may proceed at variable rates (maximum section size = 1), planners should estimate how long an individual student will be allowed to remain in the event. They supply this information in terms of a number greater than or equal to 1.0 for the appropriate learning events. This number, multiplied by the average time for the learning event, will give the maximum time allowed in minutes.

The number is usually administratively determined; students are not allowed to dally in a learning event forever. Therefore, if there is no diversification by grouping or tracking, it would be reasonable to enter the same number for all events. If there is diversification by grouping or tracking, planners may wish to choose T or SMGT as a combination for assignment of maximum time, allocating as much additional time for slower groups or tracks as they deem can be tolerated.

If maximum section size is greater than 1, the number entered for maximum relative time will have no effect. All students will require the average time to complete the event.

Assign Minimum Relative Time X.B.6

A similar technique is used to set the minimum time students will require for a learning event with maximum section size = 1; that is, a number less than or equal to 1.0 is entered as a multiplier of the average time. The considerations of what this multiplier might reasonably be are different, however. Obviously some time will be needed for any event a student is scheduled to take, even if it is just the time required for him to decide he already knows the subject matter. This can be a very short time indeed, perhaps only a minute or two out of a learning event that would ordinarily take an hour. If none of the students will be familiar with the course material, minimums may lie between .25 and .75, depending on the expected spread in student ability and physical limitations on performance. In general, achievable minimums are lower than most people expect, so it is wise to tend toward the low end of the scale. Exceptions will occur in subject matter types 7-10, where physical limitations set lower bounds on the time for performance.

Assignment of minimums should generally be made at a lower level of aggregation of learning events than assignment of maximums. As the foregoing discussion suggests, the combination SMLE or even SMLS might be a reasonable choice.

As with the maximum relative time, if the maximum section size is greater than 1, the number chosen for minimum relative time will have no effect.

NOTES

Appendix A

WORKSHEETS

WORKSHEET I--DESCRIBE OBJECTIVES

Table A

CODE AND SEQUENCE OBJECTIVES

Instructions: Column 1--Enter an alphanumeric code of 8 characters or less that will remind you of each objective or topic to be taught. Star (*) those that might be left out, if necessary (see Sec. II.A).[a]

Columns 2 and 3--Resequence the objectives listed in Column 1 if necessary and enter an alternative sequence in Column 3 if desired. Transfer the stars also (see Sec. II.B).

Column 4--(To be filled out later). List the code for each objective to be added on a separate line. On the same line, precede the code for the added objective with the code for the objective it follows. Then complete Table B of this Worksheet for the added objectives.

(1) Assign Codes	(2) *Resequence;* Add Repeats	(3) Alternative Sequence	(4) Enter Objectives From Worksheet IV, Table A, Part 2, Col. 1

[a]Section designators refer to basic text.

WORKSHEET I (CONT.)

Table A (Cont.)

(1) Assign Codes	(2) Resequence; Add Repeats	(3) Alternative Sequence	(4) Enter Objectives From Worksheet IV, Table A, Part 2, Col. 1

WORKSHEET I (CONT.)

Table B

ASSIGN SUBJECT MATTER TYPES AND SPECIAL RESOURCES TO OBJECTIVES

Instructions: Column 1--Enter codes from Columns 2 and 4 of Table A.

Column 2--Assign subject matter types in the order in which they will be taught (see Sec. II.C.).

Column 3--Enter alphanumeric codes (8 characters or less) for special resources to be used for objectives with subject matter types 7, 8, 9, or 10.

(1) Objective	(2) Subject Matter Type	(3) Special Resources

WORKSHEET 1 (CONT.)

Table B (Cont.)

(1) Objective	(2) Subject Matter Type	(3) Special Resources

Worksheet II

DESCRIBE TESTS AND TEST COVERAGE

(1) Test No.	(2) Code of Objective Test Follows	(3) Codes of Objectives Test Covers[a]	(4) S.M. Types of Objectives Covered (from Worksheet I, Table B)

[a]See Sec. III A., B., and C.

WORKSHEET II (Cont.)

DESCRIBE TESTS AND TEST COVERAGE

(1) Test No.	(2) Code of Objective Test Follows	(3) Codes of Objectives Test Covers[a]	(4) S.M. Types of Objectives Covered (from Worksheet I, Table B)

[a]See Sec. III A., B., and C.

WORKSHEET III--DESCRIBE STUDENT POPULATION

Table A

DESCRIBE STUDENT ENTRIES

(1) Option Description (See Sec. V.A)	(2) Check (✓) if Chosen	(3) If Column (2) Checked, Enter Variations to be Tried
Group Size : Fixed Arrival Interval : Fixed		Group Sizes : Arrival Interval (Hrs.):
Group Size : Varies Arrival Interval : Varies		Average Group Sizes : Average Arrival Interval (Hrs.) :
Group Size : Varies Arrival Interval : Fixed		Group Sizes: Average / Spread; Arrival Intervals (Hrs.)
Group Size : Fixed Arrival Interval: Varies		Group Sizes; Arrival Intervals (Hrs.): Average / Spread

WORKSHEET III (Cont.)

Table B

DESCRIBE STUDENT CATEGORIES

(1) Basis for Categorizing Students (Circle one)[a]	(2) Enter Designator of Characteristic (8 letters or less)	(3) No. of Categories (Circle one or more)	(4) Category ID	Percent of Students (5) Category	Percent of Students (6) Enter %	(7) Percent of Total Failures[b]
Ability		2	S	S		
			F			
		3	S	S		
			A	A		
			F			
		4	S	S		
			S	S´		
			F´	F´		
			F			
Other characteristic		2	NC	C		
			C			
Ability and another characteristic		4	SNC	S		
			SC	C		
			FNC			
			FC			

[a]See Sec. V.C. [b]See Sec. VII.

WORKSHEET IV--DESCRIBE TEACHING POLICY

1. If two or more tracks of students will be taught on the same shift, complete Table A, below.

2. If content will be diversified, complete Worksheet IV, Table B.

3. If teaching method will be diversified for different tracks/ groups of students, complete Worksheet IV, Table C.

Table A

ALLOCATE STUDENT CATEGORIES TO TRACKS

(1) Track No.	(2) Student Categories in Track[a] (from Worksheet III, Table B, Column 4)	(3) Alternative Allocation
1		
2		
3		
4		

[a]See Sec. VI.B.1.

WORKSHEET IV (CONT.)

Table B

DESIGNATE OBJECTIVES SKIPPED BY STUDENT CATEGORIES

Part 1

OBJECTIVES SKIPPED IN PROFICIENCY ADVANCE

Instructions: Column 1--List codes and subject matter types for objectives to be skipped from Worksheet I, Table B, Columns 1 and 2. (See Sec. III.F.)

Column 2--Enter categories from Worksheet III, Table B, Column 4.

(1) Objectives and Subject Matter Types Skipped	(2) Students Skipping

WORKSHEET IV (Cont.)

Table B (Cont.)

Part 2

OBJECTIVES ADDED FOR SPECIAL STUDENTS

Instructions: Column 1--List code for objective to be added for special students. Also enter on Worksheet I, Table A, Column 4. (See Sec. V.B.2.)

Column 2--Enter categories from Worksheet III, Table B, Column 4.

Column 3--Enter categories of students not listed in Column 2.

(1) Objective Added	(2) Students for Whom Added	(3) Students Skipping

WORKSHEET IV (Cont.)

Table B (Cont.)

Part 3

OBJECTIVES SKIPPED FOR OTHER REASONS

Instructions: Column 1--List codes for objectives and subject matter type to be skipped from Worksheet I, Table B, Columns 1 and 2. (See Sec. V.B.2.a.)

Column 2--Enter categories from Worksheet III, Table B, Column 4.

(1) Objectives and Subject Matter Types Skipped	(2) Students Skipping

WORKSHEET IV (Cont.)

Table C

DESIGNATE DIVERSIFICATION OF METHOD FOR SUBJECT MATTER TYPES[a]

Instructions: Column (1) -- Enter **subject matter types** for which **teaching method** is diversified. Column (2) -- For each **subject matter type** listed in Column (1), allocate student categories (Worksheet III, Table B, Column 4) to groups to be used for diversification. Column (3) -- Enter sequence of learning event types to be used for each student group.

(1) Subject Matter Type with Diversified Method	(2) Student Categories Allocated to Groups	(3) Sequence of Learning Event Types

[a]See Sec. VI.B.3.

WORKSHEET V--SELECT SPECIFIC MEDIA SYSTEMS

TABLE A--RELATE UI AND RUM OUTPUT TO SELECT SPECIFIC MEDIA SYSTEMS

(See Sec. VIII.G.2.)

Instructions from Column (13): Use information from Columns (1), (6), (7), and (10) to identify sets of appropriate media systems on Worksheet V, Table B. Next, choose a specific media system from the set of appropriate systems.

	Output from RUM (Enter from Output Report 2[a])			User Decision
(1-9) Attach Summary of Media Use from UI	(10) Maximum Section Size Achieved	(11) Maximum No. of Concurrent Sections	(12) Maximum No. of Students	(13) Specific Media Systems

[a]Discussed in detail in R-1703-PR.

Worksheet V (Cont.)

Table B

APPROPRIATE MEDIA SYSTEMS FOR COMBINATIONS OF MEDIA CLASS, GROUP SIZE, TEACHING FORMAT, AND TEACHING AGENT[a]

MEDIA CLASS	GROUP SIZE	TEACHING FORMAT	TEACHING AGENT	MEDIA HARDWARE NUMBERS
AMV	24-100	AF	I	(56+57+54+10) (56+57+54+11) (56+57+54+12)
AMV	10-24	AF	I	(56+15[b]+57+63) (56+17[b]+57+63) (56+15[b]+57+54) (56+17[b]+57+54)
AMV	4-10	AF	I	(56+14[b]) (56+14[b]+55) (56+14[b]+57) (55+14[b]+57+55) (56+16[b]) (56+16[b]+55) (56+16[b]+57) (56+16[b]+57+55) (56+14[b]+34) (56+14[b]+57+54) (56+16[b]+54) (56+16[b]+57+54)
AMV	1-3	AF	I	(56) (56+46[b])
AMV	1	AF	L	(56)
AMV	1	AF	AP	(56+58+53)
AMV	30-150	RF	I	(6+10+57+54) (7+10+57+54) (6+11+57+54) (7+11+57+54) (8+12+57+54) (9+12+57+54)
AMV	10-30	RF	I	(6+15[b]+57+55) (7+15[b]+57+55) (8+17[b]+57+55) (9+17[b]+57+55) (6+15[b]+57+54) (7+15[b]+57+54) (8+17[b]+57+54) (9+17[b]+5 +54)
AMV	4-10	RF	I	(6+14[b]) (7+14[b]) (6+14[b]+55) (7+14[b]+55) (6+14[b]+57) (7+14[b]+57) (6+14[b]+57+55) (7+14[b]+57+55) (8+16[b]) (9+16[b]) (8+16[b]+55) (9+16[b]+55) (8+16[b]+57) (9+16[b]+57) (8+16[b]+57+55) (9+16[b]+57+55) (6+14[b]+54) (7+14[b]+54) (6+14[b]+56+54) (7+14[b]+57+54) (8+16[b]+54) (9+16[b]+54) (8+16[b]+57+54) (9+16[b]+57+54) (6) (7) (6+13[b]) (7+13[b])
AMV	1-3	RF	I	(6) (7) (6+13[b]) (7+13[b])
AMV	1	RF	L	(6) (7)
AMV	1	RF	RP	(58+53+6) (58+53+7)
AMV	30-150	R	I	(3+54) (6+10+54) (7+10+54) (6+11+54) (7+11+54) (8+12+54) (9+12+54)
AMV	10-30	R	I	(2+55) (2+54) (6+15[b]+55) (7+15[b]+55) (8+17[b]+55) (9+17[b]+55) (6+15[b]+54) (7+15[b]+54) (8+17[b]+54) (9+17[b]+54)

Worksheet V, Table B (cont.)

MEDIA CLASS	GROUP SIZE	TEACHING FORMAT	TEACHING AGENT	MEDIA HARDWARE NUMBERS
AMV	4-10	R	I	(2) (2+55) (2+54) (6+14[b]) (7+14[b]) (6+14[b]+55) (7+14[b]+55) (8+16[b]) (9+16[b]) (8+16[b]+55) (9+16[b]+55) (6+14[b]+54) (7+14[b]+54) (8+16[b]+54) (9+16[b]+54)
AMV	1-3	R	I	(1) (6) (7) (6+13[b]) (7+13[b])
AMV	1	R	L	(1)
AMV	>150	S	I	(4)
AMV	30-150	S	I	(3) (6+10) (7+10) (6+11) (7+11) (8+12) (9+12)
AMV	10-30	S	I	(2) (6+15[b]) (7+15[b]) (8+17[b]) (9+17[b])
AMV	4-10	S	I	(2) (6+14[b]) (7+14[b]) (8+16[b]) (9+16[b])
AMV	1-3	S	I	(1) (6) (7) (6+13[b]) (7+13[b])
AMV	1	S	L	(1)
MV[c]	4-30	S	I	(27)
MV	1-3	S	I	(26)
MV	1	S	L	(26)
ASV	10-30	AF	I	(22+54)
ASV	4-10	AF	I	(21+54)
ASV	1-3	AF	I	(21)
ASV	1	AF	L	(24)
ASV	1	AF	AP	(25)

Worksheet V, Table B (cont.)

MEDIA CLASS	GROUP SIZE	TEACHING FORMAT	TEACHING AGENT	MEDIA SYSTEM NUMBERS
ASV	10-30	RF	I	(20+54) (22+54)
ASV	4-10	RF	I	(19) (21) (22) (19+54) (21+54) (22+54)
ASV	1-3	RF	I	(18) (21)
ASV	1	RF	L	(23)
ASV	1	RF	RP	(25)
ASV	10-30	R	I	(20) (22) (20+54) (22+54)
ASV	4-10	R	I	(19) (21) (22)
ASV	1-3	R	I	(18) (21)
ASV	1	R	L	(18) (21)
ASV	10-30	S	I	(20) (22)
ASV	4-10	S	I	(19) (21) (22)
ASV	1-3	S	I	(18) (21)
ASV	1	S	L	(18) (21)
A	?	AF	I	CHECK LEARNING LAB EQUIPMENT
A	1	AF	L	(52)
A	1	AF	AP	UNKNOWN
A	4-30	RF	I	(51+54) (49+54)
A	1-3	RF	I	(50)
A	1	RF	L	(50)
A	1	RF	RP	UNKNOWN

Worksheet V, Table B (cont.)

MEDIA CLASS	GROUP SIZE	TEACHING FORMAT	TEACHING AGENT	MEDIA SYSTEM NUMBERS
A	4-30	R	I	(51) (48) (49) (51+54) (49+54)
A	1-3	R	I	(50) (48)
A	1	R	L	(50) (48)
A	4-30	S	I	(48) (51) (49)
A	1-3	S	I	(50) (48)
A	1	S	L	(50)
SV	>30	AF	I	(40+54) (37+54)
SV	10-30	AF	I	(38+55) (36+54)
SV	4-10	AF	I	(38+55) (36) (36+54)
SV	1-3	AF	I	(38) (36)
SV	1	AF	L	(59) (42)
SV	1	AF	AP	(44)
SV	>150	RF	I	(40+54) (35+54)
SV	30-150	RF	I	(39+54) (34+54)
SV	10-30	RF	I	(31+55) (38+55) (33+55) (31+54) (38+54) (33+54)
SV	4-10	RF	I	(30) (38) (33) (30+55) (38+55) (33+55) (30+54) (38+54) (33+54)
SV	1-3	RF	I	(28) (29) (32) (38)
SV	1	RF	L	(60) (41)
SV	1	RF	RP	(43)

Worksheet V, Table B (cont.)

MEDIA CLASS	GROUP SIZE	TEACHING FORMAT	TEACHING AGENT	MEDIA SYSTEM NUMBERS
SV	>150	R	I	(40+54) (35+54)
SV	30-150	R	I	(39+54) (34+54)
SV	10-30	R	I	(31+55) (38+55) (33+55) (31+54) (38+54) (33+54)
SV	4-10	R	I	(30) (38) (33) (30+55) (38+55) (33+55) (30+54) (38+54) (33+54)
SV	1-3	R	I	(28) (29) (32) (38)
SV	1	R	L	(61)
SV	>150	S	I	(40) (35)
SV	30-150	S	I	(39) (34)
SV	10-30	S	I	(31) (38) (33)
SV	4-10	S	I	(30) (38) (33) (47)
SV	1-3	S	I	(28) (32) (38) (29) (47)
SV	1	S	L	(62)

[a]Media hardware numbers refer to Worksheet V, Table C. Systems are listed in order of increasing cost.

[b]Not sure that this accepts videotape recorder input.

[c]All AMV systems can be used in the MV mode.

Worksheet V (Cont.)

Table C

SELECTED MEDIA HARDWARE TYPES[a]

No.	Media Class	Hardware Type
	AMV	Sound Motion Picture Projectors/Viewers
1		Individual Viewer
2		Classroom Projector
3		Large Classroom or Small Auditorium Projector
4		Auditorium Projector
5		Variable Speed Viewer
		Videotape Recorders and Players
6		Monochrome (1/2 inch tape)
7		Monochrome (1 inch tape)
8		Color (1/2 or 3/4 inch tape)
9		Color (1 inch tape)
		Video Projectors
10		Monochrome, Low Cost
11		Monochrome, High Cost
12		Color
		Video Monitors and Receivers
13		Monochrome, Individual Monitor
14		Monochrome, Group Receiver and/or Monitor
15		Monochrome, Classroom Receiver and/or Monitor
16		Color, Group Receiver and/or Monitor
17		Color, Classroom Receiver and/or Monitor
	ASV	Sound Filmstrip Projectors/Viewers
18		Individual Viewers
19		Group Projector
20		Classroom Projector
		Sound Slide Projectors/Viewers (2 x 2")
21		Individual and Group Projector/Viewer
22		Classroom Projector
		Individual Audio Still Visual Teaching Machines
23		Learner Control of Rate of Presentation
24		Learner Control of Content of Presentation
25		Machine Control of Rate of Presentation
	MV	Silent Motion Picture Projectors/Viewers
26		Individual Viewer
27		Classroom Projector

Table C (Continued)

SELECTED MEDIA HARDWARE TYPES[a]

No.	Media Class	Hardware Type
	SV	Silent Filmstrip Projectors/Viewers
28		Individual Viewer, Low Cost
29		Individual Viewer, High Cost
30		Group Projector
31		Classroom Projector
		Silent Slide Projectors/Viewers (2 x 2")
32		Individual Viewer
33		Classroom Projector
34		Large Classroom or Small Auditorium Projector
35		Auditorium Projector
		Random Access Access Slide Projectors
36		Classroom Projector
37		Auditorium Projector
		Overhead Projectors
38		Classroom
39		Large Classroom or Small Auditorium
40		Auditorium
		Individual Still Visual Teaching Machine
41		Learner Control of Rate of Presentation
42		Learner Control of Content of Presentation
43		Machine Control of Rate of Presentation
44		Machine Control of Content of Presentation
		Microform Readers
45		Microfilm Reader
46		Microfiche Reader
47		Chalkboard or charts
48	A	Audio Disc Players (Monaural)
		Audio Tape Recorders and Players (Monaural)
49		Reel-to-Reel Classroom
50		Cassette, Individual
51		Cassette, Classroom
52		Individual Audio Teaching Machine with Learner Control of Content of Presentation

Table C (Continued)

SELECTED MEDIA HARDWARE TYPES

No.	Media Class	Hardware
53	Response Devices	Terminal for Student Response
54		Student Response Monitor
55		Show of Cards or Other Method of Response Display of Negligible Cost
56	AMV[b] (Programmed)	Videotape Player with Random Access Coding On Tape
57		Remote Control for Above
58		Computer Software for Control of Above
59	Printed Materials	Text or Workbook, Adaptive (branching) format
60		Text or Workbook, Response-Paced (linear) format
61		Text or Workbook, Recitation Format (Consists Largely of Exercises)
62		Text, Simple (Conventional) Format

[a]Performance characteristics of these typical models are in Appendix B.

[b]May require engineering development.

WORKSHEET VI--ASSIGN AVERAGE TIME

If lock step instruction will be used, enter the basic instruction period in minutes _____.

Table A

ASSIGN AVERAGE TIME TO COMBINATIONS OF LEARNING EVENTS

For instructions, see next page. (See Sec. X.B.5)

(1) Choose Assignment Basis		(2) List Course Elements	First Time Estimate (3) Teach. Agent	(4) Teach. Format	(5) Student Group/ Track	(6) Time (min.)	Adjusted Time Estimate (7) Teach. Agent	(8) Teach. Format	(9) Student Group/ Track	(10) Time (min.)
W	B									
SM	T									
LET	SMGT									
SMLE	SMLS									
LE										

Worksheet VI (Cont.)

Table A (Cont.)

(1) Chosen Assignment Basis	(2) List Course Elements	First Time Estimate (3) Teach. Agent	(4) Teach. Format	(5) Student Group/ Track	(6) Time (min.)	Adjusted Time Estimate (7) Teach. Agent	(8) Teach. Format	(9) Student Group/ Track	(10) Time (min.)
W B									
SM T									
LET									
SMGT									
SMLE									
SMLS									
LE									

Instructions for Worksheet VI, Table A

Column (1)--Choose the basis for assigning average time. If diversification is used, the basis should probably include student groups or tracks.

Column (2)--List the combinations of learning events associated with the basis chosen from Worksheet VI, Table B.

Columns (3)-(6)--Next enter in Column (6) an estimate of the time in minutes required for each element of the course associated with the basis chosen. This estimate should reflect the teaching method (Teaching Agent-Teaching Format combination) and student population with which you are most familiar, be it conventional classroom instruction or self-paced instruction with programmed text. Note in Columns (3)-(5) on the worksheet the Teaching Agent-Teaching Format Student Group/Track combination represented. This is particularly important if lock-step instruction is not being planned and the course is being designed to use teaching methods with which you are less familiar or if the course is to be diversified by grouping or tracking.

Columns (7)-(10)--It is quite likely that if the course design is at all complex you will not know the effect of previous decisions in sufficient detail to recall which learning events will be taught to which categories of students using what teaching methods. If this is the case, it would be wiser to wait to adjust time estimates until the UI can present this information while you are at the console. Then you can use the entries on Worksheet VI, Table A, along with Table C to adjust the time estimates. An example illustrates how adjustments may be made:

First Time Estimate				Adjusted Time Estimate			
(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teach. Agent	Teach. Format	Student Group/ Track	Time (min.)	Teach. Agent	Teach. Format	Student Group/ Track	Time (min.)
I	R	A	60	L	RF	S	64
				L	RF	A	55
				L	RF	F	51

Since Table C applies to slow or undifferentiated students, it may be used directly to adjust the time for slow students as follows:

$$\text{adjusted time} = \frac{.75}{.70} \times 60 = 64 \text{ min. (approx.)}$$

The time for fast students could be derived from an estimate that self-pacing reduces time for bright students from lock-step instruction by at least 15 percent, resulting in an estimate of .85 x 60 = 51 min. (approx.). The average students fall between these two figures with a reduction over lock-step instruction of between 5 and 10 percent at, say, 55 min. (approx.).

Worksheet VI (Cont.)

Table B

LEARNING EVENT COMBINATIONS ASSOCIATED WITH RESOURCE ASSIGNMENT BASIS

(1) Assignment Policy	(2) Combinations	
W, N	All, None	
B	Blocks 1, 2, ... N; User defines by beginning and ending L.E.s	
SM	Subject matter types 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
T	Tracks 1, 2, 3, and/or 4 as selected by user	
LET	P, GP, UP, GD, CP, R, T, C, H	
SMGT	Subject matter type:	Track/Group:
	1	1, 2, 3, 4
	2	1, 2, 3, 4
	3	1, 2, 3, 4
	4	1, 2, 3, 4
	5	1, 2, 3, 4
	6	1, 2, 3, 4
	7	1, 2, 3, 4
	8	1, 2, 3, 4
	9	1, 2, 3, 4
	10	1, 2, 3, 4
SMLE	Subject matter type:	Learning Event Type:
	1	P, GD, CP, R, T, C, H
	2	P, GD, CP, R, T, C, H
	3	P, GP, UP, GD, CP, R, T, C, H
	4	P, GP, UP, GD, CP, R, T, C, H
	5	P, GP, UP, GD, CP, R, T, C, H
	6	P, GP, UP, GD, CP, R, T, C, H
	7	P, GP, GD, CP, R, T, C, H
	8	P, GP, GD, CP, R, T, C, H
	9	P, GP, GD, CP, R, T, C, H
	10	P, GP, GD, CP, R, T, C, H

WORKSHEET VI (Cont.)

Table C

RELATIONS AMONG TIMES REQUIRED FOR MASTERY USING DIFFERENT TEACHING METHODS[a]

Teaching Format	SV Media ?	Learner	Instructor	Response-paced Program	Adaptive Program
Simple/ Recitation	Yes	.85	N/A	N/A	N/A
	No	1.00	.70	N/A	N/A
Response-paced	Yes	.75	N/A	.65	N/A
	No	.90	.55	.75	N/A
Adaptive	Yes	.60	N/A	N/A	.50
	No	.75	.45	N/A	.65

[a]For slow students or undifferentiated students. Apply primarily to subject matter types 1-6 and to presentation/demonstration events in subject matter type 7-10.

Appendix B

CHARACTERISTICS OF TYPICAL CLASSROOM MEDIA HARDWARE

This appendix contains characteristics of the typical classroom media hardware types referred to in Table C, Worksheet V. It has been based on a sampling of hardware contained in *The Audio-Visual Equipment Directory*. The objective was to classify media hardware so as to be useful to course planners who may not be media experts. However, this analysis did not attempt to make quality judgments.

A. AUDIO MOTION VISUAL

Sound Motion Picture Projectors

Individual Viewer

Cost range: $175 to 500; average: $335
Screen width: 6 to 16 inches
Sound amplifier power: less than 10 watts
Sound method: primarily magnetic; alternative method: optical
Maximum program length: 6 to 30 minutes depending on type of cartridge used
Threading system: continuous-loop cartridge
Film: Super 8
Weight: up to 45 pounds; portable
Maximum audience: 1 to 3 people

Classroom Projector

Cost range: $145 to 1000; average: $510
Screen width: 3 to 4 feet
Sound amplifier power: Less than 10 watts
Sound method: magnetic
Maximum program length: open-reel projectors: 40 minutes; cartridge type: 30 minutes or less
Threading system: equally likely to be self-threaded or cartridge-loaded
Film: Super 8
Weight: less than 27 pounds; portable
Maximum audience: 30 people

Large Classroom or Small Auditorium Projector

Cost range: $710 to 1350; average: $990
Screen width: 4 to 8 feet
Sound amplifier power: 10 to 20 watts
Sound method: primarily optical; alternative method: magnetic
Maximum program length: at least 55 minutes
Threading system: manual
Film: 16 mm
Weight: 28 to 45 pounds; portable
Maximum audience: 150 people

Auditorium Projector

Cost range: $670 to 3995; average: $2160
Screen width: 8 feet and over
Sound amplifier power: over 20 watts
Sound method: optical; alternative method: magnetic
Maximum program length: at least 55 minutes
Threading system: equally likely to be manual or self-threaded
Film: 16 mm
Weight: over 45 pounds; stationary
Maximum audience: over 150 people

Variable Speed Viewer

These systems present motion pictures where motion is needed and stop on single frames when motion is not required. Meanwhile, a separate sound cassette continues running and, with nonaudible pulses on a second track, controls the visual presentation. Because still frames (or long-frame-period), motion pictures are common, large savings in film footage are possible (manufacturer's estimate: 25 percent reduction).

Cost range: $280 to 495; average: $410
Film: super 8 mm in continuous-loop cartridge or in special reel-to-reel cassette
Screen size: 4 x 6" to 6 x 8" (built-in); one sample model can also front project 40 x 40" image
Sound source: cassette
Maximum program length: 45 minutes
Weight: 14 to 25 pounds; portable
Maximum audience: 1 to 3 people; 30 people for model with front projection capability

Videotape Recorders and Players

Monochrome (1/2 inch)

Cost range: $595 to 2250; average: $1220
Tape size: 1/2 inch
Maximum program time: 60 minutes
Threading: primarily reel-to-reel; alternative method: cassette
Recording capability: all models
Resolution: 300 lines (center)
Weight: 29 to 58 pounds; portable

Monochrome (1 inch)

Cost range: $1650 to 5950; average: $3465
Tape size: 1 inch
Maximum program time: 60 minutes
Threading: reel-to-reel
Recording capability: most models
Resolution: 300 to 400 lines (center)
Weight: 73 to 78 pounds; portable

Color (1/2 or 3/4 inch)

Cost range: $875 to 1745; average: $1310
Tape size: 1/2 or 3/4 inch
Maximum program time: 30 to 60 minutes
Threading: primarily cassette; alternative method: reel-to-reel
Recording capability: most models
Resolution: 240 lines (center)
Weight: 31 to 64 pounds; portable

Color (1 inch)

Cost range: $2150 to 8000; average: $5340
Tape size: 1 inch
Maximum program time: 60 minutes
Threading: primarily reel-to-reel; alternative method: cassette
Recording capability: all models
Resolution: 300 to 400 lines (center)
Weight: 45 to 110 pounds; portable

Video Projectors

Monochrome, Low Cost

Cost range: $3000 to 7800; average: $4350
Inputs: CCTV, videotape recorder, and "off-the-air" broadcast
Resolution: 300 to 600 lines
Picture Size: can produce 12-foot wide picture in a dark auditorium
Weight: 322 to 900 pounds; stationary
Maximum audience: 150 people

Monochrome, High Cost

Cost range: $11,000 to 30,000; average: $20,500
Inputs: CCTV, videotape recorder, and "off-the-air broadcast"
Resolution: 600 lines
Picture Size: can produce 12-foot wide picture in a dark auditorium
Weight: 450 to 460 pounds; stationary

Color

Cost range: $16,500 to 43,000; average: $32,510
Inputs: CCTV, videotape recorder, and "off-the-air broadcast"
Resolution: 320 to 600 lines
Picture Size: can produce 12-foot wide picture in a dark auditorium
Weight: 322 to 900 pounds; stationary

Video Monitors/Receivers

Monochrome, Individual Monitor

Cost range: $165 to 335; average: $245
Screen size: 4 to 11 inches
Inputs: primarily CCTV
Sound output: generally 3" (round) speakers, side-mounted
Weight: 9 to 20 pounds
Maximum audience: 1 to 3 people

Monochrome, Group Receiver and/or Monitor

Cost range: $130 to 445; average: $250
Screen size: 12 to 17 inches
Inputs: most models CCTV and UHF/VHF
Sound output: generally 3 x 5" (oval) speakers, side-mounted
Weight: 9 to 20 pounds
Maximum audience: 1 to 3 people

Monochrome, Group Receiver and/or Monitor

Cost range: $130 to 445; average: $250
Screen size: 12 to 17 inches
Inputs: most models CCTV and UHF/VHF
Sound output: generally 3 x 5" (oval) speakers, side or front-mounted
Weight: 15 to 41 pounds; portable
Maximum audience: 10 people

Monochrome, Classroom Receiver and/or Monitor

Cost range: $195 to 630; average: $350
Screen size: 22 to 23 inches
Inputs: generally CCTV and UHF/VHF
Sound output: 4 to 6" (round) speakers, front-mounted
Weight: 16 to 95 pounds; generally stationary
Maximum audience: 30 people

Color, Group Receiver and/or Monitor

Cost range: $550 to $745; average: $615
Screen size: 12 to 19 inches
Inputs: CCTV and UHF/VHF
Sound output: 3 to 4" (round) speakers, front-mounted
Weight: 42 to 70 pounds; generally portable
Maximum audience: 10 people

Color, Classroom Receiver and/or Monitor

Cost range: $480 to 850; average: $640
Screen size: 25 inches
Inputs: CCTV and UHF/VHF
Sound output: 4 x 6" to 5 x 7" (oval) speakers, front-mounted
Weight: 120 to 133 pounds; stationary
Maximum audience: 30 people

B. AUDIO STILL VISUAL

Sound Filmstrip Projectors/Viewers

Individual Viewer

Cost range: $100 to 365; average: $235
Screen size: 3 x 4" to 9 x 12" (built-in)
Projects: 35 mm filmstrip
Sound source: primarily cassette; alternative methods include audio disc and continuous-loop cartridge
Sound output: 2" (round) to 4 x 6" (oval) speaker
Operation: primarily automatic (nonaudible pulse superimposed on audio track); alternative: manual
Weight: 6 to 30 pounds; portable
Maximum audience: 1 to 3 people

Group Projector

Cost range: $125 to 490; average: $285
Screen size: 9 x 12" to 11 x 15" (built-in or contained in cover)
Projects: 35 mm filmstrip
Sound source: primarily cassette; alternative methods include audio disc and continuous-loop cartridge
Sound output: 2" (round) to 4 x 6" (oval) speakers
Operation: equally likely to be manual or automatic
Weight: 7 to 32 pounds; portable
Maximum audience: 10 people

Classroom Projector

Cost range: $315 to 500; average: $385
Projects: 35 mm filmstrip
Sound source: primarily cassette; alternative method: audio disc
Sound output: 3 x 6" to 6 x 9" (oval) speakers
Operation: manual or automatic with remote control
Weight: 18 to 25 pounds; portable
Maximum audience: 30 people

Sound Slide Projectors/Viewers (2 x 2 inch)

Individual and Group Projector

Cost range: $280 to 795; average: $445
Screen size: equally likely to require front projection screen or have built-in rear projection screen (ranging in size from 9 x 9" to 12 x 18")
Sound source: primarily cassette; alternative method: sound-on-slide clip
Sound output: 3" (round) to 6 x 9" (oval) speakers
Operation: primarily automatic with remote control; some manual
Weight: 12 to 35 pounds; portable
Maximum audience: 1 to 10 people

Classroom Projector

Cost range: $330 to 995; average: $505
Screen size: equally likely to require front projection screen or have built-in rear projection screen (ranging in size from 10 x 10" to 18 x 18")
Sound source: primarily cassette; alternative method: sound-on-slide clip
Sound output: 6" (round) to 4 x 10" (oval) speakers
Operation: automatic with remote control
Weight: 11 to 45 pounds; portable
Maximum audience: 30 people

Individual Audio Still Visual Teaching Machines

"Teaching machines present information via some audio, visual, or audio/visual unit which is integral to, or controlled by, the device. Generally, teaching machines employ a 'multiple choice' type of test. The user is required to indicate, by pressing a response button, a single-choice correct answer from a field of four or five possible answers. However, only a limited number of teaching machines employ branching type programs. In most cases pressing a 'wrong answer' button only results in a 'try again' direction to the learner."[1] Most teaching machines allow only *learner control of the rate of presentation*, often referred to as "self-paced instruction."

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[1] Brian G. Boucher et al., *Handbook and Catalog for Instructional Media Selection*, Educational Technology Publications, Englewood Cliffs, New Jersey, 1974, p. 43.

Learner Control of Rate of Presentation

Cost range: $235 to 995; average: $450
Type of response: primarily multiple choice; alternative method is constructed response. Response usually recorded on separate answer sheets, workbooks, or data processing cards, but some machines allow for recording responses (selected response only) on the program itself
Type of program: linear (response-paced)
Method of operation: either the machine or the learner stops the presentation until the learner responds or otherwise signals the machine to proceed
Visual display: primarily built-in rear projection screen ranging in size from 4 x 5" to 9 x 7"; alternative method is front projection
Picture source: primarily filmstrip; alternative methods are 35 mm slide or integrated audio visual combination cartridge
Sound source: primarily audiotape cassette; alternative methods are audio disc or integrated audio visual combination cartridge
Weight: 5 to 33 pounds; generally portable
Maximum audience: one person

Learner Control of Content of Presentation

Cost: $1950
Type of response: multiple choice
Type of program: branching (adaptive)
Method of operation: learner is supplied with branching directions for each answer that may be selected and advances the program to the point indicated
Visual display: built-in rear projection screen 4 x 6" in size
Picture source: 35 mm microfilm
Sound source: encoded audiotape cassette presented in a separate unit
Weight: visual unit 15 pounds, audio unit 30 pounds
Maximum audience: one person

Machine Control of Rate of Presentation

Cost range: $295 to 795; average: $510
Type of response: multiple choice. Response usually temporarily recorded on program itself; alternative methods are to record errors on a counter or to record answers on separate answer tape
Type of program: linear (response-paced)
Method of operation: program advances automatically upon receipt of correct answer
Visual display: primarily built-in rear projection screen about 4 x 8"; alternative method is front projection
Picture source: various--filmslide, filmstrip, or integrated audio still visual cartridge
Sound source: various--audio disc, audio tape cassette, or integrated audio still visual cartridge
Weight: 8 to 38 pounds; generally portable
Maximum audience: one person

C. MOTION VISUAL

Silent Motion Picture Projectors

Individual Viewer

Cost: $175
Screen: 4 x 6" (built-in)
Maximum program length: 4 minutes
Threading system: continuous-loop cartridge
Film: Super 8
Weight: 18 pounds; portable
Maximum audience: 1 to 3 people

Classroom Projector

Cost range: $145 to 255; average: $190
Maximum program length: 6 to 14 minutes
Threading system: continuous-loop cartridge
Film: Super 8
Weight: 10 to 15 pounds; portable
Maximum audience: 30 people

D. STILL VISUAL

Silent Filmstrip Projectors/Viewers

Individual Viewer, Low Cost

Cost range: $25 to 90; average: $50
Screen size: 3 x 4" to 6 x 9" (built-in)
Projects: 35 mm filmstrip
Operation: manual
Weight: 3 to 15 pounds; portable
Maximum audience: 1 to 3 people

Individual Viewer, High Cost

Cost range: $225 to 400; average: $310
Screen size: 5 x 6-1/2" to 14 x 14" (built-in)
Projects: 35 mm filmstrip
Operation: manual
Weight: 10 to 16 pounds; portable
Maximum audience: 1 to 3 people

Group projector

Cost range: $40 to 145; average: $65
Projects: 35 mm filmstrip; some also have 2 x 2" slide capability
Operation: manual
Weight: 4 to 9 pounds; portable
Maximum audience: 10 people

Classroom Projector

Cost range: $65 to 265; average: $135
Projects: 35 mm filmstrip; most also have 2 x 2" slide capability
Operation: manual; a few have remote control
Weight: 4 to 24 pounds; portable
Maximum audience: 30 people

Silent Slide Projectors/Viewers (2 x 2 inch)

Individual Viewer

Cost range: $85 to 110; average: $100
Screen size: built-in rear projection screen ranging in size from 7 x 7" to 8 x 8"
Capacity: 24 to 30 slides
Operation: manual
Weight: 7 to 20 pounds (portable)
Maximum audience: 1 to 3 people

Classroom Projector

Cost range: $40 to 880; average: $320
Screen size: some of models have built-in rear projection screens ranging in size from 14 x 14" to 16 x 25"; others require front projection screens
Capacity: 80 to 140 slides
Operation: primarily remote control, some manual only
Weight: 3 to 20 pounds; portable
Maximum audience: 30 people

Large Classroom or Small Auditorium

Cost range: $530 to 1530; average: $795
Capacity: 2, 80, or 140 slides
Operation: primarily remote control; a few manual only
Weight: 16 to 41 pounds; portable
Maximum audience: 150

Auditorium Projector

Cost range: $3500 to 3975; average: $3740
Capacity: 2 slides
Operation: manual
Weight: 300 to 500 pounds; fixed
Maximum audience: over 150 persons

Random Access Slide Projectors

A random-access projector is a slide projector in which a user may identify the storage location of a slide.

Classroom Projector

Cost range: $500 to 1915; average: $1070
Capacity: 80 slides
Search interval: 2 to 4 seconds
Weight: 15 to 63 pounds; portable
Maximum audience: 30 people

Auditorium Projector

Cost range: $1515 to 5950; average: $3215
Capacity: 50 to 500 slides
Search interval: 2.5 to 4 seconds
Weight: 28 to 180 pounds; portable and fixed
Maximum audience: 150 people and more

Overhead Projectors

Classroom

Cost range: $150 to 395; average: $210
Aperture size: 10 x 10"
Lamp power: 600 watts
Lens focal length: usually 14 inches
Weight: 16 to 36 pounds; portable
Maximum audience: 30 people

Large Classroom or Small Auditorium

Cost range: $255 to 900: average: $580
Aperture size: 10 x 10"
Lamp power: 600 to 1200 watts
Lens focal length: 8.5 to 16"; one sample model has adjustable focal length of up to 40" (for use at rear of room)
Weight: 17 to 54 pounds; portable
Maximum audience: 150 people

Auditorium

Cost range: $1800 to 3500; average: $2325
Aperture size: 10 x 10" up to 14 x 14" (for x-rays)
Lamp power: 1000 to 2000 watts
Lens focal length: 18 to 70"
Weight: in the 100 pound range; fixed
Maximum audience: over 150 people

Individual Still Visual Teaching Machines

Learner Control of Rate of Presentation

Cost range: $140 to 375; average: $270
Type of response: generally constructed; alternative method is multiple choice. Response recorded on separate answer sheet, punched card, workbook, or tape; alternate method is to record on program itself temporarily
Type of program: linear (response-paced)
Method of operation: either the machine or the learner stops the presentation until the learner responds or otherwise signals the machine to proceed
Visual display: primarily built-in rear projection screen ranging in size from 2 x 3" to 8-1/2 x 11"; alternate method is front projection
Picture source: primarily filmstrip cartridge; alternate method is filmstrip
Weight: 9-1/2 to 21 pounds; generally portable
Maximum audience: one person

Learner Control of Content of Presentation

Cost range: $220 to 825; average: $565
Type of response: multiple choice. Response recorded in machine memory or errors recorded on counter
Type of program: branching (adaptive)
Method of operation: learner is supplied with branching directions for each answer that may be selected and advances the program to the point indicated
Visual display: built-in rear projection screen size 4 x 6", magnifying viewer, or front projection
Picture source: encoded 35 mm microfilm or 35 mm slides
Weight: 13 to 15 pounds; plus 10 pounds if front projection used
Maximum audience: one person

Machine Control of Rate of Presentation

Cost range: $225 to 375; average: $300
Type of response: multiple choice. Errors recorded on counter
Type of program: linear (response-paced)
Method of operation: program advances automatically upon receipt of correct answer
Visual display: built-in rear projection screen about 7 x 10"
Picture source: filmstrips or slides
Weight: 5 to 25 pounds; portable
Maximum audience: one person

Machine Control of Content of Presentation

Cost: $1200
Type of response: multiple choice. Temporarily recorded on program
Type of program: branching (adaptive)
Method of operation: learner automatically provided with immediate feedback as to correctness of response and then sent to material appropriate to the response
Visual display: built-in rear projection screen 7 x 9"
Picture source: 35 mm filmstrip cassettes
Weight: 36 pounds
Maximum audience: one person

Microform Readers

Microform readers use built-in projection screens to magnify a reduced image back to its original size. The reduction ratio is at least 12 to 1 and usually 20 to 1 or greater. Micro*film* is generally a 16 or 35 mm filmstrip. Micro*fiche* is a film card usually 4 x 6" in size.

Microfilm Readers

Cost range: $370 to 770; average: $615
Operation: generally manual
Magnification: 24X
Screen size: 14 x 14"
Weight: 40 to 50 pounds; generally fixed
Notes: 2/3 of models are also fiche readers
Maximum audience: 1 person

Microfiche Readers

Cost range: $80 to 600; average: $235
Operation: manual
Magnification: 24X
Screen size: 8-1/2 x 11" to 14 x 14"
Weight: 3 to 80 pounds; mostly lightweight, portable
Maximum audience: 1 person

E. AUDIO

Audio Disc Players (Monaural)

Cost range: $55 to 325; average: $115
Maximum record size: generally 12 inches; a few will handle 16-inch discs
Compatibility: most stereo-compatible (that is, will not damage stereo discs)
Speeds: practically all have four speeds (16, 33-1/3, 45, and 78 rpm)
Headsets: most have headset provisions
Sound output: 4 x 6" (ovals) to 12" (round) speakers
Sound amplifier power: generally 4 to 40 watts
Weight: 8 to 41 pounds; portable
Maximum audience: 1 to 30 people

Audio Tape Recorders and Players (Monaural)

Reel-to-Reel, Classroom

Cost range: $165 to 280; average: $215
Maximum reel size: 7 inches
Recording capability: all sample models
Sound amplifier power: 8 to 25 watts
Speeds: 3-3/4 and 7-1/2" per second
Response: 50 to 20,000 Hz
Sound output: 3 x 6" to 4 x 10" (oval) speakers
Weight: 12 to 25 pounds; portable
Maximum audience: 30 people

Cassette, Individual and Group

Cost range: $30 to 85; average: $70
Speed: 1-7/8 inches per second
Recording capability: about half sample models
Sound amplifier power: 1/4 to 1-1/2 watts
Response: 200-4000 Hz to 50-10,000 Hz range
Headset provisions: nearly all sample models
Sound output: 2-1/2" to 4" (round) speakers
Weight: 2 to 11 pounds; portable
Maximum audience: 1 to 10 people

Cassette, Classroom

Cost range: $140 to 290; average: $200
Speed: 1-7/8 inches per second
Recording capability: nearly all sample models
Sound amplifier power: 8 to 25 watts
Response: 50 to 10,000 Hz range
Sound output: 4 x 8" to 6 x 9" (oval) speakers
Weight: 12 to 18 pounds
Maximum audience: 30 people

Individual Audio Teaching Machine with Learner Control of Rate of Presentation

Cost range: $186 to $470; average: $328
Response: constructed; no provisions for recording response
Program: linear (response-paced)
Method of operation: machine stops until learner restarts the presentation
Sound output: audiotape cassette
Weight: 6 lbs; portable
Maximum audience: one person

F. OTHER

Study Carrel

Cost range: $95 to 330; average: $160
Construction: all models are single position carrels with side panels, bookshelf, and AC power outlet
Dimensions: in 36 x 24" range
Height of working surface: 29 inches

Terminals for Student Response

Terminals for student response are connected to computers. They contain both the means by which the student enters his answers in the computer (input device) and the means by which the computer communicates with the student (display). Input devices typically are keyboards, either teletype or typewriter-like. Sometimes a light pen, a touch-sensitive surface, or an electronic tablet is used alone or in conjunction with a keyboard. The display is usually printed one character at a time as a teletype machine does (the "Type" medium) on paper (called "hard copy") or on the face of a cathode ray tube (CRT). If a terminal uses a light pen, touch-sensitive surface, or electronic tablet for input, it must use either a CRT or TV receiver for display.

Hard Copy Display

Cost:
Purchase range: $985-4995; average: $3400
Lease (annual) range: $600-2760; average: $1800
Maintenance (annual) range:[1] $300-540; average: $432
Line length: generally 132 characters; alternative is 80 characters
Type-out speed: generally 30 characters per second; alternatives are 10 and 120 characters per second
Weight: generally not portable but a few in 25 to 45 pound class are

[1] Maintenance usually included in lease, if leased.

Cathode Ray Tube Display

Cost:
Purchase range: $720-9000; average: $3640
Lease (annual) range: $588-3720; average: $1680
Maintenance (annual) range:[1] $120-480; average: $312
Visual display: screen size 8 x 4" to 7 x 10";
average is 8.75 x 5.7"
Line length: generally 80 characters
Number of lines: generally 24
Type-out speed: generally 1200 characters per second
Weight: usually stationary

Group Response Monitor

These receive, display, and summarize student responses to multiple choice questions entered through individual response units. Three or four choices may be provided. Responses are monitored on meters showing the number of students choosing a given answer, the number of correct answers, and other summary data. The more expensive of the two monitors described below also allows for instructor control of projection equipment through the same equipment.

Cost range: $720 (plus $17.50 per individual response unit) to $3656 (which includes the cost of 20 individual response units)
Weight: 6 pounds, portable (less expensive unit) to 200 pounds, stationary (more expensive unit)
Maximum audience: 100 (less expensive unit) to "any number" (more expensive unit)

[1] Maintenance usually included in lease, if leased.

Appendix C

ALLOCATING CATEGORIES OF STUDENTS TO TRACKS OR GROUPS

This appendix displays the ways in which categories of students can be allocated to tracks or groups when there are fewer tracks or groups than categories. (If the numbers of tracks or groups and categories are the same, each category forms a track or group). This can occur when students are placed in three or four categories on the basis of ability only or when students are categorized on the basis of both ability and another characteristic, which always results in four categories of students.

ABILITY ONLY

THREE CATEGORIES (S,A,F), TWO TRACKS/GROUPS

Option	Track/Group ID	Category ID
1	A	S,A
	F	F
2	S	S
	A	A,F
3	M[1]	S,F
	A	A

Option 1, in which a fast track or group is formed, might be used if there were an appreciable number of students who were far above the average and who could profit by being grouped together for similar instructional treatment. Retaining the differentiation between slow and average students in the average track or group allows some special treatment for slow students, if desired, but keeps the slow students with the average wherever group instruction will be used.

Option 2 is similar to Option 1 except that it allows slow students to be dealt with separately, rather than fast students. Option 3, in which slow and fast students are separated from the average, would be less likely to be used, as would any option containing a mixed

[1] Mixed.

track or group. It is included for completeness and because the planner might want to provide a highly individualized approach for such a combination but not for average students.

FOUR CATEGORIES (S,S',F',F), TWO TRACKS/GROUPS

Option	Track/Group ID	Category ID
4	S	S,S'
	F	F',F
5	A	S,S',F'
	F	F
6	S	S
	A	S',F',F
7[1]	M	S,S,F
	F	F'
8	M	S,F',F
	S'	S'
9	M	S,F'
	M'	S',F
10	M	S'F
	A	S',F'

Of these seven possibilities, Options 7, 8, and 9 would seem to have less utility. Options 5 and 6 are similar to Options 1 and 2 in the preceding set but permit even more differentiation of treatment within the average track or group. Similarly, Option 10 corresponds to Option 3, and permits more differentiation within the average track or group. Option 4 provides both a slower and faster track or group with differentiation possible within each.

[1]Options in shaded areas are included primarily for completeness.

FOUR CATEGORIES (S,S',F'F), THREE TRACKS/GROUPS

Option	Track/Group ID	Category ID
11	S	S,S'
	F'	F'
	F	F
12	S	S
	A	S',F'
	F	F
13	S	S
	S'	S'
	F	F',F
14	M	S,F
	S'	S'
	F'	F'
15	M	S,F'
	S	S'
	F	F
16	S	S
	M	S'
	F'	F'

Options 11-13 add the possibility of providing more diversity for students who are better than average (Option 11), average (Option 12) or poorer than average (Option 13). Option 14 is similar to Option 3 in the first set, except that average students are separated into a slower and faster track or group to facilitate diversification. Options 15 and 16 are less likely to be used.

ABILITY AND ANOTHER CHARACTERISTIC

FOUR CATEGORIES (SC, SNC, FC, FNC)

TWO TRACKS/GROUPS

Option	Track/ID	Category ID
17	S	SC, SNC
	F	FC, FNC
18	M	SC, SNC, FC
	FNC	FNC
19	SC	SC
	M	SNC, FC, FNC
20	M	SC, SNC, FNC
	FC	FC
21	M	SC, FNC, FC
	SNC	SNC
22	C	SC, FC
	NC	SNC, FNC
23 ////////////	M /////////	SC, FNC //
////////////	M' ////////	SNC, FC //
////////////////////////////////////		

Each of the above options might be useful in a particular circumstance except for, probably, the last one. The others have the effect of forming slower and faster tracks groups (Option 17), tracks/groups with and without the designated characteristic (Option 22), or separating a particular category of student from the others (Options 18-21).

FOUR CATEGORIES, THREE TRACKS/GROUPS

Option	Track/Group ID	Category ID
24	S	SC,SNC
	FC	FC
	FNC	FNC
25	SC	SC
	SNC	SNC
	F	FC,FNC
26	C	SC,FC
	SNC	SNC
	FNC	FNC
27	NC	SNC,FNC
	SC	SC
	FC	FC
28	SC	SC
	M	SNC,FC
	FNC	FNC
29	M	SC,FNC
	SNC	SNC
	FC	FC

Option 24 groups the slower students and Option 25 the faster; Option 26 groups the students with the chosen characteristic, and Option 27 groups those without it. Options 28 and 29 are less likely to be used.

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