DOCUMENT RESUME

ED 056 494		EM 009 350
AUTHOR	Horn, Robert E.; And Others	
TITLE	Information Mapping for Computer-Based Learning and Reference.	
INSTITUTION	Information Resources, Inc., Cambridge, Mass.	
SPONS AGENCY	Air Force Electronic Systems Div. L.G. Hanscom Field, Mass.	
REPORT NO	ESD-TR-71-165	
PUB DATE	Mar 71	
NOTE	167p.	
AVAILABLE FROM	Information Resources, Inc., 1675 Massachusetts Avenue, Cambridge, Massachusetts 02138 ($4.95)	
EDRS PRICE	MF-$0.65 HC-$6.58	
DESCRIPTORS	*Computer Assisted Instruction; *Display Systems; Documentation; Human Engineering; *Individualized Instruction; *Information Retrieval; *Information Systems; Library Reference Services; Man Machine Systems; Programed Instruction; Teaching Methods; Training Techniques	
IDENTIFIERS	*Information Mapping	

ABSTRACT

A new conception of computer-based instructional systems is presented in this design of a system that can deliver individualized information sequences not only to learners and trainees, but to reference workers, reviewers, etc. Underlying the system is a flexible data base organized into labelled, movable information blocks according to the principles of "information mapping"-- a system for categorizing and displaying information. This report itself is written in modified information-mapping style. A significant feature of this computerized information service is that the control of information selection and arrangement can be assigned entirely to the user, entirely to the system, or to both in one of the many possible patterns of shared responsibility. When the system takes part in information-sequencing decisions, its many mechanisms for individualizing come into play. The executive program consults short-term and long-term data about the individual, his objectives, capabilities, interests, and present status before it selects and arranges blocks from the data base to display for him. Evaluation and feedback are also individualized. The system's capability for controlling conditions and recording user-system interactions make it suitable for research on individualization in education. (Author)

ESD-TR-71-165

INFORMATION MAPPING FOR COMPUTER-BASED LEARNING AND REFERENCE

Robert E. Horn
Elizabeth H. Nicol
Richard A. Roman, et al

March 1971

DEPUTY FOR COMMAND AND MANAGEMENT SYSTEMS
HQ ELECTRONIC SYSTEMS DIVISION (AFSC)
L. G. Hanscom Field, Bedford, Massachusetts 01730

(Prepared under Contract No. F19628-70-C-0103 by Information Resources, Inc. 1675 Massachusetts Avenue, Cambridge, Massachusetts 02138.)

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FOREWORD

This research was conducted under Project 2801, Information System Design Methodology; Task 280104, Computer-Aided Instruction Techniques. The objective of this task is to develop design principles and specifications for automated systems which support training and performance-aiding. Such systems can be built into Air Force computer-based information systems and used in a time-sharing mode for on-site training and performance-aiding of system personnel; or they can be used in Air Force resident schools for training the student population.

This report is one in a series supporting Task 280104. It is the second of two reports on a systematized technique for formatting and sequencing training and performance-aiding information. The study was aimed primarily at a specification methodology for dynamic information displays sequenced by a computer. The principles involved are also applicable to conventional hard copy information display, e.g., military manuals.

This design study was carried out between November 1969 and February 1971 under Contract No. F19628-70-C-0103 with Information Resources, Inc. Cambridge, Massachusetts. Project staff members and their areas of responsibility were: Robert E. Horn, who directed the project and undertook documentation and classification functions; Richard A. Roman, who was primarily responsible for the design of the executive control program (the sequence generator) and the command language; Elizabeth H. Nicol, general project consultant, who was engaged in planning, analysis, and evaluative functions and who wrote the final report; Margaret P. Razar, who served as project coordinator and who wrote extensive system documentation.

The Air Force Task Scientist and Contract Monitor was Sylvia R. Mayer.

Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published for the exchange of information and stimulation of ideas.

Sylvia R. Mayer

SYLVIA R. MAYER, Ph.D
Project Officer, Project 2801

EDMUND P. GAINES, JR., Col, USAF
Director, Systems Design & Development
Deputy for Command & Management Systems

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ABSTRACT

A new conception of computer-based instructional systems is presented in this design of a system that can deliver individualized information sequences not only to learners and trainees, but to reference workers, reviewers, browsers and the like. Underlying the system is a flexible data base, organized into labelled, movable information blocks according to the principles of Information Mapping--a system for categorizing and displaying information. This report is itself written in modified Information-Mapping style. A significant feature of this computerized information service is that the control over information selection and arrangement can be assigned entirely to the user, entirely to the system, or to both in one of many possible patterns of shared responsibility. When the system takes part in information-sequencing decisions, its many mechanisms for individualizing come into play. The executive program consults short-term and long-term data about the individual, his objectives, capabilities, interests and present status before it selects and arranges blocks from the data base to display for him. Evaluation and feedback provisions are also individualized. The system's capability for controlling conditions and recording user-system interactions will make it a valuable force in research on individualization in training and education. The development of this complex design was facilitated by a Documentation-Updating System that produced system documents in Information-Mapped form and kept them up to date throughout the project.

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CHAPTER 1 INTRODUCTION TO THE PROJECT

OVERVIEW OF THIS DOCUMENT

Introduction	This document describes the design of a computer-controlled information system whose specially organized data base serves a variety of users' purposes: initial learning, reference, reviewing, browsing, and briefing. The data base consists of information segments organized according to Information Mapping, a system of rules and policies for classifying and formatting information into separate labelled modules. These information blocks can be drawn from the data base, arranged and displayed in a form best suited to the purposes of the individual client. This document describes how the system design accomplishes the objective of delivering information sequences to the individual taking into account his capabilities and previous experience.
The First Chapter	An information system that is to serve multiple purposes from a common information base must rely on a variety of concepts and procedures to accomplish its functions. This first chapter will introduce the main features of the system.
The Second Chapter	Information Mapping is one of the key concepts in this system design. Here we tell what it is, how it developed from research results, educational practice, graphics, and so on. Its application to computer data bases requires some new procedures, which are outlined here.
The Central Chapters	The mechanisms and procedures that were designed to select and deliver appropriate information sequences are described in the next three chapters. How the system makes an individualized response to members of each user class is explained here and illustrated with fictitious case histories.
Documentation-Updating System	The data and information being developed about the Learning-Reference System were documented from the beginning and were maintained in an updated state throughout the project. The methods for producing documents in Information Mapped form and the explicit updating procedures are described.
The Last Chapters	The final chapters summarize the description of the total system, some ways of evaluating it, and some future applications.

THE CONTEXT OF THE NEW SYSTEM

Introduction

When a new development emerges, we are usually curious to know where it fits into the current scene.

The system we are introducing here is a new kind of computer-assisted instruction. It serves reference uses, reviewing, browsing and briefing, too, but it is within the context of computer-aided training and instructional systems that its similarities and differences may best be identified.

Individualized Instruction

Back in the early 1950's, one of the impressive selling points of teaching machines was the fact that they let the individual proceed at his own pace. Through the heyday of teaching machines on into the development of more versatile computer-based systems, the search for new ways of adapting instructional sequences to the individual user has continued.

In spite of undoubted gains, the goal of achieving individualized instruction has been advanced only slowly. The main progress has been in the area of adjusting instruction to short-term information about the user--a wrong answer, for instance, causes him to be shunted off to a corrective sequence, while consecutive correct responses may cause him to by-pass some materials. The long-term history of the user seldom enters into information sequencing decisions.

The system we are reporting is designed with the capability to respond to the individual by basing its sequencing decisions on both permanent and changing information about the user--for example:

- his capabilities, attitudes, interests, objectives
- his academic training and history
- his performance and patterns of behavior within the learning system
- his personal wishes and preferences.

Thus the system has the capability of responding to the long-term as well as short-term history of the user. The extent to which this capability is used depends upon whether the course designer will specify how individual differences are to be served by differences in information sequencing. It also depends upon whether the individual user is guided by the system or controls his own interaction with the information base.

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Control of Instructional Conditions

An important difference between this system and others lies in the variations in degrees of control that this system can exercise over the sequencing of information.

In the majority of CAI systems, the path of the learner is almost totally determined by the computer program. In a few other systems, the so-called "ad lib" systems*, it is the user who determines what information is called up from the data base.

Our Learning-Reference System is designed to operate not only under either one of these extremes of total user control or total system control, but also at any one of numerous points in between. In other words, the learner can take charge of all sequencing decisions, he can share some with the system, or he can be totally dependent on the system for information selection and display.

This range of possible controls adds another set of dimensions for individualizing instruction, but, most importantly at this imperfect stage of our knowledge, it allows experimental control of variations in learning conditions so that research may refin the prescriptions that link personal data, information sequences, and learning results.

Such an outcome is realizable because the system has record-keeping advantages that permit study of long-term effects of sequencing strategies.

Later

After the capabilities of this Learning-Reference System have been described in this report, we shall return, in the final chapter, to some of the topics raised here.

* Bryan, G.L. "Current ONR Research Efforts Involving Computerized Instruction," Proc. of the Conference on Applications of Computers to Training (ACT), Washington, D.C., 1970.

THE ORIGINS OF THE PROJECT

Introduction

The idea of designing a computer-controlled system that would serve many users from a common information pool originated in a previous research and development effort to design more effective materials for both learning and reference users.

From that work, Information Mapping emerged as a system of rules for identifying, categorizing and interrelating the information needed for learning-reference purposes.

When applied to any subject matter, Information Mapping yields a network of labelled and classified information blocks. From these blocks, materials in book form can be produced for self-instruction and reference purposes.

It was no large step to conjecture that if a computer data base were organized by Information Mapping rules, it might serve the information needs of a wider range of users. The separate blocks could be drawn from the common pool as needed and then assembled into sequences suitable for initial learning, reference work, browsing, reviewing and the like.

In order to accomplish such a service, the system must be able to evaluate and respond to the needs of the various users and then to deliver information sequences that are appropriate.

Basic Objective of This Project

The objective of this project was to plan a computer information system that selects blocks from an Information-Mapped data base and assembles them into displays of information suited to the needs of the individual user.

The Learning-Reference System

Although we conceive of this system as providing information services to a variety of users, we refer to it as the Learning-Reference System because we expect the main traffic to be from those with initial learning and reference needs. Nevertheless it is also designed to serve those who come for reviewing, briefing or browsing.

The Design Process

The project began with general ideas about the nature of the system; then the characteristics desirable in such a system were formulated in detail. The main work of the project consisted in developing a design for the structures and programs that would make the system a reality.

This report is the description of the system design that evolved.

Comment

Before taking up the process of defining the system, we first say more about Information Mapping itself for it plays a fundamental role in the system.

INFORMATION MAPPING: ITS BACKGROUND

Description

Information Mapping is a set of rules and procedures for writing, organizing and displaying information about a subject matter. According to a unique classification scheme, information is categorized and collected into labelled blocks. The order and format in which these blocks are displayed are geared toward making learning easier and information retrieval more efficient.

The system has been applied to the production of books for learning and reference and now in this project it is applied to the organization of multipurpose data bases for computerized information systems.

Basic Aims

Research and development on Information Mapping have been concerned primarily with these objectives:

- to make learning, reviewing, reference work and browsing easier and quicker than in conventional texts and in computer-aided instruction
- to provide information services responsive to the needs of the individual user
- to make the preparation of learning and reference materials easier and quicker than for conventional materials
- to make the task of maintaining and updating information banks both systematic and economical.

Origins of Information Mapping Features

Initially, research findings, generalizations, and procedures from many areas were considered with a view to their possible practical value for instruction or reference.

Gradually we evolved the set of guidelines and rules for organizing and displaying information that we now refer to as Information Mapping. These guidelines have their origins in such areas as these:

- logical analyses of subject matters
- learning research findings
- teaching practice
- programmed instruction techniques
- display technology
- human factors research
- communications techniques, including effective writing principles.

The implications of the various ideas were translated into practical form and were documented as rules or procedures for preparing Information Maps.

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Applications	Information Mapping has been applied to the production of self-instructional books in the areas of probability, statistics, computer programming, and Information Mapping techniques as well. Exploratory work with simulated computer displays and information block assemblies has provided some useful spadework on the kinds of options and display variations that a computerized system could offer to its users (Horn, Nicol, Kleinman, Grace, 1969).
Comment	Because Information Mapping is of central importance in the present project, Chapter 2 will give a more detailed account of how came about and how it is done. However, it may be useful at this point to see the form of a map designed for self instruction. An example is shown on the next two pages; other examples appear in the appendix to this report.

EXAMPLE OF A CONCEPT MAP

THE INTERSECTION OF TWO OR MORE EVENTS IS ALSO AN EVENT *

Introduction

Sometimes we are interested in an outcome that has more than one description - as, for instance, in a car that is yellow, Jaguar, and convertible. Such an outcome would be common to three different events.

Definition

The intersection of two or more events consists of those sample points that are common to the given events. These common sample points in the intersection or "overlap" of the events constitute a new event. The new event is said to occur if an outcome common to the intersecting events occurs.

Notation

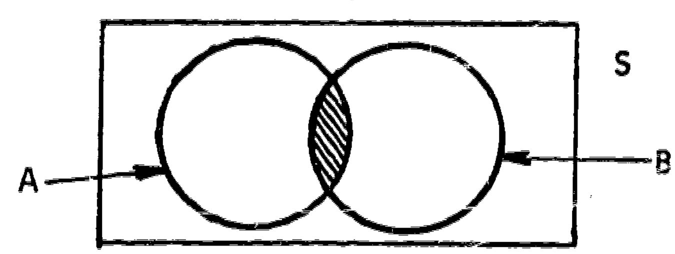
The symbol for intersection is $\cap$. $P\cap Q$ is read "the event P intersection Q," or "the event composed of the intersection of events P and Q." The event $P\cap Q$ is said to occur if both events P and Q occur.

The general case of the intersection of any number (n) of events can be written:

$$A_1 \cap A_2 \cap \ldots \cap A_n$$

Diagram

The shaded part is $A\cap B$



Comment

Outcomes in the "overlap" where events intersect have more than one description since they belong to more than one event; for example, "both red-haired and blue-eyed" is the intersection of two events; "left-handed, a pitcher, and a Yankee" is the intersection of three events; and "tall, dark and handsome but married" is the intersection of four events.

continued on next page

* From Introduction to Probability, Kleinman, Nicol, Grace, Horn, 1971. (In preparation.)

THE INTERSECTION OF TWO OR MORE EVENTS IS ALSO AN EVENT (continued)

Example One

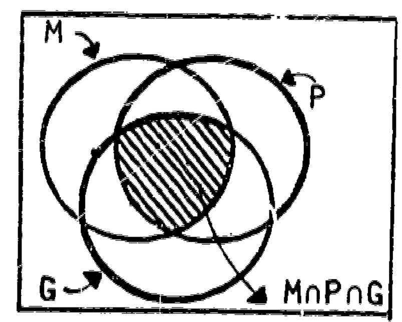
A survey at a college asked each student about his interest in these subjects: mathematics, psychology, government. Those with a strong interest in all three were given another questionnaire about career plans.

Event M = strong interest in mathematics
Event P = strong interest in psychology
Event G = strong interest in government

Then the new event

$M \cap P \cap G$

represents those who received the second questionnaire.



Example Two

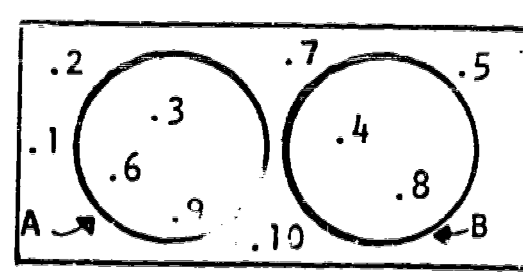
An urn contains ten balls numbered one through ten. One ball is drawn.

Event A = the ball drawn has a number divisible by three.
Event B = the ball drawn has a number divisible by four.

$A \cap B$ is the new event: "the ball drawn has a number divisible by three <u>and</u> by four."

$A = \{3,6,9\}$

$B = \{4,8\}$



$A \cap B = \phi$

Note: <u>No</u> member of A are in B. $A \cap B$ is the empty event.

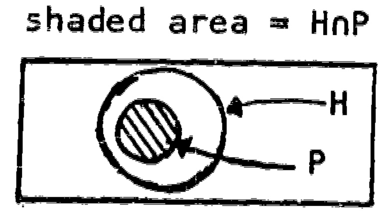
Example Three

If the 52 cards in a bridge pack are the sample space, we can define:

Event H = all heart cards
Event P = all heart picture cards

The event $H \cap P$ is identical with event P since <u>all</u> outcomes in P are also in H.

shaded area = $H \cap P$



Related Pages: outcome, 14; event, 23; sample point, 17

MAJOR TASKS OF THE PROJECT

Introduction

A data base consisting of movable information segments could have the flexibility required for a system that aspired not only to serve various purposes but to serve them in a manner responsive to the individual inquirer.

To accomplish the design of such a computer system, we outlined four major task areas and specified the end result we expected from each.

1 Data Base Organization

The rules and formatting policies for writing Information Maps were originally developed for making books for initial learning and reference use. Now to apply them not only to the organization of computer data bases but also to the serving of other client classes means that they will need expansion and adaptation. For example, study of the reviewing and briefing situation may show the need for additional maps to be made available in storage. Also it is clear that the data base must contain not only the information blocks themselves but also all sorts of data about the blocks (name, content, difficulty level, etc.) so that the computer can judge their relevance for a particular user.

The end product: The expansion of Information Mapping rules to cover the preparation of information bases for computers and a document of detailed directions for carrying out the necessary procedures.

2 The Sequence Generator

If we think of Information Mapping as a set of rules for partitioning the sentences about a subject matter so that they may be categorized, labelled and stored in the computer, we realize we need a second set of rules to govern the retrieval and arrangement of the information modules for display to the user.

This second set of rules we have called the "sequence generator." This will be the executive program that consults various kinds of data about the user and the state of the system before selecting from the information-block bank a series of displays appropriate for the objectives and needs of that user.

The design of such a sequence generator was another major task of this project.

The end product: The specification of all classes of data required by the sequence generator and a set of decision rules that indicate in detail the course of the sequence generator's functioning in all user-system interactions.

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3	The Command Language	The system must have a language through which the user can communicate his information needs and his reactions to the displays presented to him. The end product: A document defining each term in the set of commands designed for the system and specifying the effects such commands have on the system functions by way of the decision rules of the sequence generator.
4	Documentation-Updating System	The development of so complex a system is achieved through the process of successive approximations. Thus it can be predicted at the outset that not only will there be a heavy demand for documentation by the team of designers who are creating the system but also there will be an urgent need for updating procedures that keep each team member in touch with the latest thinking of his colleagues. This fourth task of the project was to devise and follow systematic procedures for keeping track of the information developed in the course of the project. System documentation is to begin when the design project itself begins. The key idea is to test the utility of Information Mapping as the form in which all system information will be written and stored. We will specify the detailed procedures for preparing system documents and for entering into multiple copies of them the latest available revisions. Procedures developed in the course of this task are expected to be applicable to the maintenance of the Learning-Reference System in the operational stage -- that is, to changing both course materials and system functions throughout the life of the system. In this aspect of the system, we expect the updating procedures to be automated and serviced through routine computer-directed interviews with the updating clerk. The end product: A tested set of procedures for: · preparing system documentation in Information Mapped form · keeping system documentation up-to-date during its evolution · maintaining the system at its highest efficiency during real-time operations.

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Project Document

The end product of the entire project: a document that gives specifications, procedures, decision rules, present limitations and possible future extensions for various aspects of the system.

The objective was to develop the design in sufficient detail so that it is capable of being implemented by programmers who can adapt it for a given computer configuration.

Project Document One presents the system design in a series of separate sections. Because of the extensiveness of the material, not all sections are equally available. The table below shows the main subdivisions of the documentation along with an availability symbol which is explained below:

SECTION	TITLE OR DESCRIPTION	APPROX. NO. OF PAGES	AVAIL-ABILITY
000-599	Detailed plans for a Sequence Generator for use with Information Mapped Data Bases	150	A
600-699	Detailed decision tables for implementing major functions of the Sequence Generator	180	A
700-799	A Reference Collection of Rules and Guidelines for Writing Information Mapped Materials (described in Chap. 2 of this final report)	175	A & B
800	A detailed description of the Information-Mapped Documentation-Updating System (described in Chap. 6 of this final report)	100	A
Index	An index to section 600-699	50	A

Availability

The availability symbols in the right hand column mean:

A System documents are deposited with the
Directorate of Systems Design and Development (MCDT)
Deputy for Command and Management Systems
Hq. Electronic Systems Division
L. G. Hanscom Field
Bedford, Mass.

B Available through
Information Resources, Inc.
1675 Massachusetts Ave.
Cambridge, Mass. 02138

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Related Document	Information Mapping for Learning and Reference, by R. E. Horn, E. H. Nicol, J. C. Kleinman, and M. G. Grace, ESD-TR-69-296. August, 1969. AD699201. (Available from Information Resources, Inc.)
COBOL Draft	As part of the project, we also wrote a brief segment of a new subject matter in order to extend the range of topics to which Information Mapping has been applied. The subject matter was COBOL and the draft of this is available as part of the system documentation under availability A above.

THE GENERAL IDEA OF THE SYSTEM

Introduction

The proje[illegible] to design a multipurpose system using Information Mapped data bases did not of course arise in a vacuum but in response to a felt need for more versatile training and reference materials in large computer facilities such as management information or military information systems.

Such instructional or training package[illegible] [illegible]s are now available in these facilities are primarily sing[illegible] -purpose programs serving all members of a given user class (such as initial learners) with almost identical information sequences.

The capabilities of a large computer facility, whatever its primary purpose, are such that it could be a significant source of information on all kinds of topics or subject-matter areas. Its capabilities are such also that it could be made to respond in a unique way to each individual in a variety of user classes.

It is against such a background that our initial thinking about system design took off.

The Computer Environment

In the design we assume the availability of a major multipurpose facility with certain characteristics which are described later. However, because a high degree of flexibility has been built into the design, certain versions can be implemented for smaller installations.

The Learning-Reference System then is planned to function either as part of a facility serving other purposes or alone as an information service mainly for educational, training and reference purposes.

The system design is not tied to any given computer but can be implemented on a variety of currently available machines.

Users of the System

The primary clients we intend to serve are those who are directly concerned with using the subject-matter materials in some way:

- for initial learning
- for reference work
- for reviewing
- for browsing
- for briefing.

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(continued) Users of the System

To serve these primary clients efficiently, the system must also be able to accommodate a secondary class of users who themselves serve the primary clients by operating the system, preparing new materials, gathering performance data, doing research -- in short:

- training supervisors
- course designers, authors, editors
- computer programmers
- clerical aides
- researchers
- updating specialists.

The Starting Point

As the design project got under way, then, certain aspects of the system were established or assumed -- we knew at least in a general way:

- the kind of situation in which the system would operate
- how the data base would be organized
- the kinds of users it was to serve
- some of the ways in which it should serve them.

Comment

From these outlines we began to work through to solutions on several issues involving teaching strategies and the control of information sequencing decisions.

SOME ISSUES RESOLVED

Introduction

When we consider how a sequence generator might be designed to serve the client who comes with a reference task, the problem seems fairly simple and straightforward -- make the sequence generator fetch blocks on the topics selected by the client from a table-of-contents display or an index display. In short, make the generator follow the user's directions.

But when we turn to the problem of how to serve the user who is learning something for the first time we encounter several troublesome interlocking issues of educational philosophy and teaching strategies.

Since one of the most important services of the Learning-Reference System is to provide instruction for the initial learner, we must consider what kind of role the sequence generator is to take with the learner.

Teaching Strategies

While educational philosophies with their various goals and teaching methods differ in many ways, it is their diversity of opinion on the amount of control to impose on the student that concerns us here.

At one end of the spectrum, educators are convinced that the only justifiable goal of education is to enable the individual to discover and develop his talents and to grow in confidence in his own capacity to find and learn whatever he wants. To produce independent learners, the role of the educational system is to provide the setting that encourages exploration and the exercise of individual choice and initiative with only a minimum of pressure from authorities or experts.

If our system were to serve a similar goal, the student would take charge of his own learning and direct the generator to bring the sequences he chooses -- again, the generator would be designed to follow directions.

Another variety of educational opinion holds rather similar views on the desirability of discovering and developing the talents of the individual but it goes about the task in a different way -- by testing and evaluating the student in order to plan a detailed program that the teacher believes will move him along toward greater development of his abilities.

A sequence generator to serve this philosophy would need provisions for testing and for performance recording, but most of all it would have to be able to prescribe sequences suitable for the student. The degree of control it would exert over the train of information displays and test items shown to the student would presumably vary in some prescribed way with the abilities and progress of the student.

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(continued) Teaching Strategies

At the other end of the educational spectrum are the fairly restrictive policies common to many conventional school systems ("compulsory education") in which courses and their proper sequencing are prescribed by authorities with only minor concessions to individual differences.

The sequence generator to serve such a system would follow fairly simple rules of testing and then presenting pre-programmed sequences of information, digressing from the path only for remedial sequences when test items are failed. Such a sequence generator would be suited to handling programmed instruction as well. Compulsory response and response evaluation would be required to keep the displays coming.

Many other in-between shades of opinion on the control issue exist but consideration of even these few points on the spectrum show that a sequence generator might be called upon to operate either under the client's direction or to assume full or partial control of sequence construction.

While most of the educational viewpoints alluded to above are concerned with long-range goals of transmitting the skills and knowledge that will serve the student over a long period, it is probable that even the strategies for achieving short-term goals will show a divergence of opinion on how much guidance to give the student.

The System Context

In reaching a decision on the design of controls within the sequence generator, we also reviewed the context in which the system may be operating and the kinds of people who may be operating it and being served by it.

Consider the environment in which the system may be used:

- in a general education facility in which
  - both long-term and short-term goals are sought, and in which
  - the educators in charge may differ concerning how much guidance and direction should be imposed on students
- in an industrial or military setting in which
  - training goals are paramount and the emphasis is on short-term mastery of specific information units, and
  - time constraints and other economic considerations may make system guidance of the individual the most feasible plan.

continued on next page

(continued) The System Context	Regardless of the educational strategy that appeals to us personally, we have to recognize that system clients come from the real world and have been exposed to various educational practices. The clients may: . range from totally docile students dependent on guidance at every step to those who have acquired some degree of independence and initiative, or . be accustomed to setting up their own learning goals and to planning how to go about achieving them.
Conclusion	Build a system to provide: . complete freedom for the independent learner . varying levels of guidance for students who either ask for help themselves or are judged in need of it by the training supervisor. For the system to respond intelligently with any degree of guidance means that it must have ways of evaluating the information needs and abilities of the student and that it then must know how to respond appropriately. The design task then is to fashion the system mechanisms that will accomplish the above functions. (The design task is not concerned directly with the information contents of the system -- these can be as dull or exciting as the skills of the subject-matter writers permit.)
Comment	While our discussion of controlling information sequencing has been focussed mainly on serving the initial learner, other clients of the system may need or prefer guidance as well. For instance, the person who comes for review may prefer a guided review provided by the system. Later chapters will describe how various degrees of guidance have been made available to other classes of clients.

DESCRIPTION OF THE TARGET SYSTEM

Introduction

Once the control issue was settled, we examined other facets of the information services a system might offer and gradually evolved a statement of the main features of the system.

This description shows the general and specific functions we want the system to perform and the kinds of interactions it will have with various client groups. This is a more formal recapitulation of some points that have already been made. Some characteristics or functions are system-wide, others are specific to one class of users.

General Features

This system will work from a data base consisting of categorized information blocks that are organized into maps (sets of blocks), units (sets of maps), and courses (sets of units).

From such a common pool, it will generate information sequences that effectively meet the information needs of users with any of the following objectives: initial learning, reference work, reviewing, browsing, and briefing. Support personnel must be provided with the means for accomplishing their work as well.

The means by which the system determines the information needs of its clients will be described presently.

The function of calling up information blocks to be displayed to the user can be controlled:

- totally by the sequence generator
- totally by the user himself
- jointly by the user and the generator with various levels of dominance by one or the other being specifiable.

Clients without special training or previous computer experience will be able to utilize the information services of the system.

The system will be interactive in the sense that the user can:

- request and receive various kinds of information
- select from menus and indexes
- request an evaluation of his responses to practice questions
- indicate a preferred order for the display of information blocks from each map.

The fact that these capabilities will exist in the system does not mean that they will be operative at all times; in fact, when the sequence generator has the dominant role in sequencing decisions, some of these functions may not be permitted to the user.

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DESCRIPTION OF THE TARGET SYSTEM, continued

Initial Learning

The system will be capable of:

- implementing different teaching strategies
- assembling learning sequences to match each client's background knowledge, aptitudes, and attitudes
- prescribing differentially for those who differ in how much of a subject matter they want to cover and in how well they want to learn it
- testing a student's knowledge of the field and its prerequisites
- providing feedback to the learner
- providing remedial sequences when requested or when a specified failure rate on feedback questions is reached.

Reviewing

The system will be able to:

- provide the user with a guided review tailored to his capabilities and objectives
- supply support services to the independent reviewer who prefers to design his own review procedures.

Reference Use

The system will be able to help the reference user find the information he wants without needing special training on the system.

Browsing

The system will enable the potential student or the casual browser to explore the nature of any course in the system and to find out what might be required to learn it.

Support Services

The system will include special aids to simplify and systematize the work of those responsible for operating and maintaining the system.

COMPUTER REQUIREMENTS

Introduction

Although we have said that the Learning-Reference System has been designed without reference to a given computer, it does nevertheless require certain capabilities which are mentioned below.

Although we envision the Learning-Reference System as part of a facility serving other purposes (management or command-and-control), there is no reason why a modified version of it could not function on a smaller scale serving only instructional/training purposes.

Hardware

In general terms the main requirements of the documented version of our system are these:

- a third-generation digital computer or better
- random-access secondary storage with read/write capability, including at least four tape drives
- cathode ray tubes that are divisible into areas in order that text can remain on screen while other areas are changed
- typewriter/teletype

Software

System software handles:

- job-scheduling
- multi-programming
- time slicing
- interrupt analysis
- input-output
- random access

Standard utility programs include:

- card to tape
- tape to random access
- sort-merge generator
- report generator
- assembler
- library maintenance

DESIGN STRATEGY

Flexibility

In this first version, we did not expect the design of so complex a system to emerge full-blown from our drawing boards in untarnished perfection. Therefore we built into the system from the beginning the flexibility that would make it easy to change, add or delete aspects of the system.

Flexibility was also required by the fact that at this stage the design was aimed at no particular computer. Whatever computer system it might be implemented on would naturally entail some modification of the design. Especially might this be so if the main work of the facility were not educational and this design would have to be fitted into the other functions.

Flexibility in the design would also be a boon during the developmental testing period when the refinement of the system would be guided by performance data.

The ways in which flexibility has been provided for will be mentioned at various points as the system is described in following chapters.

First Pass

Thus we intend in this first pass to sketch in with as much detail as possible those major structures of the system that are not hardware-related and to specify the interactions among the various components that will accomplish the system objectives.

At times, relatively simple solutions were adopted for the present version because it would be economically unwise to devise more elaborate mechanisms at this stage. For example, in the present version we assume that the information blocks are written at a given readability level. With little difficulty, however, the same information blocks could be written at, say, three different reading levels to serve a wider range of clients. The modification required to permit selection of blocks from three parallel banks instead of from one is simple, albeit tedious, but little is to be gained now from spending the time to work out the extra details in the absence of any firm need and in ignorance of how an unspecified computer could handle the extra storage space requirements.

Summary of Strategy

In short, then, we take as our task the description of how major functions can be accomplished, leaving elaborations or more complex alternatives until such time as a specific computer facility may have need of them.

Comment

Certain of the design solutions accepted in this first pass merit explicit mention. They will be discussed in a separate map.

LIMITATIONS OF THE CURRENT VERSION

Introduction	In order to separate the problem of creating a general structure for the sequence generator from other more detailed problems, we restricted the scope of this first version in several ways. These limitations and some of our rationale are discussed below. Throughout the pages of system documentation, it has been our practice to record notes concerning alternative solutions and possible directions for future extensions.
Displays	The sequence generator does not keep track of or control the positioning, color, size, flashing, brightness or underlining of any text on the display screen. We felt that selecting content for display was more important now than these other aspects which are dependent on system-specific characteristics. The design does assume that the amount of text displayed at one time will be adjustable by the client or by the system supervisor. In the future, we expect to have dynamic displays not only to illustrate processes or trends but to guide reading and analysis. If split-field scopes are available, other opportunities for creative use of displays open up. In some installations such scopes will serve as a more convenient response medium since in addition to the main display, they can offer simultaneously lists of topics or instructions from which the user can choose via lightpen action.
Computing	The computing capability of the computer has not been integrated into the design of the Learning-Reference System. Again, it is the nature of the specific computer that will determine how much of this capability can be put at the service of the user. Given sufficient capacity, the system can be amended to enable users to do on-line computations, problem solving, simulations and so on.
Time Control	The ability of the computer to keep track of the time duration of events in the system is useful in many ways, such as in keeping track of clients' behavior, identifying blocks that require an inordinate amount of time, and so on. There are teaching strategies also in which it may be desirable to put certain types of learners under time pressures. In this version of the system we make no attempt to formulate such refinements.
Printout Capability	It would be of obvious utility to the major clients to be able to take home hard copies of some materials. We expect this system to have such printout capability but its use and the nature of the controls that would be necessary have not been defined.

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Single Track	The sequence generator's present design operates on a single version of the information blocks in the data base. The blocks are written at a given level of reading difficulty. If the need arose to provide a wider range of levels, several versions of blocks could be prepared; either the supervisor or an internal decision rule could guide the generator to match the level with the individual user's capabilities. The simpler solution would be to treat each version as a separate course; pretests would determine which version was best suited to the client. Here the sequence generator would have the responsibility for assigning the user to courses.
The Supervisor	The role of supervisor has been created to perform certain functions concerned with getting the user established in the system initially and with determining how he will be treated by the sequence generator. Eventually all of these functions can be handled by the generator. Through a computer-directed interview and testing program, the generator would gather the necessary user data and then refer to internal algorithms to find out how to interact with him in the session.
Teaching System Operation	At this time the sequence generator makes no coordinated effort to teach users about operating the system nor about Information-Mapping aspects of the information base. While we regard these as important aspects of the final system, they are of relatively low priority at this stage of refinement. However, some provisions for explaining such things as the meaning of certain commands have been included in this present version. Otherwise, we assume that instructional materials about the system are present in the data base and can be called up just as any other course materials can be. In the final system, the sequence generator will be able to intrude hints about more effective use of the system into the interactions with the user.
Single Course Scope	This version of the generator copes only with the progress of the learner through a single course, although it does provide mechanisms for switching courses and communicating about courses. Later we expect that the generator will be able to utilize data from other courses that the user has taken in the system and that it will be able to supply some interesting effects as a result of indexing across courses.

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Long-Term Educational Objectives

At this stage of system design, our services to the initial learner do not include the teaching of those long-term educational goals that require prolonged exposure over courses to a teaching method or to a way of thinking. For example, we have in mind those long-range programs that are designed to promote the development of skills or of modes of thinking and problem solving.

Our first priority was to build a sequence generator that can cope with courses and units of courses where specific learning outcomes have been outlined and reflected in unit tests and review tests. While these latter need not concern the independent learner who is pursuing his own course, they do afford the sequence generator with the means for prescribing for those students whom it is guiding.

CHAPTER 2 INFORMATION MAPPING

OVERVIEW OF THIS CHAPTER

Introduction	Although Information Mapping was introduced briefly in the previous chapter, we need to take a closer look at it since it provides the basic building blocks for this Learning-Reference System.
This Chapter	The topics that concern us in this chapter are: . the main features of Information Maps and their origins . previous subject-matter applications and learning studies . general procedures for preparing Information Maps . special procedures that are needed to prepare maps for a computer-based system.
Comment	Information Mapping is a growing, changing set of procedures and policies. It is probable that experience with a wider range of subject matters and with an operational computer system will reveal the need for new categories and new procedures. This chapter then describes the current state of Information Mapping.

MAIN FEATURES OF INFORMATION MAPS

Introduction

Information Maps are conspicuous for their physical features, the format in which they present information.

An equally important aspect of such Information Maps, however, is that the content itself is selected and organized according to a classification scheme and a set of analytical procedures.

The <u>method of presentation</u> and the <u>organization of content</u> may be thought of as the visible and invisible features of a map.

Visible Features

The more obvious visible characteristics are these:

- information is presented in blocks
- marginal labels identify the kind of information in each block
- a consistent format is used for each kind of information: procedures follow one format, concept maps follow another distinct format, and so on
- functional and uniform headings and subheadings are used to make scanning easy and to speed up reference work
- feedback questions and answers are located in close proximity to the relevant Information Maps
- a local index at the end of maps provides map numbers for quick location of prerequisite topics.

(Several of these features are not used in technical reports.)

Invisible Features

The arrangement and sequencing of materials presented in Information Map formats are the result of:

- detailed specification of learning and reference objectives
- specification of prerequisites for the subject-matter area

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(continued) Invisible Features	. classification of the subject matter into component types (concepts, procedures, etc.) . definition of the contingencies required for successful learning and reference.
Footnote	This map and the four following ones are slightly modified versions of maps that appeared in the first account of Information Mapping by Horn, Nicol, Kleinman and Grace, 1969.

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INFORMATION MAP FEATURES DERIVED FROM LEARNING RESEARCH AND TEACHING PRACTICE

Introduction

Although Information Map features have their origins in several fields, there is no doubt that their principal foundations lie in education and learning research. On the chart below, we indicate briefly some of the findings that led to the design of certain Information Map features. This chart (which is not intended to be exhaustive) is one example of the research support behind Information Mapping.

Naturally, the evidence is not all of equal strength, but we have tried to bring to bear on a practical task some of the most promising factors.

Because the experimental basis for some map features is extensive, we cite wherever possible research review articles to put the reader in touch with the main sources of evidence. In the citations below, such major review articles are marked by asterisks to distinguish them from reports of original research.

These results of educational research lead to . . .	. . . these implications for the design of instructional materials.
Active responding generally aids learning. (Lumsdaine and May*, 1965; Briggs*, 1968; Glaser*, 1965) The act of writing responses helps some learners. (Edling*, 1968) Feedback or knowledge of results (or 'reinforcement') often facilitates learning by: • confirming or correcting learner's understanding • providing a motivational effect • improving scanning behavior (Lumsdaine and May*, 1965; Smith , 1964; Gagné and Rohwer*, 1969; Glaser*, 1965)	Insert feedback questions after introducing new materials. Locate answers conveniently nearby.

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INFORMATION MAP FEATURES DERIVED FROM LEARNING RESEARCH AND TEACHING PRACTICE, continued

These results of educational research lead to . . .	. . . these implications for the design of instructional materials.
The insertion of questions, "test-like events," after text segments has a positive effect on learning. Giving knowledge of results further increases the effect. (Gagné and Rohwer*, 1969; McKeachie*, 1963) Self-tests, pretests facilitate retention. (Glaser*, 1965; Briggs*, 1968; Bloom*, 1963)	Use feedback questions after maps with new information and use sets of review questions after natural clusters of maps and at the end of topic treatments. Provide answers as well.
In concept learning, a variety of examples promotes learning. (Gagné and Rohwer*, 1969; Lumsdaine*, 1963)	Use examples and nonexamples to point up differences and similarities among concepts.
Instructions are useful in calling learner's attention to important features. (Gagné and Rohwer*, 1969; Gagné, 1965)	Use introductory paragraphs or previews to alert learner to importance of upcoming ideas.
Judicious use of underlining often helps to focus attention on key elements. (Hershberger and Terry, 1963)	Underline important words in definitions.

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INFORMATION MAP FEATURES DERIVED FROM LEARNING RESEARCH AND TEACHING PRACTICE, continued

These results of educational research lead to . . .	. . . these implications for the design of instructional materials.
"Cueing" or labelling appears to aid by alerting learner to nature of upcoming information and informing him what his learning task is. (Glaser*, 1965)	Use marginal labels and informative map titles.
Pictorial materials often help learning. (Briggs*, 1968)	Use diagrams and drawings to illustrate concepts and procedures.
For some kinds of materials, charts of the information are valuable. (Feldman, 1965)	Use tables and verbal matrices to display concept relations.
Simple sentence structures in the active voice make learning easier. (Gagné and Rohwer*, 1969; Coleman, 1965)	In general, use active voice and simple sentences.

ORGANIZATION AND INTEGRATION OF INFORMATION IMPORTANT FOR LEARNING

Introduction

Some important features of information mapping owe their origins to a topic of current theoretical interest among learning psychologists - namely, the logical and psychological structures of knowledge and their impact on learning and retention.

Theoretical Discussions

Piaget had long ago speculated that "learning . . . is facilitated by presenting materials in a fashion amenable to organization" (Flavell, 1963), but it is only in recent years that psychologists have actively taken up the problems of how cognitive structures develop and of the role of organization in learning and retention.

The 'atomistic' approach of most programmed instruction materials has been criticized (Stafford and Combs, 1967) and a firm case made for the advantages of "meaningful organization and holistic presentation of materials."

In a symposium on "Education and the Structure of Knowledge" (Phi Delta Kappa, 1964), P.H. Phenix remarked: "It is difficult to imagine how any effective learning could take place without regard for the inherent patterns of what is to be learned."

David Ausubel (1960, 1963, 1964, 1968) has developed a logical and psychological case for believing that learning and long-term retention are facilitated by 'organizers' which provide an 'ideational scaffolding.' He has now amassed considerable experimental support for his hypotheses.

The well-known studies of Katona (1940) with college students pointed up the importance of organization for learning and for retention.

The relation of organization of materials to ease of learning also finds support in the area of verbal learning research (Underwood*, 1966).

Implications for Information Map Books

Although many issues remain to be settled by research, a strong case can be supported both logically and empirically for the advantages of organizing and integrating features in materials for learning. Both verbal and graphical means can be used to inject a sense of organization and direction into a subject-matter presentation.

In the practical effort to design effective learning materials, we have incorporated a number of features intended to help the learner integrate and organize the ideas for more efficient storage in memory. These are listed on the next page.

FEATURES TO AID IN ORGANIZATION AND INTEGRATION

Introduction

The following list of features designed to promote integration of concepts and relationships contains some that we have already adopted on other grounds. For instance, the guidelines called for practice questions and answers throughout the text because learning research suggested their value in several ways; but questions can also be phrased to encourage integration of ideas over sections of learning materials.

Examples of maps showing some of these features are given in the appendix.

List of Features

Features that aid in the organization of ideas are:

- reviews and previews: to take stock of the ideas developed up to that point and to prepare the ground for relating them to new concepts about to be encountered
- introductions to each map: to relate new idea to previous concepts or to familiarize with nature and importance of new idea
- recaps or capsules: to summarize succinctly the essential ideas of rules or principles in nutshell form
- tree diagrams: to sketch the ideas and procedures of a topic so as to show the role of each and its links to others
- compare-and-contrast tables: to point up the similarities and differences between two concepts that are sometimes confused
- summary tables: to chart in easy reference form the main concepts of an area
- review tests after short sets of maps and at the end of units: to promote the integration of several concepts and to practice using them in problem solving
- prerequisite charts: to show schematically the paths the learner can take through a subject matter in order to reach the learning objectives.

INFORMATION MAP FEATURES FOR EASE OF REFERENCE AND REVIEW

Introduction

In designing materials for initial learning, we added features to facilitate the return to ideas previously encountered, an activity that is often frustrating with conventional materials where the contents of the paragraphs are mostly unlabelled. Common sense, human factors research, and graphic technology were used in formulating aids for easy retrieval of information. A list of these aids appears below.

It is clear also that these same features would be important in Information Mapped books such as reference manuals or job aids. In the computer-based Learning-Reference System, these same features are still present, although they are of less importance because the sequence generator can take on the tasks of quickly locating information needed by referencers and reviewers.

List of Features

Features that aid in locating information are:

- Tables of Contents are organized and formatted to speed location of topics and special features. (This report does not use the standard format but follows certain ESD report requirements.)
- A predictable format for each type of map (concept, procedure, etc.) facilitates location of needed information.
- Map headings in consistent typography help in scanning for map topic.
- Marginal labels help not only in locating the kind of information sought but also in skipping that not required.
- "Related Pages" or local indexes at end of each map permit quick location of concepts prerequisite to the given map.
- Decision tables display the choices appropriate for each possible situation.
- Summary tables assemble main facts and relations for easy review and reference.
- Capsules provide "kernel" statements of key rules or concepts.
- Diagrams show graphically the sequences of events in a process or procedure.
- Indexes aid information retrieval.

EXPERIENCE WITH INFORMATION MAPPED MATERIALS

Introduction

Our experience with Information Mapped materials can be discussed under two headings:

- the range of subject matters to which the techniques have been applied
- the learning results from the use of these materials in research studies.

Subject-Matter Experience

Subject-matter experience is relevant to the Information Map classification system because this system evolved from attempts to categorize the kinds of topics dealt with in certain subject areas. Undoubtedly the kinds of information we have tried to handle will color the category scheme and undoubtedly we shall have to add terms when we confront entirely different subject-matter areas.

The major part of our experience has been gained in writing, testing, and revising a 150-page introduction to sets and probability. This book of mapped learning materials constitutes a ten-hour self-instructional course. It served as the basis for several research studies mentioned below. Recently several more units of approximately 100 pages have been added to it. Other volumes in the statistical field are currently in preparation.

The entire documentation for the Learning-Reference System has been written in Information Map form, as the previous chapter noted. It consists of several hundred pages.

The staff training/reference manual for Information Resources, Inc., is Information Mapped and so arranged that short courses can be assembled from it to suit the needs of various classes of new personnel, such as temporary typists, map writers, editors, updating clerks, and so on. These self-instructional materials may take as little as one hour for temporary typists or as much as several weeks for map writers.

Other subject areas with which the system has been tried are:

	APPROX. NO. OF INFOMAPS
• computer programming	75
• the binary number system	60
• CONVRS, an experimental computer language	150
• CANARD, a simulation language	150
• introduction to descriptive statistics	75
• introduction to matrix algebra	35
• permutations, combinations, and the binomial theorem	50
• introduction to COBOL (see p. 12 for availability)	25

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EXPERIENCE WITH INFORMATION MAPPED MATERIALS, continued

(continued) Subject-Matter Experience

In addition, brief units have been written for:

- basic concepts of operant conditioning
- some topics in American history
- two dentistry topics: how to extract a tooth, and periodontology
- a topic in chemistry: the structure of the atom
- the Munsel color system in art
- darkroom procedure in photography.

Learning Results

The Information Mapped book on sets and probability served as the research vehicle for several evaluative studies of initial learning by college students. The results (reported in Horn, Nicol, Kleinman, Grace, 1969) showed significant achievement scores and the students rated the materials attractive and valuable.

Although we have made no other formal studies of learning from Information Map books, the short training courses for staff personnel have been of considerable practical importance. Because the courses are self-instructional with self-tests and practice exercises, they enable us to obtain productive work from even temporary typists with only a minimum investment of staff time in training them.

MAP CLASSIFICATION RULES AND WRITING GUIDELINES

Introduction

Thus far we have talked about what Information Maps look like, how they came to look that way, what kinds of subject matters have been mapped and how maps have been used.

Now, in preparation for extending the ideas to computer data base organization, we must take up the topic of how Information Maps actually get made--how the content of a subject area gets transformed into labelled information blocks.

Planning

Most writing of information banks about a subject matter will probably start with writing for the beginning student who knows little or nothing about the area. Curriculum planning can proceed according to whatever educational philosophy the author prefers.

We suggest that eventually the outline of topics to be covered be translated into a prerequisite chart (see example, appendix), a schematic display that works backward from program objectives to the topics required to meet those objectives. Such a chart depicts in network format the relation of each concept or procedure to others and naturally suggests some sequencing possibilities.

From this chart the author works, following the extensive set of guidelines for writing, formatting, and classifying information. These guidelines also assist the author in identifying the materials that have to be written to serve reviewing, reference and browsing purposes as well.

The Mapping Guidelines

An important part of the Information Mapping documentation is the set of guidelines for classifying information and for writing the information blocks appropriate for the different types of maps. The guidelines themselves occupy several hundred pages (Information Mapped, of course) of format policies, instructions, and illustrations (reference given, Chapter 1 on page 11).

Tables showing the present classification of map types and permissible information blocks are given in the appendix to this report. These lists are not considered complete nor fixed for we regard Information Mapping as an evolving system. Wider experience with varied subject matters will show other categories that are needed to cover the information comfortably.

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(continued) The Mapping Guidelines

The guidelines originated with the need to specify rules and policies for writing book-type materials. In the course of the present project they have been extended to cover the preparation of information banks for the computerized system.

Various types of supplementary maps, that is, maps containing no new information, are required for initial learning and for reviewing, browsing and reference needs as well. Some of these maps are:

- previews
- reviews
- compare-and-contrast maps
- summaries
- decision charts

Tables of contents and indexes are also among the materials that have to be prepared. For all of these, writing rules, formatting policies and when-to-use guidelines have been documented.

Comment

While the guidelines suggest some principles that often make for effective writing, it is the author who must assume the ultimate responsibility for the style of writing in the blocks of his course. The course materials will probably be as varied in content and approach as are individual tutors--imaginative, boring, humorous, pompous, terse, verbose, challenging, trivial and so on.

Developmental Testing

No matter how inspired the formulation of guidelines may be, they can never eliminate the need for developmental testing. For all Information Mapped materials empirical testing and revision are standard policies.

Introduction

When Information Mapping is applied to the preparation and organization of computer information bases, certain new policies or procedures are required. Some of these are only slight variations of the rules for writing books but others entail extra writing tasks for the authors.

Documents

As the design for the Learning-Reference System evolved, the documentation of new writing requirements kept pace. This is kept up to date in the project document (cited in Chapter 1) and is available for the immediate training of course writers for the new system.

It is possible that in actual practice some of the map preparation tasks will be assumed by mapping specialists other than authors. For the present, we are concerned primarily with identifying the general nature of the procedures now needed in a computer application and not with allotting functions to personnel.

Modified Procedures

The guidelines for planning, writing and formatting Information Maps remain essentially the same. In writing for the computer setting, however, there is the additional requirement that blocks be independent in phrasing; since these blocks will eventually be assembled in unspecified configurations, we must avoid such phrases as "as we mentioned in the block above" or "the previous map explained...," and the like.

A major modification for the author is that he must prepare much more material for the computer base. Whereas in writing for a book he may find through experience that three or four worked examples are sufficient, with the computer system he will be dealing with a wider range of user abilities and thus needs a larger store of worked examples and practice exercises or feedback questions.

An earlier map mentioned that the author writing for the Learning-Reference System must also provide special maps for users with browsing, briefing, reference or review needs. This means that he will need to write information blocks about the course itself, including such materials as how much time it usually takes, what are its prerequisites, what are the main ideas and major applications (if any), and so on.

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New Writing Requirements

The main effect of the computer's advent into the picture is to increase the number of writing tasks. These may be categorized under two headings:

- telling the computer about various classes of potential users of the subject-matter materials, and
- telling the computer about various aspects of the information materials themselves.

User Characteristics

It is up to the author or subject-matter expert to record for the sequence generator any rules or recommendations he may have for handling users with different background characteristics. For example, the author of mathematical materials might recommend that initial learners with an antipathy for mathematics should be shown certain types of blocks that would be boring for learners who had a strong background in mathematics. Such advice from authors will be mainly of importance in dealing with initial learners.

Among the classes of information that an author might recommend as bearing on information sequencing decisions are these:

- intelligence quotient
- vocabulary level
- areas of major interest
- subject-matter competence
- attitude toward subject area
- job and socioeconomic status
- pretest scores

In each case in which the author formulates a relationship between user background data and sequencing treatment, it is his responsibility to specify as well <u>how</u> the user data are to be obtained. Some may be collected on-line using interview questionnaires or tests provided by the author or they may come from specified off-line sources and be entered into the computer by supervising personnel.

Pretesting will provide a major source of guidance to the sequence generator since it will have an influence on the selection of maps to display to the learner.

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Course Characteristics	Many characteristics of the course and its various parts have to be identified and stored in the computer in a fixed format in order for the sequence generator to carry out its task of assembling information blocks. Some of these characteristics must be indicated by the author while others can be supplied by support personnel. Some examples of the kind of information the authors must provide are: . difficulty rating for each feedback question . instructions for judging all possible user responses . instructions for remedial sequences following each incorrect response . possible following maps. Numerous characteristics of each course, map and information block must also be coded for the sequence generator but these can be determined by support personnel following routine checklist procedures.
Comment	More about the special aids to authors appears in Chapter 5. The various characteristics of users and courses will be encountered again in the next chapter where data base organization is described.

CHAPTER 3 THE CONCEPT OF A SEQUENCE GENERATOR

OVERVIEW OF THIS CHAPTER

Introduction	The heart of the Learning-Reference System is the executive program that acts as intermediary between the user and the stored information blocks. It can either fetch the information requested by the user or it can recommend suitable sequences for those who want or need guidance. These functions are accomplished by a set of rules and procedures to which we have given the name "the sequence generator." To respond to the different purposes of different kinds of users wanting to interact with different types of subject matters, the sequence generator must be capable of tapping a wide range of information if it is to deliver sequences of suitable displays.
This Chapter	The kinds of information the generator needs and the mechanisms that enable it to work are sketched out in this chapter. The command language comes in here also as the medium through which the user interacts with the generator.
The Next Chapter	In the next chapter we will show how the mechanisms enable the sequence generator actually to respond <u>individually</u> to the person who comes with a <u>learning</u> purpose in mind. How the system responds to <u>other</u> classes of users will be described in the following chapter.

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A SEQUENCE GENERATOR: THE GENERAL IDEA

Introduction

If a common data base is to serve multiple purposes, there must be a guidance system for selecting, assembling and displaying those information blocks that are appropriate for each user's purpose and for his own unique pattern of capabilities, attitudes and personal preferences.

Definition

The sequence generator is the set of rules and procedures for selecting and arranging information blocks into a sequence of displays appropriate for a given user.

Nature of the Sequence Generator

The sequence generator is written as a series of decision tables that check on the values of certain stored data and then take the actions that are prescribed for the value configuration found.

The stored data are of many kinds:

- about the user, his abilities, preferences, and so forth
- about the system itself, how to use it, what kinds of materials it contains
- about each course and its various subdivisions even down to the individual information block and practice exercise
- about the state of the system at the moment as shown by various counters and indicators.

As the user interacts with the information base, the sequence generator keeps track of the action by updating the indicators and by entering new data into the system.

Example

Since the decision table is a key ingredient in the system, we illustrate it first in a very simple form. At the end of this chapter a more complex example will be given.

Let us imagine that the Learning-Reference System has been activated for the user and that the computer has asked the person to identify himself by typing his name and code number.

The computer must then examine the response to see whether the person is authorized to use the system. The way it does this is shown very simply in the following decision table which we arbitrarily entitle TABLE 100 WHO IS IT. The table is explained below.

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(continued)
Example

	TABLE 100 WHO IS IT	1	2	3
CONDITIONS	Is his identification legal? (Does his response match any item on LEGAL CODE LIST?)	Y	N	N
	Has he given an illegal identification once? (What is the value of TIME FLAG?)		N	Y
ACTIONS	Display: "Illegal identification"		X	X
	Put Y (yes) into TIME FLAG (Shows one illegal identification given)		X	
	Display: "Identify yourself"		X	
	Put user's name into CURRENT USER STRING	X		
	GOTO TABLE 100 WHO IS IT		X	
	GOTO TABLE 105 WHICH MODE	X		
	Stop interaction			X

Explanation of Example

The top section of a decision table records the answers to questions about some current condition.

The lower section of a decision table shows what actions are to be taken for each relevant pattern of answers.

The table is read by considering the pattern of answers given in the first numbered column and then looking down the column to see what actions are prescribed (shown by X's). And so on, for each column.

In our example, when the answer to the first question is Yes, then we have no interest in the answer to the second question about whether an unacceptable answer was given before--that is why the answer box for the second question is left empty in Column 1.

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(continued) Explanation of Example

If the identification is legal, the computer takes the actions marked by X's in the lower half of Column 1, namely: the user's name is put into a computer storage location called "Current User String" and the computer goes to Table 105 WHICH MODE to find out whether the user's purpose is learning, browsing, reviewing, etc.

Column 2 in the table shows what the computer does if the user has given an illegal response to the first query--"NN" is the pattern of answers to the two questions. We see that the computer:

- tells the user the problem
- records in a place called TIME FLAG the fact that one illegal answer has been given
- again asks the user to identify himself, and
- then returns to step through this same table again.

If the user gives a proper code this time, we are of course back in Column 1; but if a false code is given a second time, we have the situation in Column 3: an illegal response has been given and the value of TIME FLAG tells the computer that this has happened once before. The computer then informs the user that his response is not legal and refuses to continue the interaction. (An accredited user who was making some error would presumably consult the supervisor at this point.)

This very simple example of a decision table illustrates two important points:

- the way that certain indicators within the computer get changed to keep track of events in interacting with the user--in this example, storage locations called "flags" and "strings" were modified

- the interlocking nature of the set of decision tables that we call the sequence generator--the example shows how the flow of action may go back through the same table again or may go on to other tables.

Comment

Although the actual decision tables of the Learning-Reference System are very much more complicated, even this simple example may give some feel for the way that a mere set of tables can constitute a sequence generator.

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(continued) Comment

The decision table offers the important advantage of flexibility which was discussed in the first chapter. An evolving system like this one needs components that may be modified easily without causing expensive changes in other structures or even in system documentation. It is easy to see that changing a line or column in a decision table would be simpler than changing a flow chart. Explicit procedures enabling support personnel to keep decision tables up to date are part of the aids supplied by the Documentation-Updating System described in a later chapter.

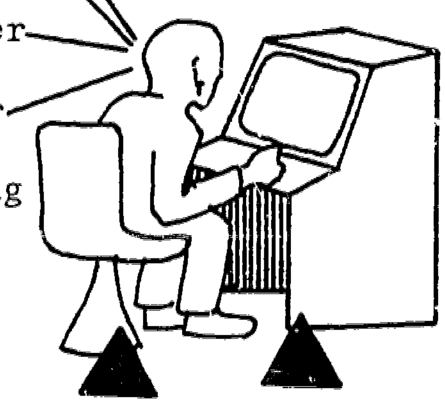
The use of decision tables simplifies the programmer's work since a number of compilers accept key-punched decision tables.

Later in this chapter we shall present a decision table of more complexity, but first we describe those other aspects of the system that provide the data for the decision tables.

SCHEMATIC OF THE INFORMATION MAP SEQUENCE GENERATOR

PRIMARY MODES OF INTERACTION

. Initial Learner
. Referencer
. Reviewer
. Browser
. Briefing



SUPPORT MODES

. Training Supervisor
. Editor
. Author
. Computer Programmer
. Clerical

USER

TERMINAL SCOPE AND KEYBOARD

The Sequence Generator finds out in which of these modes the user regards himself and provides appropriate services.

SEQUENCE GENERATOR PROGRAM

. responds to user commands and needs
. sets goal and criteria
. computes decisions about next displays
. administers tests, evaluates results, and gives feedback to user
. provides routine updating of various data bases

Designed to operate not only under total user control and total system control, but also at any one of numerous points in between.

DATA BASES USED BY SEQUENCE GENERATOR

Courses, composed of

. Information Maps divided into
  . Information Blocks
. Questions:
  . pretest
  . feedback
  . review

User Data Bases for each user composed of

. user background data
. current status
. place-keeping data

MODES OF OPERATION

Introduction

One of the primary objectives of the Learning-Reference System is to serve equally well users who come to the system for quite different reasons.

Within the sequence generator certain sets of decision tables and other mechanisms have been designed to serve each of the separate purposes for which users might come.

Description

A mode of operation is a set of rules for serving the needs of a particular type of user. It includes decision tables, switch settings and data storage locations especially designed to assemble the kind of displays needed by a given class of user.

Because the needs of user groups frequently overlap, the modes share many elements and computer routines. The mode requiring the most complex mechanisms is that for initial learning; hence this mode was designed first so that later modes could make use of its components.

In the current version of the sequence generator thirteen different modes have been tentatively defined and these are described briefly below. The modes for most primary clients of the system have been worked out in detail but some of the support modes have been defined only in general terms and may eventually be consolidated into two or three modes.

A mode is brought into operation by setting a "mode switch" to tell the sequence generator what kind of person is using the system. (At present such a switch setting would be made by a supervisor in consultation with the client, but this task will eventually be done automatically through a user-system dialogue.)

MODE	DESCRIPTION
Initial Learner	The purpose of this mode is to provide sequences of materials for those who come to learn something for the first time or to re-learn something mostly forgotten. A major goal is to deliver learning materials that are chosen especially to match the needs and interests of the individual. Whether the learner chooses his own path through the material or is guided to a greater or lesser degree by the tutorial provisions of the sequence generator depends upon a decision that is made by the supervisor or by the learner himself.

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MODE	DESCRIPTION
Referencer	The function of this mode is to enable a user to retrieve information from the data base easily and quickly. The user controls his interaction with the system and receives relatively little guidance from the generator except for some prompting when inappropriate commands are used or when he asks for help. The reference user needs little knowledge of the system since he can accomplish most tasks quickly with only four commands.
Reviewer	This mode serves those who wish to review a subject area they were once familiar with to some unspecified degree. It provides a user with : · a quick assessment of his knowledge of the subject area · an individualized review of those aspects that he has forgotten or wishes to see again · re-learning sequences where necessary either under system control or under the user's control. The aspects of the system that are to be controlled by the user or by the system are assigned by the supervisor or reviewer.
Briefing	Intended primarily for the potential user of another mode, this mode enables the individual to find out about the general nature and content of any subject matter stored in the system. The user of the briefing mode can see many special maps describing a given course, its difficulty level, an estimate of time required to learn it, some of the big ideas of the subject, its applications and so on. The degree of sequence control allocated to the user and to the system can be specified for this mode also.
Browser	Browsers need the tools to explore the information base in any manner they like. This means they need access to all courses. The system provides aids in terms of suggested commands and techniques that minimize the need for special training on the system. This mode has not been defined in detail.

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MODE	DESCRIPTION
Supervisor	The objective of this mode is to collect the information about a user that the sequence generator needs in order to serve him. The supervisor supplies the data required about the primary users and how they are to use the system. The information is obtained from the supervisor in a structured interview. Thus he has little need of the command language and little control over the system. As supervisor, he has no ıing to do with instructional materials. Future versions expect the supervisor functions to be accomplished by internal algorithms and not by support personnel.

Explanatory Note: The following support modes have been described in general terms but they have not yet been implemented in decision-table form for this version of the system.

MODE	DESCRIPTION
Instructional Designer	These users have the responsibility for specifying the sequencing rules for learners who are guided by the sequence generator. The system provides such on-line aids as directed interviews for eliciting the required information from them.
Author	Authors create course materials. They work in English and need not be concerned with technical aspects of formatting. They may occasionally need to create blocks on-line, but in general they rarely interact with the sequence generator.
Editor	Editors need to be able to call up blocks on demand and to insert, delete, or replace materials. They have access to block usage summaries and to clients' comments on the materials.
Clerk	Clerical workers who prepare course materials for the computer work mainly with off-line keypunching or typewriting equipment. However, they may need to do on-line editing of the newly inserted materials. The system provides aids that make it unnecessary for them to learn many commands or details about operating the system.
Programmer	These users are charged with implementing the system design and with devising support programs. They need a thorough understanding of all facets of the system.

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MODE	DESCRIPTION
Researcher	These users need summaries of client-system interactions and various tables of data. They must have access to the user data bases. The system provides the support programs that enable them to extract the information they need in the form they prefer.
Proctor	Some versions of the system may operate with an attendant for the area in which user stations are located. Such personnel should be able to answer user questions, suggest courses of action, explain ambiguous situations and the like. They may need access to the user-system data in order to answer some questions about the interaction.

DOMINANCE CONTROLS

Introduction

Two pieces of information have a marked influence on the way the sequence generator treats the client--first, his purpose in coming as indicated by the mode he is going to operate in, and second, the degree of control the client is permitted to exercise over sequencing decisions.

The system is set up, as Chapter 1 explained, to operate at any point on the continuum that extends from total user control to total system control of the information displays.

Now we describe the mechanisms that tell the sequence generator just where on this continuum the current client stands and what aspects of the system (if any) he is to control.

Control Switches

The amount of control that the user is able to exercise over the system is defined by a series of "switches." Here a "switch" is not a physical knob-like or lever-like gadget, but it acts like one; it is actually a variable, a quantity stored in computer memory, that can take on different values just as a switch setting can. For instance, the Mode Switch tells the sequence generator what the user came for and it is "set" by inserting a number between 1 and 13 in the computer location called Mode Switch. The number 1 shows that the client is an initial learner, and so on.

Some other dimensions that are controlled by switches are such things as whether the client can use certain commands (such as to go forward or go back), whether he should see and/or pass feedback questions, whether he can change the order of block displays and so on. A full listing of the switches will be given later in this chapter after we have talked about the commands with which many switches are so closely associated.

In all, twenty-six aspects of system functioning are controlled by switches. Of these, approximately twenty aspects can be placed under control of the user or of the system itself by adjusting the appropriate switches. (The remaining switches are concerned with the user's goal, certain display options and the like, and are not relevant to the control issue per se.)

A switch may have two or more "settings." Complete control of his own path through the information can be put in the hands of the user by setting all switches toward the free end of the continuum. On the other hand the system can assume complete control of selecting displays if the switches are set toward the restricted end of the continuum. Numerous patterns of shared control can be achieved by the way the switches are adjusted.

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(continued) Control Switches

Not all switches are relevant for every mode; for instance, control dimensions for initial learning are determined by twenty or so switches, but for the review mode only eleven switches are involved and for the briefing mode six switches are sufficient to define different control aspects.

The variety of switch settings makes it possible to give enormous freedom to reference and browsing users and to retain various degrees of control over some initial learners.

The present version of the sequence generator design calls for these switches to be set initially by a training supervisor, who hopefully will take into account the background and preferences of the user when making the settings.

Later versions of the generator envision the switch-setting task performed by a series of internally stored algorithms which react to data obtained in a user-computer dialogue at the beginning of a session and to stored data from previous sessions with the user.

Control Levels

In this version where switch-setting is carried out by the supervisor, the control switches, each with two or more settings, are too numerous for the supervisor to cope with in a reasonable time span. Therefore, as a temporary measure, we have made up for the supervisor sets of switch-setting patterns to serve as guides for placing a client somewhere on the continuum ranging from total user control to total system control. From these sample patterns, demonstrating how to set up different levels of control, the supervisor can select the one best suited for his client. Then, working from this basic pattern, he can alter the relatively few switch settings that will make it serve the client more effectively.

In addition, some of the switches may be reset within a session as a result of the user's behavior (e.g., errorless performance) or at the user's request.

For initial learners, recommended switch patterns exemplify five "control levels," ranging from the level at which all sequencing decisions are made by the system to levels with increasing freedom for the learner and on up to the fifth level where he is in control of all sequencing decisions.

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(continued) Control Levels	For reviewers, on the other hand, fewer levels need be illustrated to make the supervisor's task more manageable. Throughout this report we will frequently use the term "control level" to refer to the relative degree of freedom experienced by a user in controlling sequencing. The term is not meant to imply a uniform pattern of switch settings for all users at a given "level" but only a relative position on a continuum. While users at a "restricted level" of control will have quite similar switch settings and those at the "free level" will have most of their switches set alike, the pattern in each case represents an individual prescription made by the supervisor for the particular user. The phrase "balanced level" is used sometimes to indicate switch positions that distribute the tasks of sequencing about equally to the user and to the system. Obviously many different switch patterns could qualify a user for such a designation. We shall come back to these relative control levels in the next two chapters where we see how the generator responds to the individual user in the different modes.
Comment	The kinds of information that influence the selection of a control level for each user and the kinds of data that the sequence generator draws on for its work are described in the next few maps.

DATA BASES USED BY THE SEQUENCE GENERATOR

Introduction

In order to accomplish its work the sequence generator must have access not only to the information blocks themselves but also to masses of information about many aspects of the system--details about the courses available, about the current users, about scoring each feedback question, about the number of blocks available for each map, and so on.

Such data are stored in a series of data bases. Each base contains a distinctive kind of information which is described briefly in the table below and more elaborately in the following maps.

Table of Data Bases

NAME	BRIEF DESCRIPTION OF CONTENTS
SYSTEM DATA BASE	Data pertaining to the total system (commands, map types, switches, etc.), information needed for all courses and users, and information about the contents of other data bases.
COURSE DATA BASE	Data describing the characteristics, content, and structure of each course; the information blocks themselves and answer evaluation materials.
USER DATA BASE	Permanent and changing data on each user, including background data, course performance records, and his status within an on-going session (switch settings and the like).

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THE SYSTEM DATA BASE

Introduction

Certain classes of information about the system itself, its parts and functions are needed for general use. Such data are stored in the system data base.

Description

The system data base contains the following classes of information:

- the name and number of each course in the system and the total number of courses
- the name and code number of each user of the system and the total number of users
- the names and descriptions of all switches, including the function of each, the number of values it can have and the meaning of each value
- a store of messages from which the sequence generator can select one as a response to an action on the part of a user
- information about the command language and the actions to take when each term occurs
- the sequence generator itself (its decision tables and programs)
- statistical data across users and courses.

Examples of Uses

The sequence generator refers to system data in order to:

- select the correct course data base for a user
- determine the next available course number for an author to use
- locate the appropriate user data base for a person logging on
- allow switch settings to be made or changed
- display a message telling the user he has used an illegal command
- display a message informing the user whether his response to a question was correct or not
- provide summaries of system performance for researchers or programmers
- provide summaries of user performance for training supervisors or researchers.

THE COURSE DATA BASES

Introduction

Each course is organized into units.
Each unit is organized in terms of maps.
Each map is organized in terms of blocks and in terms of feedback questions as well because these require special treatment and evaluation.

Each of these structures and their contents must be described to the sequence generator so that it can select appropriate materials to display.

Description

To organize all this information systematically, a separate data base is established for every course in the system. The names and locations of these course data bases are specified in the system data base.

Each separate course data base consists of a hierarchy of smaller data bases for each structural part of the course.

Hierarchy of Structures Within Each Course Data Base

Each course data base is composed of:

- data pertaining to the whole course, such as:
  - table of contents
  - course index
  - prerequisite chart
  - objectives
  - main points
  - applications
  - overview and summaries
  - sample blocks and questions
  - difficulty level
  - time estimate for learning
  - final examination.
- the name, code number and location of every unit data base.

Each unit data base is composed of:

- data describing the unit to the sequence generator, including:
  - major concepts in the unit
  - unit pretest and review questions
  - prerequisite units
- the names, code number, and location of a data base for every map in the unit.

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(continued) Hierarchy of Structures Within Each Course Data Base

Each map data base contains:

- data describing the map, including:
  - map number
  - map type (concept, procedure, etc.)
  - blocks available
  - number of examples
  - possible following maps
- the information blocks themselves in display format
- the number of each feedback question and the location of the data describing it.

Each feedback question data base contains:

- data about the question, including:
  - relative difficulty on a scale from 1 to 5
  - possible answers that can be expected
  - the correct answer in the form preferred by the author (may be displayed as part of feedback to user)
  - the identity of the information block that is the basis for the question (block can be displayed again if question missed)
  - the number of times the user is allowed to try to answer the question.
- the question itself in display format.

USER DATA BASES

Introduction

Just as each course in the system has its own data base, so does each user of the system. It is here that all information pertaining to a specific user is stored for use by the sequence generator.

Description

The user data base describes the user to the sequence generator. It not only holds data about the person himself but it stores data about how the system treats him and about his current status in interacting with the information bank. Among the items contained in a user's data base are:

- background information such as:
  - name
  - age
  - sex
  - current job
  - reading level
  - mathematical level
  - areas of interest
  - achievement scores, attitude data, or other information a course designer believes related to information sequencing strategies
- data concerning user's experience with the system, including:
  - what course materials he has used and for what purposes (learning, reference, etc.)
  - performance records in Initial Learning or Review Modes
  - experience with the command language
  - the control levels at which he has been operating
- data concerning his current interaction with system materials, including:
  - the mode in which he is operating
  - name of the course
  - unit pretest scores if his purpose is learning or review
  - goal in terms of breadth of coverage (if relevant to the current mode)
  - criterion in terms of level of mastery sought (if relevant to the current mode)
  - switch settings (while the system data base contains general information about each switch and its possible values, the specific value each actually has for this individual on this occasion is stored in the user's own data base).

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(continued) Description	. data recording his path through the materials such as: . maps seen and passed . units passed . units failed . temporary data needed by the sequence generator in order to keep track of the user's current status and to conduct the session in an orderly, meaningful succession of displays, commands and responses. They include: . the number of blocks he has seen . list of maps whose prerequisites he has met . the name of the current map . the number of feedback questions failed . and many others.
Comment	The devices for managing some of these data classes and for keeping them current are important aspects of the Learning-Reference System. The next map describes more about how they function.

VARIABLE DATA SOURCES FOR THE SEQUENCE GENERATOR

Introduction

In the various data bases, we have said, the sequence generator finds not only the displayable information blocks themselves but also the detailed description of the information to be found at different levels of organization--courses, units, maps, blocks, feedback questions, and so on.

And we noted that an important data base is that reserved for details about each user--his capabilities, academic history, attitudes, experience with the system and so on. These are the details that influence the switch settings that determine how much control the user exerts over the sequencing.

But to assemble meaningful sequences of information, the generator must keep track of many things during a session. It needs other data sources in order to do such tasks as these:

- determine whether prerequisites have been met
- assemble blocks for the next map
- determine how many blocks to show at a time
- check on the legality of a command from a user
- evaluate the response to a feedback question
- determine whether the current map has been passed
- re-display a previous map that the user asks for again
- display a list of maps from which the user may select his next topic.

Several classes of variables have been defined to maintain the data needed.

Description

The term variable is used in computer programming to refer to several classes of memory locations whose contents are subject to change. In general the different kinds of variables (listed below) are used to keep track of changing conditions, the number of times events have occurred, lists of things that have been done or are yet to be accomplished and so on.

The data held in these memory registers are changed during an interaction with a user through the decision tables. The decision table example at the beginning of this chapter showed how flags and strings get changed. The switches, which we discussed earlier in reference to the control of information sequencing, belong to this group of variables also, but we shall save further description of them for a separate chart following the command language maps.

We do not give these tables with the expectation that readers will need this information, but rather with the idea that they might care to browse through to get a feeling for the kinds of tasks these variables help with.

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VARIABLE DATA SOURCES FOR THE SEQUENCE GENERATOR, continued

VARIABLES OF THE LEARNING-REFERENCE SYSTEM		
NAME	DEFINITION AND USE	EXAMPLES
string	any combination of letters or numbers;	CURRENT MAP STRING holds name of map the user is working on.
	mostly used to indicate names of courses or maps or blocks.	LAST STRING contains name of the last information block displayed.
list	an ordered set of strings or of other lists;	EXAMPLES SEEN LIST shows which examples from each map were actually displayed.
	mostly used to keep track of data about displays from maps--blocks seen, blocks available, blocks requested; feedback questions seen, passed, or failed; examples seen; ordering of blocks for display, and so on.	USER DISPLAY LIST gives in order the names of blocks routinely shown to a particular user.
		SUPPLEMENTARY BLOCKS REQUESTED LIST keeps track of the kinds of blocks the user asks for beyond those on his regular display list.
stack	a list that can be read at one end only; items are taken on or off from same end;	LAST MAP STACK saves map names for possible re-visiting later.
	used for remembering map names and display conditions so that a user can return later; they also remember which units were passed or failed during pretesting.	LINK STACK saves map names and display conditions so that a user can return to his place after a brief excursion elsewhere.
		UNITS FAILED STACK keeps a list during unit pretesting.

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VARIABLE DATA SOURCES FOR THE SEQUENCE GENERATOR, continued

VARIABLES OF THE LEARNING-REFERENCE SYSTEM, continued		
NAME	DEFINITION AND USE	EXAMPLES
vector	a sequence of bits whose length equals the number of maps whose status it is remembering; mostly used to keep track of which maps in a course are to be shown to a user, which ones he has failed, passed, and so on.	GOAL VECTOR is as long as the number of maps in the course and the only bits that are turned on show which maps are recommended for the current user. MAPS SEEN VECTOR has as many bits as the number of maps in the user's course; all bits are off at first but as each map is seen, its bit is turned on. REVIEW VECTOR operates in the reviewer mode to keep track of units whose review questions were not passed at an acceptable level.
flag	flags are usually set to Y (yes) or N (no) to show whether or not some condition has been met; they remember what the user has done or whether the sequence generator has gone through a decision table before; they are also important in judging feedback questions and in showing whether commands are legal.	SIL TIME FLAG shows whether this is the first pass through the Start Initial Learner Table. GOAL MET FLAG is set to Y when the user has seen/passed all the maps indicated on his GOAL VECTOR. NEXT ONLY FLAG, when set to Y, indicates that NEXT is the only command legal for the user at that moment. GIVE RIGHT ANSWER FLAG, when set to Y, directs display of the correct answer to the current feedback question.

Comment

In the course of subsequent chapters more about the functioning of these variables will be illustrated as we see how the sequence generator interacts with several types of user.

THE COMMAND LANGUAGE

Introduction

In every machine-based instruction system, the user must have some means of communicating his instructions, questions or responses to the system.

The interactive Information-Mapped Learning-Reference System has two main ways in which a user can communicate:

- he can type
- he can push a button.

These response modes are used either singly or in combination to convey instructions to the sequence generator, such as:

- show me the next display
- go back to the last display
- give me another example
- let me see the index.

In actual practice such instructions are given not by such time-consuming phrases but by abbreviated commands: next, back, example, index.

Definition

The command language consists of a restricted set of terms defining specific instructions that the user can give to the computer. There are approximately two dozen commands in this set at the present time plus the names of information blocks which function as request commands.

Using the Language

Some commands are accomplished by pushing a command button (e.g. NEXT, STOP) or by using a button plus a typed phrase (REVIEW 6, GOTO 17) in which the number typed refers to a specific map.

The terms "command button" or "pushbutton" are used throughout this report but how these specific functions will actually be implemented will depend upon the nature of the particular computer facility. It is quite possible that the command terms might be selected not from a pushbutton bank but rather from a scope display of the appropriate terms; in this case a choice could be indicated with either a light pen or a teletype key.

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(continued) Using the Language	Typing is mainly limited to giving map numbers, block names, and certain letters or numbers in response to multiple-choice questions. English phrases or sentences would be typed only: . in answer to a test question that requires a constructed response . in a comment which can be typed in after using the REMARK command and which allows the user to record comments and suggestions about the materials or the system.
Restriction	The entire set of commands is not available to all users. To some extent the number that are permitted is a function of the degree of control the user is able to exercise over the system. In other words, the switch settings and certain flags can make some commands inoperable. For example, a certain class of user might not be allowed to use the command to change courses. Restrictions on command use vary also with the mode in which the system is operating. For instance, the reviewer is allowed to use those commands that enable him to list the kinds of information blocks he wants to see regularly; but a person operating in the briefing mode would not be permitted that option. The briefing mode user can however change courses at any time while other classes of clients are sometimes prevented from doing this.
Comment	Because commands and switches are very closely associated and because they both relate to the important issue of how display sequencing is controlled, we devote the next few pages to: . a chart of the commands and their meaning . a table of switches and what they accomplish.

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THE KINDS OF COMMANDS OF THE COMMAND LANGUAGE

Introduction

Some commands are:

- executed by simply pushing the appropriate command button (e.g., NEXT, BACK)
- put into action by pushing the command button and typing some map number (e.g., GOTO 1, REVIEW 6) or block names
- interactive in that they enable the user to engage in a specific dialogue with the system (e.g., REMARK, SWITCH).

Classification Table of the Commands

The tables below give the name and a brief meaning of the instruction of each of the available commands.

SIMPLE COMMANDS	
NAME	MEANING
NEXT	Show the next display.
BLOCKNAME	Display a particular information block.
FEEDBACK	Display a feedback question from the current map.
TABLE OF CONTENTS	Display the Table of Contents for the current course.
INDEX	Display the Index for the current course.
ALL BLOCKS	Display all of the displayable information blocks from the current map. (Feedback questions are not shown.)
LAST MAP	Show all of the displays except feedback questions from the map that the user last saw before the current one.

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THE KINDS OF COMMANDS OF THE COMMAND LANGUAGE, continued

(continued) Classification Table of the Commands

SIMPLE COMMANDS (continued)	
NAME	MEANING
BACK	Show the previous display from the current map.
JUDGE	Evaluate the user's answer to a feedback question.
STOP	Stop the interaction for this session.
RETURN	Go back to where the user digressed.
POSSIBLE MAPS	Display a list of the maps that the user can see.
APPROPRIATE COMMANDS	Display a list of the commands that would be appropriate for the user to employ at this point.
BLOCKS AVAILABLE	Display a list of the information blocks available in the current map.
CURRENT DISPLAY	Display the names of the blocks on the USER DISPLAY LIST.
SUMMARY	Show a summary of the user's work.

BUTTON-PLUS-TYPE COMMANDS	
NAME	MEANING
GOTO "MAP"	Go to the first display of the map whose number is indicated.
REVIEW "MAP"	Display all of the blocks on the MINIMUM DISPLAY LIST of the map whose number is indicated.
DESCRIBE "COMMAND"	Display the map that describes the command indicated.
NORMAL DISPLAY	Change the USER DISPLAY LIST as indicated.

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THE KINDS OF COMMANDS OF THE COMMAND LANGUAGE, continued

(continued) Classification Table of the Commands

INTERACTIVE COMMANDS	
NAME	MEANING
HELP	Provide suggestions as to how the user can better understand the material he is working on.
REMARK	Allow the user to make a comment.
SWITCH	Allow the user to change the value of one of his switch settings.
CHANGE COURSE	Allow the user to choose another course from the list of available courses.

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SWITCHES USED BY THE SEQUENCE GENERATOR

Introduction

Switches tell the sequence generator, first of all, why the user came to the system, what his goal and criterion are (if applicable to his mode). After that, they mainly specify the degree of freedom appropriate for the individual user. Most restrictions are defined in terms of limits on the use of the language.

Just as some commands were not relevant for some modes, so also are some switches inapplicable in some modes.

The following table will give the reader an idea of the functions the switches serve.

Table of Switches

SWITCH NAME	MEANING	NUMBER OF SETTINGS AND EXAMPLES
CRITERION	level of mastery of course materials is set in terms of feedback questions that must be answered correctly in order to pass each map	6 settings, including . no feedback questions shown unless requested . must answer two successive questions correctly
GOAL	the breadth of course coverage is set in terms of what maps must be seen/passed to complete course	7 settings, including . no goal is set . pass major maps . see all maps . user selects those he wants to see/pass
MODE	identifies the user's purpose in coming to the system	13 settings, one for each of the modes defined earlier in this chapter
GOTO LIMIT	use of GOTO COMMAND can be limited to certain kinds of maps	13 settings, including . unlimited use . use only for maps passed . never use (system controls sequencing)
WHEN GOTO	specifies the times when use of GOTO is legal for the given individual	7 settings, including . anytime . not during a feedback question . never use

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SWITCHES USED BY THE SEQUENCE GENERATOR, continued

(continued) Table of Switches

SWITCH NAME	MEANING	NUMBER OF SETTINGS AND EXAMPLES
BACK LIMIT	specifies when the BACK COMMAND can be used	3 settings, including . never . only for displays within current map
BLOCK LIMIT	defines the times when user can ask for additional blocks (except feedback questions and examples)	6 settings, including . never . after required blocks on map have been seen . use anytime
CURRENT DISPLAY LIMIT	shows when user can ask to see which blocks are on his current map and in what order they will be shown	4 settings, including . never . not during a feedback question . anytime
POSSIBLE MAPS LIMIT	specifies when user can ask to see the list of the maps he has already seen	4 settings, including . never . not during a feedback question . anytime
NORMAL DISPLAY LIMIT	shows to what extent the user can use the NORMAL DISPLAY COMMAND to change the kinds of blocks and their order on his routine display list	7 settings, including . never . can only re-order blocks . can only add blocks . can change at will
EXAMPLE LIMIT	shows when additional examples can be requested	6 settings, including . never . only after all required blocks have been seen
EXAMPLE ORDER	shows whether to display easier or harder examples first	3 settings, including . easier first . harder first
FEEDBACK ORDER	shows whether to display easier or harder feedback questions first	3 settings, including . easier first . harder first

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(continued) Table of Switches.

SWITCH NAME	MEANING	NUMBER OF SETTINGS AND EXAMPLES
FEEDBACK LIMIT	specifies conditions under which user can ask for more feedback questions	6 settings, including . only after required blocks on given map have been seen . anytime
MAPS PASSED LIMIT	shows whether user must do more than meet his criterion in order to pass a map	4 settings, including . meet criterion only . must see all blocks from display list
DESCRIBE LIMIT	shows whether user may ask for the description of a command	4 settings, including . only when system suggests . anytime
REMARK LIMIT	shows whether user can record some comment about the system or materials	3 settings, including . never . anytime
TEACH LIMIT	defines how much on-line teaching of commands the system should provide	5 settings, including . only minimal prompting . teach only when user asks
BLOCKS AVAILABLE LIMIT	shows under what conditions the user may ask to see what other blocks are stored for the current map	6 settings, including . anytime except during a feedback question . never
REVIEW LIMIT	specifies which maps the user can see via the REVIEW COMMAND	6 settings, including . none . any map in current course or prerequisite course
SEE	records which of his switch settings the user is allowed to see	a vector with bits turned on for each switch setting user can see
MODIFY	specifies which switch settings the user can change	a vector with bits turned on for switches that may be modified

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SWITCHES USED BY THE SEQUENCE GENERATOR, continued

(continued) Table of Switches

SWITCH NAME	MEANING	NUMBER OF SETTINGS AND EXAMPLES
DISPLAY BLOCKS	tells how many blocks to display at one time	7 settings, including . one . all blocks except examples and feedback questions
LABEL BLOCKS	shows whether marginal labels of blocks are to be displayed	3 settings, including . yes . no
COURSE LIMIT	defines when user is allowed to change courses	5 settings, including . on system suggestion . at end of present course
SET	shows which switches are not yet set	a vector with turned-off bits showing which switches to set before user can begin session

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KINDS OF DECISION TABLES

Introduction

Now that we are acquainted with the various kinds of data that the sequence generator must consult before delivering displays to the client, we can return to the topic of decision tables and consider some of the major functions that they accomplish.

Description

Three basic classes of decision tables in this system are:

- those concerned with initialization, getting the system set up to serve the client
- those concerned with display-response interaction during the session
- those concerned with termination of the session or the course.

Each class will be described briefly.

Initialization

When the user begins his interaction with the system, he is recognized and either his old data base is activated or a new one is established for him. The first example in the chapter showed how decision tables could accomplish that.

Probably even before the user logged on, the supervisor would have considered his background data, his purpose, and so on and would have set the various switches to establish his degrees of freedom and, if relevant to the mode, to set up a USER DISPLAY LIST, indicating the blocks from each map type that are suited to this individual's purpose and the order of displaying them. (The user may be allowed the freedom to change these.)

About a dozen or so decision tables enter into this phase of initialization. They check switches, set or unset flags, get the user's data base ready to receive new data, specify the minimum number of examples to be displayed, and so on. A simplified example of such a table is given at the end of this chapter.

Display-Response Interaction

The fundamental work for which the system was made takes place during the cycle of display followed by user action. The sequence generator presents a display; the user then responds by saying NEXT, or by expressing a desire for some other display or information.

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KINDS OF DECISION TABLES, continued

(continued) Display-Response Interaction	Two tables carry the main burden of this interplay: . Table 260 Displays . Table 135 Response. The first table relies upon several subtables to decide whether the user has passed a map or course, or what should be displayed next. The second table has various subtables to help it decide how to react to user's responses--they must identify the nature of the response; if it is a command, they must see if it is legal; if it is an answer to a question, they must see whether it is to be evaluated. In either situation they must find what action is prescribed by stepping through the sets of decision tables governing these aspects of the interaction.
Termination	When the user stops at the end of a session or a course, various housekeeping routines must be taken care of. Certain data collected about the user need to be saved for future occasions--as, for example, when he returns to continue from the point at which he stopped. These various chores are done by the third group of decision tables.
Status Comment	At present approximately one hundred two tables have been written for these tasks.

EXAMPLE OF A DECISION TABLE

Introduction

The entries in most of the decision tables of the sequence generator are more complex than those illustrated at the beginning of this chapter. Some tables have twenty or thirty columns and rows. Sometimes the cell entries are more varied than the simple Y, N and X shown earlier--digits may be used to indicate a wider range of values.

For example, a user's aptitude might be indicated by H, M, or L to refer to high, medium or low. In the actions section of a decision table, digits might appear to show, for instance, how many examples are to be displayed.

Most of the actual decision tables are unsuitable for illustrative purposes because they contain special terms or programming conventions and are not understandable without considerable study or familiarity with the variables that have been described in previous maps.

The table chosen for illustration here does contain some special names for computer memory locations and it uses the backward arrow to say "put something into such-and-such a location." Nevertheless, it may give a feeling for the way the operating decision tables work and keep the interaction flowing from one table to another.

Purpose of the Table

Table 200, shown below, prepares the system to respond to the initial learner or reviewer. If the person has used the system before, this table brings up the relevant data that insure continuity in its interaction with him. For instance, under the heading of "fetch restart data," the system reinstates the conditions that existed at the last session--the display conditions, the switch settings, the status of vectors, strings, lists and so on.

It initializes various memory locations. It calls upon other tables to perform special routines such as selecting a new course.

It ends by transferring control to tables that will start up the displays for a learner or will interview the reviewer to find out his objectives.

Legend

The terms in upper case in the following table are system-specific, referring to memory locations, to variables or to other tables, which are distinguished also by the table number. For example, "DO 680 COURSE CHOICE" means that the computer should carry out the instructions given in Table 680, entitled, "Course Choice."

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EXAMPLE OF A DECISION TABLE, continued

200 START INITIAL LEARNER OR REVIEWER	1	2	3	4	5	6	7	8	9	10	11	12
(Has he already used the table today?) Value of SIL TIME FLAG?	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
(Is he ready to start a course?) Value of START NEW COURSE user attribute?	N	N	N	N	Y	Y	N	N	N	N	Y	Y
(Is he ready to select a new course?) Value of CHOOSE NEW COURSE user attribute?	N	N	Y	Y	-	-	N	N	Y	Y	-	-
(What type of user is he?) Value of MODE SWITCH? 1 Initial learner 7 Reviewer	1	7	1	7	1	7	1	7	1	7	1	7
(Show that table has been used today.) SIL TIME FLAG ← Y	-	-	X	X	X	X	X	X	-	-	-	-
(Set up the cross course data.) DO 250 DATA THERE	-	-	X	X	X	X	X	X	-	-	-	-
Fetch user restart data	X	X	-	-	-	-	X	X	-	-	-	-
DO 680 COURSE CHOICE	-	-	X	X	-	-	-	-	X	X		
DO 203 CREATE USER RESTART DATA	-	-	X	X	X	X	-	-	X	X	X	X
START NEW COURSE ← N CHOOSE NEW COURSE ← N CURRENT MAP STRING ← NAME OF FIRST MAP DISPLAY STACK ← USER DISPLAY LIST (TYPE STRING)	-	-	X	X	X	X	-	-	X	X	X	X
GOTO 260 DISPLAYS	X	-	X	-	X	-	X	-	X	-	X	-
GOTO 551 REVIEWER INTERVIEW	-	X	-	X	-	X	-	X	-	X	-	X

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CHAPTER 4 THE SYSTEM'S RESPONSE TO THE INDIVIDUAL LEARNER

OVERVIEW OF THIS CHAPTER

Introduction	Now that the major elements and functions of the Learning-Reference System have been introduced, we shall follow the system in its interactions with several representative clients. This may convey a clearer picture of the workings of the system in concrete situations.
This Chapter	The topic of individualized instruction is a convenient one around which to organize a fuller description of the system's capacities because it affords opportunities to demonstrate some of the options available to users or to system managers. Although all sequences are drawn from the same pool of organized information blocks, the sequence generator assembles quite different configurations of blocks for each individual. The factors and processes responsible for the differences in information delivered are pointed up in this chapter. The stage is set in the early phases of initialization when the supervisor and the generator come to various decisions about how the new client is to be treated. The first part of the chapter deals with that process. To illustrate the differential response of the generator to the user, the hypothetical cases of three initial learners are traced next. A summary map draws together the various dimensions along which individualization occurs in this system.
The Next Chapter	Other classes of clients who come with information needs are also treated on an individual basis. This chapter describes some typical interactions of the system with these users.

GETTING THE LEARNER STARTED IN THE SYSTEM

Introduction

An important part of making the sequence generator responsive to the individual consists in telling the generator about the person the first time he comes to the system. This is accomplished by a series of tasks assigned at present to the supervisor and slated eventually to be performed by the generator itself after on-line interviewing and testing of the client.

In the present version of the system, the supervisor's work is simplified by a computer-directed interview in which the generator elicits from the supervisor the information it needs in the form in which it will be used.

Initial Tasks

In the following cluster of maps we shall describe the tasks involved in starting a new learner. They include:

- deciding on how control of sequencing is to be allocated to the system and to the client
- establishing the learner's objectives in terms of the breadth of subject matter he wants to cover and the level of mastery he wants to achieve
- specifying the mode (initial learning) and the first course the learner wants to see
- collecting various background data about the learner in order to set up appropriate display recipes
- pretesting the client in order to start him at the proper point in the course.

How each of these tasks is done is discussed in the next group of maps. Fortunately the actual work can be done more quickly than it can be described.

For clients who have used the system before, the system has retained their initial data and has added to it the records of their work in the system. Thus for them the initializing chores are quickly dispatched.

ESTABLISHING A CONTROL-ALLOCATING POLICY FOR THE FACILITY

Introduction

We have a system that can provide varying levels of guidance for its clients or can leave them free to use the system as they will.

Whether a level of control will ever be imposed upon users or whether they are to choose the guidance level they wish is a matter of policy for facility managers to determine.

Some Relevant Factors

Some of the factors that bear upon establishing a policy on this issue are:

- the purpose of the facility--whether it is concerned with educational or training objectives
- whether any job requirements are related to courses passed
- the attitude of the administrators toward teaching strategies
- cost factors for operating the facility--where training time per person is important, restrictions may be imposed
- customer load--a facility that has queues may need to restrict the time allowance for each user.

The various factors interact in affecting the decision reached by the managers. The latter may establish a uniform policy for the system or a mixed one with differences defined for time periods or user classes.

In the examples in this chapter, a supervisor presides over setting up control levels for the user and we shall assume that his actions reflect the facility policy.

SELECTING A CONTROL LEVEL FOR THE LEARNER

Introduction

The level of control determines how the learner will interact with the system. In this version of the generator where the supervisor sets the control switches initially, he must take into account certain information about the learner. He may find what he needs in the user's data base if the learner has been there before, or he may have to collect it from the learner himself or from other sources.

Factors Influencing Control Selection

Some of the factors that enter into the choice of control or guidance level are these:

- user's history of independence or experience in managing own learning program
- user's experience with this system and skill with the language
- user's own wishes
- facility policy (as noted in the last map).

The learner's wishes may include such considerations as his own time pressures or a desire to expand his acquaintance with the system. In the first case, he may have only a short time to learn something and, even though experienced with the system, he may prefer to be guided along the shortest path commensurate with his goals. In the second instance, he can be assigned to a guidance level that gives him a chance to expand his understanding of commands gradually while he concentrates on his main learning task.

The amount of control that the user is allowed to exercise over the system should be compatible with his ability to make efficient use of it. It should not put demands on him that distract him from his main objective.

The level selected can of course be changed if the user finds it uncomfortable and in any case, switch settings may change through the course of a session as a result of the learner's performance or behavior patterns.

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Future Plans	In planning one's own learning program, the amount of freedom or self-direction that is optimal is not now known. It will probably be found to vary with characteristics of the learner and with his stage of development. One attractive feature of the Learning-Reference System of the future is the opportunities it offers for a practical research attack on this problem. With its facilities for allocating degrees of control, for measuring learner's progress, for recording interactions, and for printing out data summaries for many variables, it is well situated to enlighten our understanding of the control issue.
Comment	How the quality of the learner's experience differs for certain control levels will be illustrated presently in examples of some representative users. First we finish explaining the process of preparing the system initially to respond to the user.

DETERMINING THE LEARNER'S OBJECTIVES

Introduction

The next important information the generator needs to know about the user is the nature of his objectives. Unless it knows these, it will not know how much of a subject matter to cover in its presentations.

The learner may come to the system for a variety of purposes. He may seek complete mastery of the subject area, or he may want only an understanding of the main ideas and a knowledge of where to find details when he needs them. He may want an even more general bird's-eye view of the subject.

The sequence generator must be able to bring sequences that are appropriate for the objectives of each individual.

Setting the Learner's Goal

In order to give the sequence generator the specific datum it needs, we can arbitrarily define goals in terms of several configurations of maps that would serve different objectives. Some plausible combinations of maps are:

- all maps of the course
- major maps--those presenting the main concepts of the course
- general maps--the previews, reviews, summaries and the like.

The grouping that seems best suited to serving the learner's goal can be selected and indicated to the sequence generator by setting the Goal Switch, one of the twenty-six switches mentioned in the last chapter. For instance, the switch could be set to 2 to indicate the second combination above. This selection would also be automatically reflected in the Goal Vector which is set up to show the generator which maps in a course can be drawn upon for displays.

The above groupings of maps are examples of the fact that different combinations can be earmarked to serve different objectives. It would be the responsibility of the course designer to tag maps that are suited for different goal statements. The sequence generator will be guided by the Goal Switch setting and the associated Goal Vector to pick out all maps with similar tags.

The Goal Switch could be set as the result of a dialog between the learner and the computer, but for the present version, the supervisor confers with the user about his objectives and then sets the switch.

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(continued) Setting the Learner's Goal

In the case of those learners who operate near the free end of the control continuum, they can set up their own Goal Vectors in a dialog with the computer. Basically what happens is that the learner selects from a table of contents the names of the maps he believes he will want to see. The numbers of these maps are tagged in his Goal Vector and the generator will derive displays from them.

Setting the Learner's Criterion

The user's goal determines what information he will be exposed to, but how well he must learn that information is specified by a criterion.

The criterion in the Learning-Reference System is a statement of a level of proficiency needed in order to "pass" each map shown. This idea of "passing a map" is stated in terms of the number of feedback questions that the user must see and/or answer correctly.

Here again a switch is used to select a level that is desirable for the specific individual's situation. The levels range from virtually no requirements at all for passing a map other than just seeing it, to the stipulation that two correct responses in a row are required before the user can go on to another map. (The requirement to pass feedback questions carries with it the implication that remedial sequences will be supplied until criterion is met.)

As the table of switches in the last chapter shows, the criterion switch has six settings at the present time; others could be added and the settings could be made to change in the course of a session as a result of the learner's performance. Research in this area will help in formulating the algorithms that can set the criterion automatically in the future.

Comment

Taking the goal and criterion settings together, we have the means of making the generator responsive to the individual's learning objectives.

A person, for example, who was preparing for an important closed-book examination might specify that he wanted to cover all maps of the course and to pass each by correctly answering two successive feedback questions.

On the other hand, the student who wanted only an understanding of the main ideas in order to prepare for an open-book test might ask for major maps only, and he might set a criterion of one correct answer to a feedback question merely to verify his understanding of the related map.

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(continued) Comment	Another user might want only a general picture of a subject, but one that was rather more detailed than that provided by the briefing mode. In this case he could ask that the generator show him all general maps but no feedback questions unless instructed to do so by the user.

PREPARING THE USER DISPLAY LIST

Introduction

Since each learner comes to the system with his own objectives and with his unique personal characteristics, the system should be able to create for him a pattern of information blocks that is tailored to his needs. The generator would not display for him all the stored blocks belonging to a given map but would select only those that serve the user's purpose.

To do this the generator sets up for each client a list of the blocks that it will routinely show from each type of map. This list, the User Display List, is prepared after the generator consults background data in the user data base or collects the information itself.

User Data

For each course, the course designer may specify certain personal data that will influence decisions about building displays for the individual. These data may be obtained via questionnaires, proficiency tests, miniature situation tests, aptitude and attitude tests and so forth, either given on-line or off-line. The nature of these tests, the scoring of them and the decisions to be taken for given score ranges will be specified by the course designer.

For example, if the course were one in the math area, the designer might supply an attitude-toward-math scale and prescribe that students below a certain score be given designated sets of blocks from each map in order to allay their fears of the subject area. But for learners with extensive training and proficiency in mathematics, he might prescribe a minimum display list consisting, for example, of only definition block, diagram and notation blocks, plus one example with a higher difficulty rating.

All such prescriptions are recorded in the course data bases. They are elicited from course designers in computer-directed interviews or via printed questionnaires.

Defining the User Display List

The <u>User Display List</u> contains the names of specific information blocks in the order in which they will be displayed for the particular user. The names always refer to the current map type (e.g., concept map, procedure map).

As the starting point for preparing a User Display List, the generator builds upon the Minimum Display List, a list that is defined in the system data base as constituting the minimum display allowed from the given map type. For example, let us

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(continued) Defining the User Display List

say that for a concept map the Minimum Display List consists of

- name
- definition/description
- formula
- notat⁻
- exampie.

(If a block named does not exist for a given map, it is simply ignored when the display list is used.)

After considering the current client's background data, the generator adds blocks to establish the User Display List:

- name
- introduction
- definition/description
- example
- formula
- notation
- example.

The user's data base may show that in past sessions this user has had a tendency to request display of "Use" blocks, for example; in such a case, that block may be made part of his display list.

Use of the Display List

The generator consults the User Display List to determine:

- which blocks to display and in what order they should be shown
- whether all blocks have been displayed when the user presses certain command buttons (under some control settings, commands will not be accepted until the recommended blocks have been shown).

Changing the User Display List

The User Display List is a list of recommended blocks but, except for the client from the most restricted control level, there are many possibilities for modifying it. We are concerned now only with establishing it in the first place. As we will see presently, the user's experience with it and his personal preferences may mold it much more precisely to satisfying his individual information requirements.

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SETTING UP DISPLAY CONDITIONS

Introduction

Before the learner finally begins his interaction with the information base, there remain a few additional chores. For one thing, several more aspects of the displays have to be mentioned to the generator. And it has to be told where to begin building displays.

Display Details

For both example blocks and feedback questions, the supervisor can recommend the difficulty level from which the items are selected for display. As the table of switches in the last chapter noted, he chooses whether easier or harder items are shown first. Under the freer control conditions, the learner himself makes these choices.

In an Information-Mapped book, the marginal labels for the information blocks are convenient for reference purposes. There is also some research that suggests that to be alerted to the nature of upcoming information facilitates learning. Nevertheless individual preferences or research purposes make it advantageous to be able to suppress or display the label. The Label Blocks Switch permits the choice and its setting is left up to the user (except in controlled research).

One more important switch remains to be set--that telling the generator how many blocks to display at a time. The present switch settings can specify from one at a time to all blocks at once (from the User Display List), and may be selected either by the supervisor or by the learner, depending upon how the control level is set.

In actual implementation in a computer facility, the display options will become much more varied and important. Since these are so closely tied to specific hardware, this version of the generator is concerned with nothing more than the number of blocks to display at a time.

Starting Place

Each initial learner beginning a new course takes a pretest (unless he is operating under the freest control conditions). This test allows the system to determine the current state of his knowledge about a subject.

The sequence generator uses the results of the pretest (which are stored in terms of unit scores) to determine on which unit the user should begin. Those units that have been passed in the pretest are bypassed by the learner but maps from them may be called up if he wishes to check on his grasp of some idea in them.

Comment

To illustrate how the interaction with the system differs for individuals whose initial settings are quite different, we will follow the sessions of three imaginary learners in the next few maps.

A LEARNER OPERATING AT THE RESTRICTED CONTROL LEVEL

Introduction

Suppose our first fictional learner, Ted, has been assigned to the most restricted level of control in which the generator makes the sequencing decisions. We shall see how the system was initialized for him and then describe the kinds of things he can and cannot do in a learning session.

Initial Setup

Ted came to the system for a course in probability. Through on-line testing and interviewing, the following facts about him emerged that led the supervisor to set up the system in this way:

These Characteristics Led...	...To These Settings
. dependent, docile learner . has never used this system . is in a hurry	Control Switches to Restricted Position except Feedback Limit Switch is set to allow any feedback question requests
. wants only main ideas . high level of mastery	Goal Switch: See Major Maps Only Criterion Switch: Pass 2 consecutive feedback questions per map
. math aptitude score=85% . lacks confidence in math ability . little interest in math . asks one example to be shown before definition	User Display List: Introduction, Example, Definition, Notation, Diagram, Comment, Example Examples and Feedback Questions: easier ones first
. prefers display of two blocks at a time	Block Display Number: Set at 2 (exclusive of Map Name block and Related Maps block)
. prerequisite test passed . all unit pretests failed	Starting Map: first major map of Unit 1.

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Explanation of Settings

Ted is assigned to the restricted control level because he is unfamiliar with the system and in a hurry. If he had more time and expected to use the system often, some switches could have been set to allow him more leeway in using commands and to enable the system to prompt him on their proper use.

Or the supervisor might have urged him to take first the short course on operating the system. However, since he has little time, the system is now set up to guide him through the materials as swiftly as possible to achieve the goal he has indicated.

Because he lacks confidence in his math ability in spite of creditable test scores, the generator follows a prescription stored by the course designer and sets up a User Display List containing both Introduction and Comment blocks. These often supply interesting context and extra learning aids that may increase his confidence. Two examples were prescribed for the same reason.

The Learning Session

The session starts with a very brief introduction to the system, explaining the block structure of the displays and the use of the few basic commands he will need.

The course begins with the first major map of the first unit. The first display shows the Name and Introduction blocks and an easy example.

After reading these blocks, Ted has only a few options -- he can push:

- NEXT button to replace the present display with the next two blocks
- APPROPRIATE COMMANDS button to see what commands he can use now
- STOP button to bail out of the session.

If he makes the usual response of pushing NEXT, the displays will continue to appear two at a time until he has seen the blocks from that map that were prescribed on his User Display List.

Then the feedback questions come up one at a time until he answers two in a row correctly (according to his Criterion). When he answers incorrectly, the generator follows the directions stored by the author in the feedback-question data base -- it may show again the block from which the missed question was derived or it may take some other recommended action.

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(continued) The Learning Session

Now a new option becomes available to the learner -- he may ask for more feedback questions if he wishes, because the Feedback Limit switch setting permits this.

From the second map on, he can use the LAST MAP command to bring up again the last map he saw. This command and NEXT are the two commands that enable him to move the displays -- but the distance he can move them is very limited. He can back up only to the just previous map and he can move ahead through the blocks of his current map. Until the required feedback questions are correctly answered, he cannot call up the next map.

These restrictions keep him on the path prescribed for him initially and prevent him from side excursions. For some educational purposes this may not be wise but for certain training objectives it is advantageous.

If, as the session proceeds, Ted consistently answers feedback questions correctly, the generator may change to the more difficult questions and may omit the second example from the User Display List.

Ted continues through a session with few variations except that he can ask for help with the HELP button and he can use the command to get a summary of his session showing how many maps or units he has passed and how much remains to be done.

When he wants to stop, he pushes the STOP button; the generator stores away all data concerning his display conditions, his place in the course and relevant lists, stacks, strings, flags. These are kept in Ted's assigned data base so that on the next occasion he can resume where he left off.

Individual Treatment

Under these restricted conditions, the learning experience <u>feels</u> to Ted very much like a session of computer-based programmed instruction. He was allowed a handful of extra choices perhaps, but otherwise he was locked into sequences assembled by the generator.

But as a matter of actual fact, the sequences Ted saw were prescribed for him as an <u>individual</u> -- he was <u>not</u> pushed through, in programmed-instruction manner, a standard series shown to everybody except for occasional remedial side trips. His sequences were tailored with an eye to his objectives, his attitudes, his prerequisite skills, his personal preferences, and even to his present situation -- a specific information need and a time limit.

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(continued) Individual Treatment	In addition, before Ted returns for another session, the supervisor or curriculum specialist may review the records of his interaction with the course materials and may insert into his data base changes in switch settings or display conditions that will make the pattern of the next session even more suitable for his current status. In a later version of the system, such adjustments will be made automatically by the generator.
	Another student assigned to this same restricted level might see a markedly different set of blocks from the same course. A person who was proficient and confident in mathematics, for instance, might have a short display list consisting of the minimum allowable blocks and he might have no requirement to answer feedback questions, depending upon his objectives in taking the course.

A LEARNER OPERATING AT A BALANCED CONTROL LEVEL

Introduction

Our second imaginary learner, Dick, has been assigned to the control level at which some sequencing tasks are performed by the system while others are assigned to Dick. It must be remembered that the setup for Dick is only one of the many quite different switch-setting patterns that are possible at this level.

Initial Setup

Dick also comes to learn probability but he seeks just a general understanding of the major ideas for his own reasons. He has taken three previous courses on this system. His stored data show that he has a good background in mathematics and is not intimidated by it. He is a moderately dependent learner but aspires to be more self-directed. In the previous courses with the system, he worked at a fairly restricted control level because he did not know the command language well. He has completed the on-line pretest for probability and has passed unit 1 at the 80% correct level, but for other units he passed less than 50% of the questions.

In conversation with the supervisor, Dick explains his objectives with regard to probability materials and his wish to assume more control over his learning experiences.

In view of these various data about Dick, the supervisor adjusts the system initially to enable him to:

- make his own Goal and Criterion setting
- specify whether easier or harder examples and feedback questions should be displayed first
- indicate how many blocks he wants displayed at a time
- set up his own User Display List naming the blocks he wants to see from each map.

Dick decided to set his Goal to "see all maps" and his Criterion to pass one of the more difficult feedback questions. Because of his switch settings, he is free to change these at any time if he is not satisfied with them.

The supervisor, in view of Dick's learning history, sets certain command switches to limit his ability to jump about at will in the course materials -- he can move forward only to maps for which he has passed the prerequisite maps. Whenever several maps are eligible, he may select the one he wants to take up next.

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(continued) Initial Setup	He may use all commands but a few cannot be used when a response to a feedback question is expected. The system is also set up to tutor him on commands and strategies in order to increase his skill and confidence in handling the system.
Actions He Can Take	During the learning session, a few of the more important actions that Dick can take are these: . use the GOTO command to see any map for which he has met prerequisites . use the RETURN command to go back to the place where his digression began . back up to a previous display from the current map . select a topic from the Possible Maps List except when asked to answer a question . ask for additional blocks to be shown from current map . add, delete or reorder the blocks on his User Display List . ask for explanation of commands . record remarks about the material, the system, his progress and the like . consult the table of contents and the index.
Actions He Cannot Take	Few things are forbidden to a user at Dick's level except that in his case switch settings specify that: . he cannot jump ahead to maps he is not prepared for . he cannot change a few switches . he cannot avoid displays of feedback after answering feedback questions . he cannot change courses (a decision of the supervisor's).
Comment	An example of Dick's interaction with the system during a learning session is charted on the next map.

SAMPLE SESSION OF A LEARNER AT A BALANCED CONTROL LEVEL

Introduction	To give an impression of how a session might proceed, we present a sample of the interaction between Dick and the computer. The example is constructed to show some of the variety of actions Dick can take; in actual practice one would hope that he would pursue a less erratic course.
Initial Setup	To recap the display situation set up in the preceding map, mainly by Dick's own choices: Goal: See all maps Criterion: Pass one feedback question per map User Display List: Definition, Notation, Diagram, One Example Examples and Feedback Questions: Display harder ones first Blocks at a Time: Display two Course: Introduction to Probability.
Format	To save space, the information blocks themselves are indicated only by their labels in parentheses; the user's answers to feedback questions are similarly indicated. Actual map names and displays of computer remarks to Dick are given in regular text format. The commands Dick uses are given in upper case. Explanations are added on the right when appropriate.

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SAMPLE SESSION OF A LEARNER AT A BALANCED CONTROL LEVEL, continued

	SEQUENCE	EXPLANATION
Display:	Events. Map 25 (Definition block) (Notation block)	The first map from Unit 2 is shown (Unit 1 having been passed in the pretest). Blocks indicated on User Display List are shown two at a time.
User:	NEXT	
Display:	Events. Map 25 (Example block) (Related Maps block)	Map 25 has no Diagram block, generator displays next available block. (Feedback questions are not shown at same time as blocks.) Related Maps block, a local index showing location of main concepts relevant to the given map, is automatically displayed at end of each map.
User:	NEXT	
Display:	(Feedback Question)	
User:	(Answer) NEXT	
Display:	Your answer is correct. Push NEXT to continue.	The criterion of one correct answer has been met; Map 25 is recorded as "passed."
User:	GOTO 17	Dick wants to review a concept in Unit 1 which he had passed. Related Maps listing helped him locate it quickly.
Display:	Sample Space, Sample Points. Map 17 (Definition block) (Notation block)	
User:	RETURN	Dick learned what he wanted from the first two blocks, stops display of remaining blocks by asking to return to his previous place.
Display:	Empty Event. Map 26 (Definition block) (Notation block)	Since Dick had passed Map 25, the computer continues with the next scheduled map.

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SAMPLE SESSION OF A LEARNER AT A BALANCED CONTROL LEVEL, continued

	SEQUENCE	EXPLANATION
User:	NEXT	
Display:	Empty Event. Map 26 (Example block) (Related Maps block)	
User:	BLOCKS AVAILABLE	This command gets the generator to list the names of all blocks available on the current map.
Display:	Empty Event. Map 26 Blocks Available Introduction Definition Notation Comment Example Non-Example	
User:	COMMENT	
Display:	Empty Event. Map 26 (Comment block)	
User:	NORMAL DISPLAY DEFINITION NOTATION DIAGRAM EXAMPLE COMMENT	User wants to make Comment blocks a regular part of his Display List in the order shown.
Display:	New Display List recorded.	
User:	NEXT	
Display:	(Feedback question, Map 26)	
User:	(Answer) NEXT	
Display:	No, that is not correct. (Notation block) (Feedback question)	The block on which the question was based is displayed again. A different feedback question on the same point is displayed as well.
User:	(Answer) NEXT	
Display:	That is correct now. Elementary Events. Map 27 (Definition block) (Example)	Map 26 recorded as passed. Notation and Diagram blocks not available for this short Map 27.

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SAMPLE SESSION OF A LEARNER AT A BALANCED CONTROL LEVEL, continued

	SEQUENCE	EXPLANATION
User:	NEXT	
Display:	Elementary Events. Map 27 (Comment block) (Related Pages block)	
User:	GOTO 34	Without passing Map 27, Dick asks to jump ahead to another topic.
Display:	Sorry, you have not passed prerequisites.	
User:	POSSIBLE MAPS	This command will get Dick the list of those maps that he is eligible to call up.
Display:	The following maps are those for which you have met all prerequisites. Asterisks mark those you have already seen and passed: Number Map Name 25 *Events 26 *Empty Events 27 Elementary Events 28 The Union of Two or More Events 29 Elementary Events Form Other Events 30 The Intersection of Two or More Events	
User:	GOTO 30	
Display:	The Intersection of Two or More Events. Map 30 (Definition block) (Notation block)	Dick prefers to take up this topic next rather than the one the generator chose for him originally.
User:	FEEDBACK QUESTION	Since Dick has the concept, he forestalls display of the other blocks by asking for a question.

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SAMPLE SESSION OF A LEARNER AT A BALANCED CONTROL LEVEL, continued

	SEQUENCE	EXPLANATION
Display:	(Feedback question Map 30)	
User:	(Answer) NEXT	
Display:	Right. Continue.	Map 30 joins Maps Passed List.
User:	STOP	
Display:	Your current status is: Passed: 25,26,30 Other Possible Maps: 27,28,29,31 This record will be kept for your next session.	Status and all display conditions, lists, flags, etc., stored for next occasion.

A LEARNER OPERATING AT THE FREE CONTROL LEVEL

Introduction

Our third imaginary learner is Henry, who is an old hand at manipulating this system as well as being a self-reliant person accustomed to setting up his own objectives and a plan for achieving them. The supervisor has intelligently adjusted the system so as to give Henry carte blanche. Let us see what help the generator can offer Henry.

Initial Setup

Any learner at this free level of control can use any command and set any switch he wishes at any time. Whether he wants to set up a Goal and a Criterion is completely up to him.

Henry's situation is this: he wants to prepare for the Graduate Record Examination. Although he is well prepared in mathematics, he knows little about probability.

His first move is to take on-line the pretest for the Introductory Probability course. Units 1 and 2 are passed at a 90% level which satisfies him. His concern now is to learn more about units 3 to 5. Rather than set any Goal or Criterion or display conditions now, he begins the learning session in his own way.

Learning Session

Henry changes the Mode Switch to the briefing mode setting. He then quickly runs over the main points of the probability course, its objectives and the course summary.

Once he has the big picture of what the course is about, he returns to the Initial Learner Mode by changing the Mode Switch.

Now he uses the goal and criterion functions of the system to design his own course. He calls for the table of contents, checks off the names of maps that he wishes to see. These go into his Goal Vector so that each of them comes up in order unless he chooses to deviate from his plan.

Because he is competent in mathematics, he sets no "passing" criterion but merely asks to be shown two difficult feedback questions for each map.

Also because of his good background in mathematics, he sets up for himself only the Minimum Display List: Definition, Notation, Diagram, One Example.

He sets the switches to display all blocks at a time, keeping the labels attached.

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(continued) Learning Session	Now he begins study of the displays from Unit 3, using the NEXT command to move the maps along on the scope. At any time he is free to depart from the sequence he has established. He may pursue related ideas to previous units or go ahead to unseen and unpassed materials. He may call up additional blocks any time he wishes or he may design a new User Display List. If, on reading feedback questions, he feels uncertain about the answer, he can give his response and by use of the JUDGE command, can get feedback concerning his correctness. (Ordinarily, he does not need feedback for he knows when he understands.) He may call for the next unit pretest, if he likes, to satisfy himself about his progress in that area. His scores have no automatic effect on his procedures -- he can adjust his strategy or not, as he wishes. If he forgets the meaning of certain terms in the command language, he can ask for help at any time. He may even leave the probability course and revisit the course on how to operate the system. He is free to record remarks about any aspects of the materials, of the system, or of his own progress. He may discard his systematic approach to the unpassed units of the course -- he might, for instance, call up the feedback questions for maps picked at random from the table of contents. Only when he is ignorant of the answer would he call up the information blocks from the map in question. After a series of experiences of that sort, he may resume an orderly inspection of the materials in each unit. He is free to follow whatever strategy appeals to him at the moment -- even to choosing a completely guided tour of the subject area, such as a learner at the most restricted level might receive.
Comment	The generator is designed to help the self-reliant learner in many ways. The system is also designed to improve its services in response to user's remarks and suggestions and in response to research summaries of operational data. Future plans for the system include the addition of special materials and simulation games designed to encourage students to become self-reliant managers of their own learning experiences.

SUMMARY OF THE SYSTEM'S RESPONSE TO THE INDIVIDUAL LEARNER

Introduction

The initial learner in the Learning-Reference System is treated as an individual because the sequence generator acts on many kinds of data that are specific to the person.

This table summarizes those factors about the learner that make a difference in system functioning. (Control switch settings modify the effect of some factors.)

THESE FACTORS. . . . . AFFECT. . . .	THESE SYSTEM COMPONENTS
I. User's Objectives	
• purpose in entering system--to learn: • general nature of subject area • entire subject matter • main ideas of the subject	Goal Switch
• proficiency level • thorough mastery for long-term retention • general understanding • other	Criterion Switch
II. User's Background Data	
• independence and experience in planning own learning experiences • proficiency in using this system and the language • user's wishes	Control Level
• experience in subject area in terms of courses and their difficulty level • proficiency in subject area in terms of prerequisite test scores • attitude toward subject area in terms of questionnaire scores • other cognitive and motivational aspects judged relevant by course designer, such as reading level, intelligence level • stored records of past command usage or other behavior tendencies	User Display List Number of Examples and Feedback Questions Their Difficulty Level
• user preferences	Display of Block Labels Number of Blocks Shown at a Time
• pretest scores	First Map Display

SUMMARY OF THE SYSTEM'S RESPONSE TO THE INDIVIDUAL LEARNER, continued

THESE FACTORS. . . . . AFFECT. . . .	.THESE SYSTEM COMPONENTS
III. <u>Learner's In-Session Choices</u> (Depending on Control Level) • request additional blocks for current map • request more feedback questions/examples • modify User Display List by adding, deleting or re-ordering blocks • return to previously seen or passed maps • call up table of contents and index • select next topic from list of maps whose prerequisites have been met • explore course materials at will (free control level only) • enter comments into the system • request session summary • ask for help of several kinds • request description of command use • request suggestions of possible next commands • modify display conditions (number of blocks, label display) • suppress display of answer evaluation (feedback) • modify switch settings	Decision Table Usage Switch Settings
IV. <u>Learner's Response Patterns</u>	
• feedback failure rate	User Display List Number of Worked Examples Number of Feedback Questions Remedial Sequences
• block order preferences • additional block requests	User Display List
• command usage record	Instruction by System

CHAPTER 5 THE SYSTEM'S RESPONSE TO INDIVIDUAL USERS OF OTHER CLASSES

OVERVIEW OF THIS CHAPTER

Introduction	The Learning-Reference System is equipped to give custom-tailored service to users other than initial learners. In order to do this it has special features that serve a given user class but it also relies heavily on the mechanisms that generate displays for the individual learner.
This Chapter	This chapter explains how individualized treatment is accomplished for clients who come for reference, review or briefing purposes. A few of the special aids to supervisors, writers/editors, and researchers are described also.

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THE REVIEWER MODE

Introduction

One of the primary purposes of the Learning-Reference System is to help the user review materials that he has previously learned. In many respects the operating mode that caters to reviewers resembles the Initial Learning Mode and it does use some of the same mechanisms.

Description

The Reviewer Mode is designed to give the user a guided review of course materials or to help him review in whatever way he wishes. Whether or not he is allowed a choice depends upon the supervisor.

The Guided Review

The guided review, whether chosen by the user or assigned to him, takes into account various kinds of information about the reviewer and his objectives in much the same way as was done for the initial learner.

The reviewer may come for a number of reasons. He may want to go over some information he expects to need in his occupation. Or he may have to instruct others and wish to refresh his memory first. Or, as a member of the academic world, he may find reviewing useful before taking exams or writing term papers. He may even have some humble purpose such as killing time.

His objectives and certain other personal characteristics enter into the supervisor's deliberations when he sets up the system to serve this person. As with initial learners, the supervisor considers the user's experience in operating this system, his self-reliance, and his wishes in regard to planning his own review.

Sets of review questions for each course unit serve as the basis for certain sequencing decisions for users in the guided review condition. The reviewer can be required to pass a specified percentage of unit review questions, depending upon his objectives. If he is reviewing in preparation for an exam, he might want to pass 90 per cent of the review questions before leaving the system. Units that are not passed at the specified level are shown again.

A guided review session very much resembles a restricted initial learner's session in that the reviewer has:

- a criterion that shows what percentage of review questions he wants to pass before leaving the unit
- a Goal Vector that shows the sequence generator the list of maps he is scheduled to see because he missed review questions based on them
- a User Display List that shows what blocks from each map are to be routinely displayed to him.

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(continued) The Guided Review

If the supervisor's switch settings permit it, the reviewer can change his display list, ask for other blocks, go forward or backward in the course materials. He may ask for feedback questions and they may be evaluated but they do not influence the sequencing of displays--only review questions affect that.

In short, the generator in the guided review condition finds out what the person does not know and then takes him through relearning sequences that are tailored for his particular objectives and personal background.

Free Review Condition

Unrestricted reviewers can go through the materials more or less as they wish. They may be as free as the top level initial learner or the referencer. All commands are available to them.

Many different strategies can be used. For example, reviewers can set up in advance the list of maps they want to see. This can be done by selecting from the table of contents or it can be based on the results of optional pretests. Maps indicated by the reviewer would be set into his Goal Vector and then the generator would go through the series with him. He can use feedback questions or not, as he wishes. In any case, they would not affect his sequencing plan.

Another reviewer might want to look over only the general maps in a course--the overviews, previews, summaries, compare-and-contrast tables and the like. These could be set into his Goal Vector to save having to ask for each one individually in the session.

Some may like to review by testing themselves on a feedback question from each map. Only when they miss or feel uncertain would they call for information blocks from the related map.

The reviewer whose switch settings allow him complete freedom is even free to ask for a guided review.

In short, the free review condition helps the reviewer follow any strategy he prefers. If his skill in manipulating the system is weak, the generator can be set to teach him that also.

THE REFERENCER MODE

Introduction

The Learning-Reference System provides a number of features to facilitate the retrieval of information from the course data base. The person who comes to the system with a reference problem is served by the Referencer Mode whose primary objective is to provide quick location of those concepts, procedures and so forth that are relevant to the user's question or problem.

Brief Description

Most often referencers approach the system with specific questions in mind and in many cases speed of retrieval is important. To accomplish his search, the system allows the referencer the greatest amount of freedom in selecting the materials he wants to see. When the user logs on and the Mode Switch is set to Referencer, then automatically all relevant switches are set at the free end of the control continuum and all commands are legal for the referencer to use.

The Inexperienced User

Basically the referencer does not have to know very much about the system in order to retrieve the information that he is seeking. When his interaction with the system begins, the generator asks him to select a course and then shows this display:

> TO FIND WHAT YOU WANT, YOU GIVE COMMANDS BY PUSHING COMMAND BUTTONS AND BY TYPING.
>
> - TO SEE THE INDEX, PUSH THE INDEX BUTTON.
> - TO SEE THE TABLE OF CONTENTS, PUSH THE BUTTON WITH THAT LABEL.
> - TO SELECT INFORMATION YOU WANT TO SEE, PUSH THE GOTO BUTTON AND THEN TYPE THE NAME OR NUMBER OF THE MAP YOU WANT.
> - TO CHANGE COURSES, PUSH THE CHANGE COURSE BUTTON.
>
> TO FIND OUT WHAT OTHER COMMANDS DO, PUSH THE "DESCRIBE" BUTTON AND THEN PUSH THE BUTTON WHOSE FUNCTION YOU WANT TO KNOW ABOUT.

If the user inserts an inappropriate command, the system will prompt him by suggesting commands that might be more useful.

When the referencer uses the GOTO command, the generator shows all blocks from that map except feedback questions. If the user wants to see those he must use the FEEDBACK command.

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The Experienced User

The person who is experienced in operating the system can use some additional techniques to save himself time.

If, for instance, he knows that he has a series of things to look up, he can set up his own Goal Vector so that the maps he wants to see are tagged for display. Otherwise, he would have to consult the table of contents and use the GOTO command to bring up each map in the series.

If the referencer wants to check his understanding of a map concept, he can ask for a feedback question to be displayed. He does not have to answer it, but he may if he chooses and he may also ask for evaluation of his answer by pushing the JUDGE command. His answer, whether right or wrong, has no effect on the sequencing of displays because the referencer has no requirements he must meet.

Future Plans

Few concrete data are available concerning the behavior of those who are doing reference work. We expect that by debriefing interviews and by keeping a record of certain data on the commands used by those in the Referencer Mode, we may learn of modifications that may serve this user class more efficiently.

FOOTNOTE ON THE BROWSING MODE

Introduction

Originally project objectives included a provision for designing services that would enable a person to browse through the information base of a computer system in the way that he would browse in a library or bookstore.

Browsing Behavior

Patterns of browsing behavior have never been very well documented, although J. C. R. Licklider has suggested some experimental studies of browsing in order that automated libraries will not destroy this rewarding pursuit (Intrex, ed. by Overhage, C.F., and Harman, R.J., M.I.T. Press, 1965).

When we considered the kinds of things we ourselves did when browsing among books, we noted such things as being attracted to a book because of its arresting cover design, the presence of either a favorite topic or of a strange, puzzling term in its title, and so on.

At the present time we see no services needed by the browser that are not now provided by the Referencer Mode. The initial single display describing the four or five needed commands and then the free control settings should be quite sufficient to let the browser explore the information base at will. He would need access to all courses and it may be found that for him additional system-wide indexes and tables of contents are required.

Future Plans

For research purposes, it might prove valuable to keep separate records of browsing and reference behaviors. That can easily be done by having the user log in and be counted as a browser, and then program control would be shifted to referencer decision tables. Until additional needs of browsers have been identified, we plan to give no further attention to this mode.

THE BRIEFING MODE

Introduction

One of the primary purposes of the Briefing Mode is to acquaint users with the general nature and content of any course in the system. The generator can provide special materials and sample lessons to enable the user to:

- learn generally what the course is about
- compare one course with another
- decide whether he wishes to take the course in the role of either learner or reviewer.

Description

In order to show the general nature of a course, the generator can present information about:

- the difficulty level of the course
- names of prerequisite courses
- number of maps in the course
- the time estimated for completing the course as a learner
- course objectives
- the main points or big ideas of the course
- overviews and previews of some units
- sample lessons and sample tests.

These kinds of information are stored in every course data base, as Chapter 3 mentioned. The author of each course is responsible for providing the details and also for tagging other maps that are suitable for briefing purposes.

Formal Briefing

Since some who might want to use this mode may not know how to operate the system and use the commands, the system offers a formal briefing in which the sequence generator takes charge of selecting displays. The client may indicate how much time he wants to spend and the presentation will be adjusted accordingly.

Only a few commands are available for the person who receives the formal briefing--he can of course use NEXT to move the display along and he can ask for the table of contents and index. He can record comments, ask for help, change courses and stop. Otherwise the displays are totally determined by the sequence generator.

The Unrestricted User

The unrestricted user is free to explore the course material as he wishes. The system can suggest certain types of overview and general materials that are appropriate and it offers certain aids such as the "course comparison table" that permits him to check the dimensions along which he would like to compare two courses. For example, he might like to see how two courses compare on the items listed in the Description block above. The comparison table can be displayed to him or can be printed for him to examine off-line.

OTHER USER CLASSES

Introduction

Although the design of modes for support personnel was outside the scope of the present project, it was natural that we should begin to see something of their outlines as we filled in the picture for the primary clients. Some support functions were occasionally worked out in detail, others were sketched in only in a tentative way.

Just how these other modes will cater to the individual needs of the users is not fully clear yet, but the techniques can be expected to parallel those of the other modes. In addition, special aids will be made available for some functions.

We report the general status of these modes here.

Supervisor Mode

Because of the important role played temporarily by the supervisor in this first version, a number of functions of the supervisor have been implemented through the decision-table level. This degree of detail was useful in conceptualizing how future versions could automatically accomplish these same tasks.

The major function of the supervisor is to provide the sequence generator with all the information it needs in order to serve a newcomer to the system.

While it is easy to conceive of a set of professional requirements desirable in a training supervisor, the specific tasks assigned temporarily to this supervisor require little educational expertise and only superficial acquaintance with this system itself. In other words, we are concerned at the moment with the minimum that a supervisor must do to set the system displays going for a user.

The system has the capability at present to deal with a hierarchy of supervisors in which the operations of more experienced supervisors are less restricted. Nevertheless, the main work of any supervisor is accomplished through an on-line interview in which the system asks for the information it needs.

It asks for specific data, prompts the supervisor on unset switches, and displays menus from which he can select the alternative appropriate for the given user. Thus little burden is put on the supervisor's memory or training background.

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Writing, Editing Modes	Several classes of support personnel may be needed to prepare course materials for the system: authors, instructional designers, editors, key-punch operators and programmers. Space has been tentatively allotted for separate modes for each of these user classes, but it is most likely that the functions will be combined into one or two modes that can serve them all. Several existing languages have been considered with regard to their suitability for authors and instructional designers in this system, and some sets of requirements have been compiled; however an in-depth study leading to solution of this issue was not within the purview of this project. The author aids that have been designed so far include a demonstration set of questionnaires to guide authors in giving the generator every last detail it needs about each information block. The data required for even one feedback question is tedious to such a numbing degree that only a structured form and preferably an automated procedure can prevent careless omissions. (<u>Each</u> feedback question is accompanied by such details as these: its associated map, its number, name of block it is based on, its difficulty rating, the number of different answers expected, the different answers themselves to be matched against the user's response, the correct answer, actions to be taken for the different possible answers, display messages geared to the response alternatives, the number of times the user can try answering, and various flag and switch settings to indicate sequencing or display instructions.) For all personnel engaged in preparing course materials--from the instructional designer to the key-punch operator--the intention is to streamline their tasks by making procedures explicit, and by providing special commands and system guidance that will enable them to function with a minimum of special training on this system.
Researcher Mode	The system is built to retain detailed records of each user's interaction with the system--not only his identity, personal data, location, date, time and purpose, but also his path through the materials, blocks called for, command usage, performance data, control conditions, display conditions, feedback conditions, and so on.

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(continued) Researcher Mode	Such data are not only essential for both system and information improvement but they are a gold mine for research purposes. They can be almost useless unless the researcher is given the tools to tabulate and summarize them in the form he requires. Future plans call for programs that enable the researcher to extract what he needs with a minimum of special system training. Special commands, displays of data-condensing options, computation packages, provisions for off-line processing and print-out formatting choices are some of the potential aids that could make the Learning-Reference System a first-class research facility.

SUMMARY OF GENERAL INDIVIDUALIZATION STRATEGY

The General Strategy

Whether the user be a prime client or one of the support personnel classes, the general strategy followed in programming the generator is the same: to make it respond to each individual by basing its actions in part on:

- the user's objectives, capabilities, and wishes
- his familiarity with the system
- the current state of his knowledge of the area in which he is operating.

Varying degrees of system guidance can be chosen or assigned. Built-in aids--computer-directed interviews, brief operating instruction sequences, questionnaires, and explicit step-by-step procedures for some modes--all are designed for the purpose of making each user's experience with the system as effective and effortless as possible.

CHAPTER 6 CREATING AND MAINTAINING SYSTEM DOCUMENTATION

OVERVIEW OF THIS CHAPTER

Introduction	The process of designing a complex system always brings with it the problems of trying to keep descriptive paperwork from lagging hopelessly behind design solutions. Because of the nature of the Learning-Reference System design project, it was particularly important that we have documentation keep pace as the design evolved. Consequently as a major task in this project we made a concerted effort to work out explicit procedures and formal communication arrangements not only for keeping project documentation parallel to design work but also for consistently carrying through modifications in the plans. The set of procedures, guidelines and special aids that were developed to make documentation and updating systematic and current is known as the Documentation-Updating System. It is considered part of the larger body of data developed about Information Mapping and its application.
This Chapter	This chapter outlines briefly the nature of the system and describes how documenting and updating procedures are organized.

NEED FOR DOCUMENTING DURING DESIGN DEVELOPMENT

Introduction

To design a computer-based system for learning and reference, we realized, would be a complex and tedious process, extending over many months. These and a number of other factors in the design project made concurrent documentation especially important.

Some Relevant Factors

Initially certain calculations about the course of the design project made us appreciate the need for documentation:

- Designs of complex systems evolve in cycles of successive approximations and even though this was to be a first-pass version, we knew it would change continuously
  - during this project itself, and
  - perhaps over a several year period.
- The information to be developed would be complex, full of small details intricately interrelated and therefore outside the range of ready recall.
- The design would be the work of four or five staff members, each with his own area of responsibility, who needed to share solutions and plans at a very current level if they were not to work at cross purposes to one another.
- The possibility existed that some staff might be dispersed at other locations in the country.
- There was also the probability of some personnel turnover, especially among support personnel.
- There was the likelihood that there might be a lag of several years between design of the system and the beginning of its implementation.
- Those who would carry out the implementation would probably not be those who created the system.

THE NATURE OF THE DOCUMENTATION-UPDATING SYSTEM

Introduction

The development of a set of organized procedures, policies and aids for documentation was an integral part of the present project and early in the first chapter it was mentioned as the fourth major task.

Its rationale and key ideas were worked out even before the design project got under way; its procedures and policies were developed, tried out on the design project and improved through try-and-revise cycles.

General Objectives

Our objective was to develop a system that would encourage the production of documentation at such a level of detail and in such an accessible and understandable form that it would serve:

- the creators of a system during the design process
- designers who are responsible for adapting a system design for implementation in a given facility
- programmers who must translate a design into operational programs
- those who eventually assume responsibility for operating the system
- system managers who in later years must consider the feasibility of modifying or adding major system functions or of adapting existing functions to new equipment.

The Main Features

The central ideas of the system are that:

- Documents are written and organized in Information-Mapped form.
- They are maintained and updated according to explicit standardized procedures and policies.
- The personnel who perform the work communicate with project staff through special record forms that serve as explicit information-channelling instructions.

These topics will be considered separately.

Comment

The system that we describe is still evolving--it improves and expands as our experience with different situations grows. Ultimately, it is expected to become an <u>automated</u> system for document maintenance.

Introduction

The key idea of the system is that Information Mapping is the basis for all document preparation and organization.

This means that documents are kept systematically in a form that facilitates scanning and retrieval. And, because maps are movable modules, documents can easily be expanded without upsetting the organizational scheme.

Writing Documents

The information that forms the backbone of project documents must come from the creators of the system, and yet these are often the people from whom it is hardest to extract systematic information. Commonly we find that:

- The thinking of creative people runs far ahead of their written output.
- They find the task of writing down their ideas in detail intolerably burdensome.
- They do frequently write themselves cryptic scribbled notes about an idea or possible future plan.

Information Mapping applied to the documentation task will not solve the problem of extracting information from designers, but it has developed procedures that relieve them of some of the more burdensome aspects of the job. It even finds a place for their scribbled notes to themselves so that the system does not risk losing an important idea.

Whether system designers can do their own documenting or must work with technical writers who can elaborate their notes or conversations into formal documents, the aids that Information Mapping can offer are these:

- explicit procedures that enable support personnel to take over the burdensome aspects of document handling
- a set of guidelines and procedures for writing documents in standardized, organized form.

The kinds of procedures that are carried out to keep documents properly ordered, organized, and updated are described in the following map.

For the writers of documents, Information Mapping provides a ready-made set of instructions and guidelines. These were described briefly in Chapter 2 and are given in detail in the manual, A Reference Collection of Rules and Guidelines for Writing Information-Mapped Materials (cited in Chapter 1).

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Use of Decision Tables	In connection with both the design and documentation of computer software, we find decision tables especially useful in that, compared with flow charts, they are: . faster to construct . more efficient in format for verifying logic . easier to revise. Since we chose to build the sequence generator on decision tables because of their flexibility, our system contains many procedures that enable tables to be constructed and revised by support personnel who need have no understanding of the system.
Physical Organization of Documents	The organization scheme for project documents will follow the nature of the project and must be worked out on an individual basis, although commonly it proceeds from general descriptive material about purposes, specifications and major components toward increasingly fine detail concerning each aspect. In our own application of the system, documentation is kept in loose-leaf books because of the frequency with which maps are added or modified. Each member of the project staff has his own copy of the documents.

STANDARDIZED MAINTENANCE AND UPDATING PROCEDURES

Introduction

Maintenance and updating tasks are simple and utterly tedious. Their successful accomplishment depends upon making detailed step-by-step instructions covering what must be done for each situation.

The set of procedures and policies that we evolved are carried out by support personnel manipulating reams of paper, but clearly the same procedures could be carried out on-line, eliminating some of the paper and most of the tediousness of the human tasks.

Description

The full account of the existing procedures and special aids appears in Section 800 of the Project Document cited, Chapter 1.

In general the procedures, rules and instructions described there consist of:

- instructions for adding, deleting, and modifying numerous aspects of the documents--maps, tables, sections, terms, and so on
- instructions for carrying changes through to all areas affected by the modification
- special aids such as tables, lists, questionnaires, record forms and so forth that are intended to streamline staffwork in applying the procedures
- formatting and typing policies made explicit for typists and editors
- various features to keep system designers informed of changes.

While the contents of many of these procedures are specific to the individual project, the principles and general policies are readily adaptable to other situations.

The Next Maps

Rather than attempt to describe each of the above classes of materials, we give a series of examples that illustrate something of the nature of the system. (The actual procedures are given in the Project Document mentioned above.)

DOCUMENTATION SYSTEM EXAMPLE: PARTIAL TABLE OF CONTENTS, UPDATING SYSTEM

Introduction — This sample from the Table of Contents of the Updating Procedures Section is reproduced here to show the kinds of tasks that must be made explicit.

End of example

DOCUMENTATION SYSTEM EXAMPLE: STARTING POINTS FOR UPDATING ORDERS

Introduction

Orders to change documentation come to an updating assistant. The table below shows him where to start in processing such orders.

The nature of the change is located in the first two columns, the appropriate starting map for each is shown in the righthand column. These latter maps contain decision points that lead to other procedural maps within the system, thus insuring that the entire document is properly updated.

ORDER	ITEM REVISED	WHERE TO START
Index	. any term . any map	HOW TO INDEX TERMS, 800/63500
	Section of the document which does not contain decision tables	HOW TO INDEX A SECTION OF THE DOCUMENT, 800/63250
	Revised map	HOW TO UPDATE THE INDEX FROM A CHANGED MAP, 800/66600
	Revised Decision Table	HOW TO UPDATE THE INDEX FROM A CHANGED DECISION TABLE, 800/66800
Change	. name of a term	HOW TO USE THE INDEX TO CHANGE THE NAME OF A TERM, 800/63600
Add	Map	HOW TO ADD A MAP, 800/56000
	Section	HOW TO INSERT A NEW SECTION, 800/43000
	Flag	HOW TO ADD A FLAG, 800/71000
	Variable	HOW TO ADD A VARIABLE, 800/72000
	Switch	HOW TO ADD A SWITCH, 800/73000
	Command	HOW TO ADD A COMMAND, 800/74000
	Decision Table	HOW TO ADD A DECISION TABLE, 800/75000

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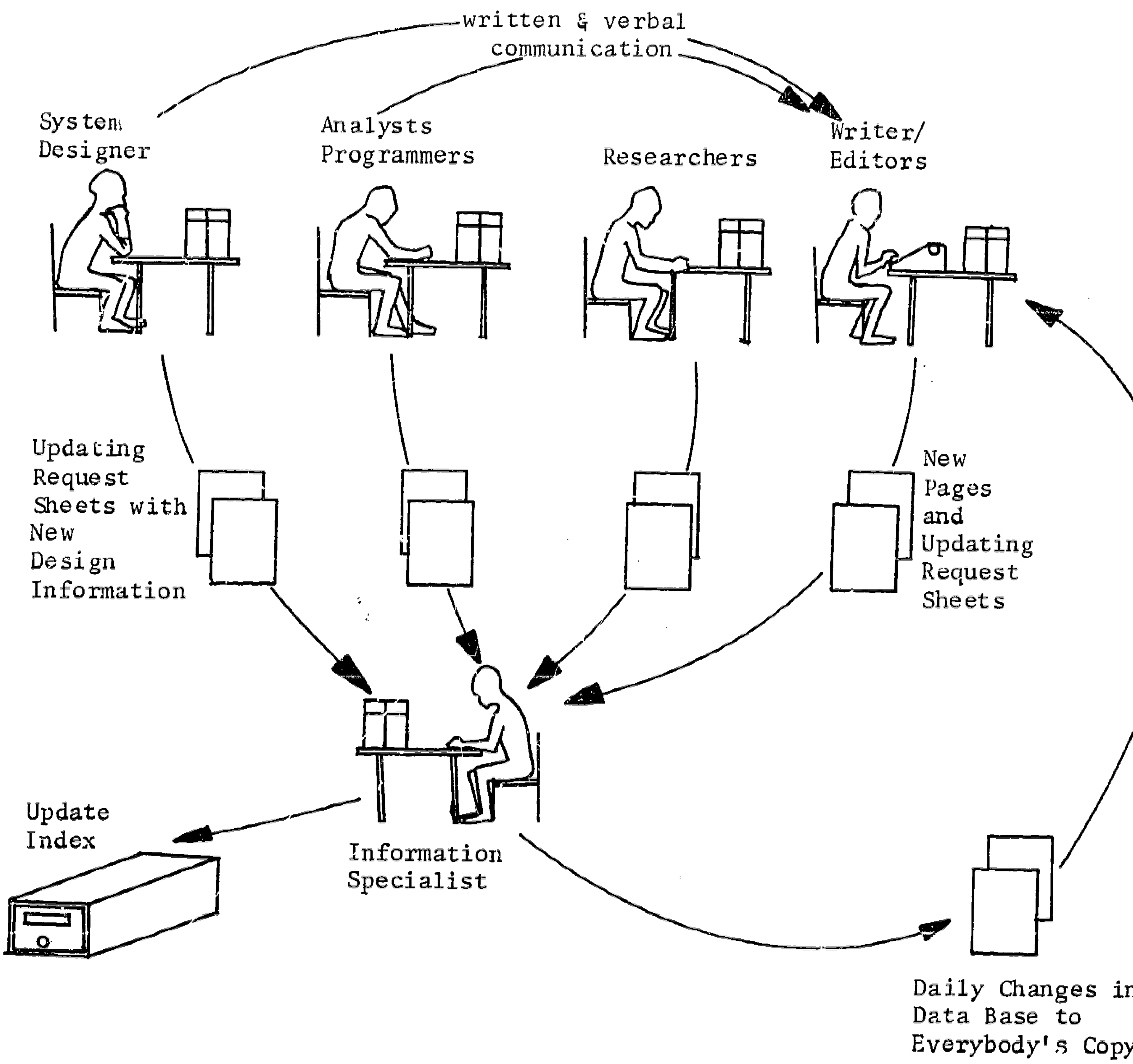
DOCUMENTATION SYSTEM EXAMPLE: STARTING POINT FOR UPDATING ORDERS, continued

ORDER	ITEM REVISED	WHERE TO START
Add (cont)	Attribute	HOW TO ADD AN ATTRIBUTE, 800/76000
	Term	HOW TO ADD TERMS TO THE INDEX, 800/16000
Date and/or Number	• any item	HOW TO DATE A MAP, 800/52000
		HOW TO NUMBER A MAP, 800/51000
Update	WHICH TABLES MENTION OTHER TABLES map	HOW TO UPDATE THE "WHICH TABLES MENTION OTHER TABLES" MAP, 800/68600
	WHERE EACH TABLE IS REFERRED TO IN THE OTHER TABLES map	HOW TO UPDATE THE "WHERE EACH TABLE IS REFERRED TO IN THE OTHER TABLES" MAP, 800/68800
	WHERE EACH FLAG IS MENTIONED map	HOW TO UPDATE THE "WHERE EACH FLAG IS MENTIONED" MAP, 800/68200
	WHERE EACH SWITCH IS REFERRED TO IN THE TABLES map	HOW TO UPDATE THE "WHERE EACH SWITCH IS REFERRED TO IN THE TABLES" MAP, 800/68400
	All copies of the document	THE "WHAT IS NEW" FUNCTION, 800/83800
	Table of Contents	HOW TO MODIFY THE TABLE OF CONTENTS, 800/24000
Delete	Section	HOW TO DELETE A SECTION, 800/42000
	Map	HOW TO DELETE A MAP, 800/57000
	Terms	HOW TO DELETE TERMS FROM THE INDEX, 800/64300

DOCUMENTATION SYSTEM EXAMPLE: MISCELLANEOUS AIDS

Status Remark Sheet	The Status Remark Sheet record form provides a means for a system designer to communicate about changes he wants made, future plans, points of disagreement on some aspect of the system. It may be addressed to specific staff members or to the project director, but in any case it will go through a central clearing point.
Request for Clarification Sheet	The Request for Clarification Sheet is a standard form by means of which questions on some aspect of the system may be routed to the appropriate person. It may be used by all project personnel and it is always routed through the updating assistant who keeps track of pending questions.
"What's New" Service	All principal staff members have copies of all project documents which are kept up-to-date by support personnel. All receive lists of changes that have been entered, but there remains the problem of calling their attention to significant changes. Special periodical summaries are issued to take care of this.
Short Courses	Selections from the documentation of various policies, procedures and formats are easily assembled into self-instructional courses for typists, clerks, writers, programmers and the like. By this means we have found it economically feasible to employ temporary personnel. The existence of such explicit base materials also has minimized project slowdowns due to personnel turnover.

SKETCH OF DAILY DOCUMENTATION ACTIVITIES DURING SYSTEM DESIGN



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DOCUMENTATION POLICIES

Introduction

Any program for documentation will work only so long as it has:

- top management support
- clearly drawn lines of decision-making authority and of responsibility for approving document entries
- an established list of priorities for accomplishing the various classes of tasks.

Management Support

If documentation is to be accurate and complete on the one hand, and useful to the community of creators on the other, it must begin when the design phase begins.

Too often documentation is the final mopping-up task after the project has been finished, ideas have grown cold, and staff has grown impatient to turn to other things. Documents could hardly fail to be superficial and incomplete.

To get good documentation, top management must support it seriously with a top priority rating and sufficient funding. They must also recognize its role as an important tool throughout the actual design process.

If documents are begun at once, made easily accessible, and kept current, designers will derive much help from them. In complex projects a designer cannot keep in mind all the consequences of a modification he makes even in his own area, let alone the effects it might have on the work of others. But system documents with lists that track each idea to all references in the system let a designer see ramifications of a change that he could not otherwise appreciate.

Thus documentation must be perceived by management not as constituting the final straw at the end of a long project but as playing a vital role in the design process from the beginning.

Priorities and Responsibilities

Documentation can become a morass unless explicit policies are formulated to control the movement of materials in and out. The statement of such policies, lines of authority and lists of priorities should be worked out by project managers before documentation begins.

Periodic reviews should be slated to examine the efficiency of the procedures and to revise them when necessary.

SUMMARY

Emphases	The Documentation-Updating System is based upon these convictions: • documentation should begin when design work begins • documentation, properly executed, is an important tool <u>during</u> the design process • change must be taken for granted and planned for • documenting and updating procedures can be made so explicit that consistent actions are taken and changes followed through • functions involved in documenting can be effectively separated and assigned to specialists in such a way that system creators are spared the more burdensome aspects • documentation needs significant management support.
Basis	Information Mapping is well suited as the basis for documentation because: • its formatting and reference features facilitate scanning and information retrieval • its modular form permits documents to be expanded and modified without upsetting the organizational structure.
The System	The Documentation-Updating System consists of: • a set of procedures for writing and organizing documents in Information Mapped form • a set of standardized procedures and policies for maintaining and updating the documents.

CHAPTER 7 SUMMARY OF THE LEARNING-REFERENCE SYSTEM

OBJECTIVES OF THE SYSTEM

Chapter Preview

Previous chapters have sketched in the main features of the Learning-Reference System. Since we have talked of many things the system can do and of the many mechanisms it uses, we propose in this chapter to draw it all together in a quick recapitulation of what the system does.

This summary may be a convenient reference aid in later discussions of assessment and future plans.

Primary Objectives

The primary objectives of this system are to provide computer-based information services for:

- initial learners: the service to consist of sequences of information displays that are either chosen by the learner himself or that are recommended for him by the system after evaluating:
  - his goal in learning and the level of mastery he seeks
  - his background experiences, abilities, and attitudes
  - his behavior and preferences shown during learning sessions.
- reviewers: the service to consist of the following aids to the person who wants to refresh his memory:
  - evaluation of his knowledge of the area
  - an individualized, guided review of those materials that he has forgotten or wishes to see
  - sequences for relearning either under system control or under the user's own direction.
- reference users: the service to consist of aids to enable the user to identify quickly the information he needs and to call it up for display.
- briefings: the service to consist of displays of information about any specified course, giving the client an overview of the course, its aims and requirements.
- browsing: the service to consist of aids to enable browsers to move about in any manner they like.

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Secondary Objectives

The secondary objectives are to build into the system those support services that will make it easy:

- to prepare information materials
- to collect performance data on system functions and on information units for the purpose of guiding continued improvement of the system
- to update information units
- to modify system functioning
- to collect for research purposes various data about system functions, information usage and clients' behavior patterns.

MAIN SYSTEM COMPONENTS AND THE FUNCTIONS THEY ACCOMPLISH

1 Modular Information Base	The contents of the information base may be characterized as follows: . written subject-matter materials are classified by Information Mapping categories and are stored in labelled information blocks that can be individually called up and displayed as required by each client . complete descriptive details about the information blocks and their various groupings into maps, units, and courses are stored in the data base in order to permit selection of materials suitable for the individual client . data about the clients are maintained in order to make possible delivery of information sequences that are responsive to their needs. The data may include: . purpose of user and level of mastery sought . previous experiences, abilities, attitudes . performance on prerequisite tests and pretests . switch settings that determine how the client and sequence generator will interact . various flags, lists, etc., that keep track of the flow of action during each client session so that meaningful sequences are displayed. . data about system components are stored to enable the sequence generator to accomplish various system functions such as reacting to commands.
2 Command Language	The command language consists of a set of terms designed to enable the user to direct the computer and to respond to displays. The set is capable of being restricted for some classes of users.
3 The Sequence Generator	The sequence generator is a computer program based upon a set of decision tables that handle all transactions between users and the information base. It not only fetches information for display but also keeps records of the interactions. The generator has the capability of responding in the ways described below, but not all clients will be allowed to take advantage of them.

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(continued) 3 The Sequence Generator	The generator operates in different modes depending on the user's purpose:

- <u>Initial Learner Mode</u>:
  - for each learner a learning <u>goal</u> is established in terms of how much of the subject matter he wants to cover
  - for each learner a <u>criterion</u> is established also to indicate how well the learner wants to know the materials
  - control of information selection and arrangement can be allocated to user or to system or it may be distributed between them in various patterns
  - level of control can be designated either by the user himself or by a supervisor, depending on how the computer facility is managed
  - the learner with freedom to control the system can use all commands and learner services of the system; he can take charge of his own learning path or he can direct the generator to take some control over the sequencing just as it would for learners with less freedom in the system
  - when the generator takes part in sequencing decisions, it takes into account many aspects of stored data about the learner
  - sequencing also depends partly on the learner's responses to feedback questions and to unit pretests
  - feedback to learner may be given or withheld at the discretion of the learner himself or of a training supervisor
  - the selection of feedback questions or worked examples for display may be based on their ratings in terms of difficulty level
  - remedial sequences may be presented when a specified failure rate is reached on feedback questions
  - a learner may change the standard order in which blocks are displayed to him and he may add other blocks to the standard pattern
  - the learner may ask to see additional blocks about a topic or to try extra feedback questions

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(continued) 3 The Sequence Generator	. the learner may depart from a sequence to revisit a previous map and may then return to his place . the learner may select the next topic from a list of appropriate maps . the learner may ask the generator to explain the meaning of commands or to suggest appropriate commands he might use next . the learner may enter comments about the materials, some aspect of the system, or his reactions to it; later these are reviewed by the supervisor or course designer.
	. Reviewer Mode: . control of information sequencing can be allocated to the reviewer, to the generator, or to both in a more or less equal distribution . in the system-dominant condition sequencing depends upon the user's responses to review questions at the unit level . units that are passed at a specified level drop out of the guided review sequences . users in the guided review condition require little knowledge of the command language . reviewers in the freer control conditions may take pretests in order to bypass units whose material they already know . reviewers in the freer conditions may review the course materials as they wish, including calling on the generator to take over routine sequencing tasks . reviewers may ask for feedback questions and may have their answers judged, but these do not affect the sequencing decisions.
	. Referencer Mode: . the user is allowed complete freedom to use the system's facilities as he sees fit . four simple commands enable the untrained user to find what he wants: Table of Contents command, Index command, Goto command, and Change Course command

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(continued) 3 The Sequence Generator

- system will instruct the user if inappropriate commands are used or if help is requested
- the user may respond to feedback questions if he likes and may ask to have his answers evaluated.

- Briefing Mode:
  - special materials give the client an overview of the content and structure of any specified course; the displays, under the control of either the system or the user, include:
    - course objectives
    - main points of the course
    - difficulty levels and prerequisites
    - applications
    - sample lessons
    - number of maps and estimates of time to learn.
  - those who come to the system for information about the general nature of course materials select whatever kinds of information they want or they can ask the system to present briefing materials to them
  - those using the briefing mode can set a limit to the amount of time they wish to spend and as a consequence the generator may reduce coverage of less important aspects
  - the mode permits comparison of two courses across significant dimensions.

- Browsing Mode:
  - the design of this mode is not yet complete, but its aim is to help the browser explore as he wishes; it will probably be built upon many of the mechanisms of the Referencer Mode except that the browser's freedom will extend across courses.

Supplementary Services of the System

The system also supplies support services, including:

- complete writing guide for the preparation of Information Mapped materials, including questionnaires to guide authors in recording descriptive data required by the sequence generator
- system documentation in Information Mapped form giving easy access to all aspects of the system
- written manual of step-by-step procedures for preparing system documentation and for maintaining it in up-to-date condition

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(continued) Supplementary Services of the System	. a "What is New" service to notify all system personnel of recent changes in the system and to call attention to significant differences . a computer-directed interview with the training supervisor to elicit from him the information that defines how much guidance the generator is to give each client . procedures for collecting statistics across courses and across users . printouts of data summaries to aid researchers and training supervisors . procedures and standard forms by which system personnel such as designers, editors, or programmers communicate about the changes they want to make . special sets of tables to aid designers, programmers, and updating clerks by providing lists of system components and of the places where each of them is mentioned in system documents . short training courses for support personnel.
Comment	Certain plans for possible extensions and modifications of these functions in a later version are mentioned in the closing chapter.

CHAPTER 8 EVALUATION OF THE SYSTEM DESIGN

WHY EVALUATE

Introduction

At various stages in a project it is customary to make an evaluation of one sort or another. In what sense could we evaluate the design for a system? We remind ourselves that evaluation is essentially a judgmental process and that it is by no means synonymous with statistical assessment of quantitative data.

Whether quantitative data are appropriate for the judging process depends entirely on the nature of the situation and the purpose for which evaluation is to be made.

The evaluation of a paper plan differs considerably from the evaluation of an operating system or of an educational program. In the latter cases, performance data, user surveys and the like can add an agreeable air of objectivity to the decision-making process. With a paper plan, we have to muster other kinds of information to aid in judgment.

Let us consider first why we would want to attach a value to a plan--that is, what would be the purpose of evaluation at this stage. Then we can see what kinds of information would be useful for the task.

Purpose

The purpose of evaluation at the design stage is to reach a decision about the project's future--whether to build the system essentially as proposed, cancel the project, or revise the plan and then reconsider its future.

Such a decision involves considering these two classes of questions:

1. Those concerned with its functions and the mechanisms for accomplishing them: Does it do the kinds of things we want? Is there some better way of doing the various functions? Are there places where we would prefer some other alternatives?

2. Those concerned with its costs: What will it cost to implement at several different levels from deluxe, say, to a stripped-down version? How much will it cost to maintain it, make new course materials for it, train personnel for it, and so on?

Comment

The problem of assembling information that bears on these questions will be considered on following maps.

THE QUESTION OF OFF-LINE SIMULATION

Introduction

Since we can get no real performance data from the system, we considered the possibility of using the simulation approach to try out aspects of system functioning.

Commonly when a real system is not yet in existence, some form of physical or symbolic model is constructed to simulate aspects of the system design in such a way that they can be tested. The purpose of course is to gather information that will help in finally implementing the system.

Models vary greatly--some are mathematical formulations subjected to computer manipulation, others are descriptive models subjected to logical analyses, and still others are actual physical prototypes that are subjected to real-time use by real people.

Possible Results From Simulation

In the earliest stage of the design process, we had conjectured that useful data might be obtainable by asking human operators to mimic the actions of the sequence generator and thus select paper displays of information blocks; the sequences might even be used by tryout subjects for learning or for reference work.

In actual fact, however, the sequence generator evolved into a much more versatile and complex program than we had anticipated. It was quite clear that its functions were dependent on too many details to be simulated by hand. In selecting information sequences, the generator has to check the status of so many computer locations and to consult and/or modify so many flags, switches, lists, stacks and so on that a hand-operated simulation could have no hope of producing displays with any useful frequency. Real subjects would perish from boredom between displays; thus no relevant information could emerge from such tryouts.

As a matter of fact a team of staff members did experiment with stepping through the programs and decision tables of the sequence generator to assemble paper "displays." The objective was to see if we could speed up our hand-operated simulation enough to warrant data collection with real subjects. Even with practice and shortcuts, the process remained unrealistically slow; we found that those parts of the sequence generator that we were using did "work" in the sense that they led to the delivery of meaningful sequences, but we discarded the hope of trying real learners or reference workers with it.

Without real test subjects, the only conceivable utility of continuing such an exercise would have been to check the linkage between program elements; that however is a trivial task better done by the routine desk-checking procedures of the computer-programming field.

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(continued) Possible Results From Simulation

Apart from the question of system functioning there is the question of whether a simulation of some sort could test the adequacy of the Information Mapped data base--that is, whether the different possible arrangements of blocks drawn from the information base make sense and are acceptable to the different classes of users.

We already had a collection of blocks cut from the Information Mapped book on Sets and individually mounted on index cards. These were useful for testing the adequacy of our guidelines for preparing course materials for the proposed system.

Now would a simulation using this collection of information blocks with tryout subjects help us in assessing the meaningfulness of reassembled information blocks? We think not--it would tell us something about the specific product, the book on Sets, and it might detect the need for a change in the writing rules. But shortcomings in either case would be corrected in routine developmental testing.

Conclusion

At this stage of the design, it is not possible to produce quantitative evidence bearing on its effectiveness. We do, however, argue that:

- the basic conceptions underlying the system have been subjected to repeated logical analyses by us and their soundness may be tested independently by anyone who wants to examine the detailed system plan.
- all components of the system, including information base organization and sequence generator details, are so designed that they can easily be improved according to procedures that have already been specified.

In short, the effectiveness of the proposed system can best be judged by experts who study the project documents. And there is the added assurance that a specified quality level is achievable through the built-in provisions for developmental testing and revision.

Apart from the question of effectiveness, however, other aspects of the system must be considered in reaching a decision about its future. These aspects are discussed on the next map.

BASIS FOR EVALUATION

Introduction

Whether a system has value for a given client depends upon whether it supplies the services he needs at a price he can afford.

Some of the questions that one would ask in order to judge the Learning-Reference System are:

- Does it provide the services you want for your clientele?
- What tasks would be required to implement this system?
- How long would it take?
- What range of costs might be associated with different versions of the system?
- What is required to operate a system like this?

Information concerning each of these will be considered.

Services

Only a prospective client can judge whether the system provides the range of services he wants. In the case of the Learning-Reference System, he can ascertain that fact by comparing his requirements with some statement of the characteristics of the system. The material in Chapter 7 may be a convenient source; if the summary statements seem promising, the prospective client would want to follow up by study of the system documents.

Preparation of Course Materials

For the Learning-Reference System, the tasks required for producing course materials are much the same as for producing mapped books. However, there is also the work of storing extra examples and feedback questions, and of recording details about the materials for the sequence generator's use.

In 1969 (Horn, Nicol, Kleinman, Grace) when the tasks and costs of Information Mapping books were estimated, we judged that the time spent on the major tasks of production was distributed this way:

. curriculum planning	25%
. writing and editing	55%
. developmental testing	20%

The direct labor cost for materials sufficient for an instruction hour was estimated to run around $1000. (Organizational overheads are not included and may run up to 150% of direct labor.)

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(continued) Preparation of Course Materials	Materials for the computer-based system can be expected to cost more since the writing tasks are somewhat greater. In view of the extra work and rising costs, our best guess now is that the materials for an hour of instruction would run in the neighborhood of $1500 (direct labor cost). Materials for an hour of instruction have been used as the basis for the estimates because they constitute the major writing chore for the information bases of the Learning-Reference System. It should be remembered, however, that these materials serve other purposes as well. Strictly speaking, then, we should point out that the cost estimates are for an hour of materials for instruction, reference, review, and briefing. The cost of preparing materials can probably be reduced if the work is broken down into separate functions and each assigned to a specialist. For example, the initial writing can be done by the subject-matter expert; the draft can be turned into Information Mapping form by a mapping specialist; support personnel can record the attribute data about the materials in the form required by the computer, and so on. We are experimenting with this procedure now but have no cost data available for comparison.
Training Writers	The above figures do not include the costs of training writers. Our experience in training for Information Mapping suggests that a one-week course followed by several weeks of practical experience under a competent editor is sufficient. The Learning-Reference System documentation includes formal questionnaires that quickly draw from writers the exact information about the materials that the system requires. Other procedures and checklists aid in streamlining the writers' work and reduce training time.
System Design and Programming	The selection of a computer system will involve consideration of many aspects of the clients' needs and resources. Once that decision is reached, system design work will be required in order to adapt the Learning-Reference System to the facilities and software of the chosen computer. This involves the working out of file management procedures, data base formats, data collection procedures and the final decision concerning what sequence generator details are to be implemented.

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(continued) System Design and Programming	Programming, coding, and debugging the sequence generator come next. Course materials must be translated from paper to the computer data base. And finally a period of system integration, checkout and revision will be needed. The amount of work involved in each of these tasks will vary with the sophistication of the system and its ready-made facilities.
Time and Costs	The time and cost of implementing the Learning-Reference System will depend upon how elaborate the system is to be and how many users it is to serve simultaneously. One system might incorporate all the major functions of the design but minimize the number of desirable-but-not-necessary services. Another system might include not only the major and secondary functions of the design but also automation of support functions such as supervising and updating. Since the possible configurations of computer facilities and versions of the Learning-Reference System are endless, the only way we can say something useful about time and cost figures is to take representative examples of a large system and a small one and try to make estimates for them: System I . Educational/training objectives primary . Limited version of sequence generator . One course available at a given time for the multiple purposes of 1 to 6 users . Small computer in the $50,000-$70,000 class with adequate time-sharing, display, and file management packages Cost to implement: $50-75,000 (direct labor cost) Time required: 12 months (Cost of course materials and computer time for system development not included.) System II . Information management as primary concern--training objectives, secondary . Expanded version of sequence generator . Up to six courses available at one time for the multiple purposes of 1 to 100 users . Large general purpose computer facility with adequate time-sharing, display and file management packages. Cost to implement: $100-150,000 (direct labor cost) Time required: 30 months (Cost of course materials and computer time for system development not included.)

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Operating the System

What is involved in the day-to-day operation of a Learning-Reference System? Although the number of support personnel will vary with the size and complexity of the installation, we can identify the functions that will have to be carried out to keep the system operating efficiently:

- managing: deciding facility policies, assigning support personnel, scheduling system operations (on-line time for primary and secondary users, and for maintenance technicians), establishing priorities for support personnel

- programming: system modification, loading of new course materials, correction of stored course materials, improvement of data collection procedures, and so on

- updating and documenting: insertion of all changes required by revision of course materials and additions to system documentation

- supervising: deciding the kinds of guidance the sequence generator is to provide for each client, entering starting data for each client into the system, evaluating performance data in order to guide initial learners more appropriately (optional)

- research: collection of performance data concerning system functions, information block use and user behavior patterns; evaluation of course materials; comparison of conditions; recommendation of changes.

In a small educational facility these functions might be carried out by a staff of two or three, while in a large facility each function might require several people. (Personnel required for the preparation of course materials were discussed in an earlier block.)

CHAPTER 9 FINAL CONSIDERATIONS AND SUMMARY

OVERVIEW OF THIS CHAPTER

Introduction

The major features of the Learning-Reference System have been charted in fairly detailed form, but the plan is only the springboard for the future. Even as the first version evolved, ideas for later versions were being recorded. Several generations of the system can already be dimly perceived.

This Chapter

In the next few maps, plans for later expansions will be mentioned. Finally we shall return to consider the immediate utility and importance of the present version and the research contributions to be expected from its implementation.

THE NEXT STEP

Introduction

In the first version of this system, a number of desirable features were left out because we were concentrating on developing the main mechanisms that would move the information blocks around and that would control interactions with the user in various ways.

Some important features were left out also because their design depended too much on the capabilities of the specific computer that may be involved.

Now the possibilities for incorporating such features may be considered. Some have already been mentioned under "Limitations of This Version" (Chapter 1) as being desirable next steps.

Display

The most important addition to the system will be the programs that determine how display capabilities of the given computer will be utilized in the Learning-Reference System.

It would have a tremendous impact on the system, for instance, if the display scopes could be used as a response medium. If area or marginal displays could be generated independently of the main information block displays, then such aspects as these could be shown:

- possible next topics
- permissible commands
- local index for related topics
- prompting comments.

The users could indicate many of their commands and selections by means of the light pen rather than by keyboard. This would probably make it much easier for the user to learn to operate the system.

The parameters of displays that can be manipulated during a session (brightness, size of characters, formats, etc.) will have to come under control of either the system or the user. New dimensions for controlling these will have to be defined and implemented in decision tables.

Various display options can be used to increase the impact of information-block materials. It is the author or curriculum specialist who would call upon these. For example, diagrams or sketches can appear in one area to illustrate the concepts or processes being explained by the information block in another area. Tables and diagrams might be revealed only a

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(continued) Display

part at a time as the text explains each. Structures can be "exploded" or "imploded" to show how parts fit together, and so on. The whole area of graphics technology can be drawn upon for ways to improve displays.

The role of animation as an educational tool has been explored in films and TV, but not enough is known about it yet in the computer setting. Animation techniques could be applied to highlight important points, focus attention, illustrate movement in networks, processes and the like. The impact of such techniques will undoubtedly vary with the individual differences in users and will have to be studied in controlled research.

If computer-display capabilities are to be put to practical use in improving the communication value of instructional materials, then the system must be prepared with supporting programs that will enable authors and designers to use the display options without the need for special training.

Sequencing and Control Decisions

Often through this report we have mentioned our intention to eliminate the supervisor from the system eventually. It is probably not wise to plan for this until after a period of experience with an operating system. While many of the supervisor's functions have already been marked for automation and could easily be turned over now, there are still other aspects of a new system taking to the air for the first time that require feedback from a knowledgeable observer. Whether that person be a training supervisor or researcher is not important at the moment, but it does appear that a period of shakedown experience should precede an attempt to formulate the algorithms to do the supervisor's work.

The expansion of dynamic sequencing decisions made during the sessions is another aim for future system versions. The system could be made more responsive to the individual if it had more opportunities for reacting to user behavior patterns and performance data as each session unfolds.

The definition of what aspects should be evaluated on a continuing basis and how they should influence sequencing decisions can also probably take place most efficiently after an operational version of the system becomes available. Study of interaction records and real user data would help in evaluating the feasibility of various alternatives.

At any rate, an on-going objective of the system should be to continue to improve its responsiveness to the individuality of its users.

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Inclusion of Common Computer Capabilities

Computers commonly possess routine capabilities that the present version does not utilize. It has been our intention to make them a part of the services of the Learning-Reference System but their inclusion must wait until a specific computer has been selected.

The remarkable power of the computer to perform on-line computations should be put at the disposal of the users of the Learning-Reference System. To be able to switch from an instructional mode to a computing mode is an exciting possibility for those who are learning or consulting mathematical or engineering materials. The motivational aspects alone of being able to do real work with a big computer system are incalculable.

The power of a computer with display capacity to aid in practical design problems--whether it be circuitry design or architectural design--might also be available for the users of some systems. Dynamic display options plus the capacity to "draw" or "write" on the scopes could enable the users to create and experiment in unpredictable ways.

These features cannot be added to the design of our system in any useful way until more is known about the memory capacity and display capabilities of the specific computer it is to use.

The printout capabilities of a computer system can also be considered an important educational resource. As we mentioned at the end of Chapter 1, there may be economical problems in controlling its use. Nevertheless, to allow system users to take home materials for review or reference may actually result in on-line time savings.

The Learning-Reference System will have to add the programs to control such printouts and to enable system clients to specify what they want and how it should be formatted.

Computers are able to tell time in remarkably small increments. This inherent capacity can be used in many ways which our system design does not include yet. The Briefing Mode, for instance, plans to adjust its presentations to clients according to the amount of time they want to spend. This needs implementation.

Evidence of varying quality suggests that time pressures may actually facilitate the learning of certain types of individuals. Time limitations on tests may be sometimes desirable as well. Time spent on maps, feedback questions and the like is useful evidence to guide revisions of materials.

Later versions of the Learning-Reference System, then, should include programs to deal with time controls and time recording.

LATER VERSIONS

Introduction

Among our dreams of second or third generation Learning-Reference Systems, we see a growing sophistication in the inclusion of other media under computer control. We also see a more effective utilization of the associative capacities of the computer.

Media

Future versions should have richer data bases in the sense that many other media can be controlled and inserted into the user-system interaction by the sequence generator. Among these are:

- printed materials ("hard copy," reproductions, etc.)
- real objects (for illustration, identification, diagnoses, etc.)
- physical models (of the brain, of the telephone, of the snail, etc.)
- sketch pads
- tape recordings
- slide and film projections
- video tapes.

We suspect that an important part of the enjoyment of learning is the unexpected encounter with surprises and humor. We hope that future versions will include a liberal lacing of these ingredients coupled with a subtle appreciation for the proper moment for inserting them.

It is unrealistic to imagine that course designers or authors will make full use of these system capabilities unless the system is ready with programs that will help them with very practical techniques for specifying what they want.

Cross-Course Links

The next version of the system will expand the cross-referencing procedures of the system. At present we have only detailed tables of contents and a cross-referenced index for each course. Greater power, especially for self-directed learners, can be gained by adding linkages across courses. Some provisions might be included to let users comment on some of their own insights about the links.

(continued on next page)

Simulation and Games

The mechanisms of the Learning-Reference System are so flexible that games and simulation exercises can be made a part of the learning, referencing, reviewing services.

Short courses to teach effective use of the system can be accomplished by games simulating system operations. Earlier we mentioned the desirability of using simulation to start users on the path to self-directed learning. Short exercises, discussions of useful strategies, and hypothetical problems can be combined to work toward that objective.

To incorporate such possibilities in a learning system requires considerable work. The feasibility of adding them depends on the specific system's capacity and on the addition of aids to the game designers so that they can easily take advantage of the full range of system capabilities.

Introduction

Organized efforts to advance the efficiency of computer-aided instruction differ in many ways, but one dimension along which they may be distinguished is that of the static or dynamic nature of the information base.

The majority of systems have data bases whose structure is fixed in advance, everything having been entered by the authors, including canned messages and all the remedial branches that can be anticipated. An example is the Air Force's Computer-Directed Training System ("The Development of a Computer-Directed Training Subsystem and Computer Operator Training Material for the Air Force Phase II Base Level System," AD 702-529).

A small but potentially very important line of development lies in the area of artificial intelligence. Exemplified by a system such as Carbonell and Collin's ("Mixed-Initiative Systems for Training and Decision-Aid Applications," ESD-TR-70-373), the data bases of these systems are capable of generating questions and answers not anticipated by the data base writer.

Still in their infancy, these so-called generative systems function through executive programs that can analyze the semantic and syntactic structures of the stored information. They are "knowledgeable" in the sense that they can produce meaningful information not stored *per se* in computer memory.

The possibility of a future union of these diverse approaches intrigues us now.

Future Union

In this context our Learning-Reference System belongs in the class of static or structured data bases from which no new inferences or generalizations can emerge as a result of the master control program.

The extensive nature of our underlying decision structures enables our system to control the conditions of user-system interaction, and to respond to the longer-term histories of system users. This capacity to respond individually to control conditions and to experiment with teaching strategies offers certain present advantages for practical applications and for controlled research into optimum conditions of learning--yet we foresee the day when artificial intelligence capacities and systems such as ours may combine to give us an automated tutor whose memory, intelligence and capacity to discern the individual needs of users far surpass the powers of human teachers.

UNIQUE RESEARCH CAPABILITIES OF THE SYSTEM

Quotation

The most important impact on education of computer technology . . . will probably be by supplying a tool for finding out what we are doing, for turning anecdotal impressionistic answers into scientifically testable ones, and so turning what has been almost purely an art into a respectable science--and without eliminating the artistic aspects either. Research in education, advances in educational understanding, education as a behavioral science will be, I think, the most important outcome.

R. W. Gerard
(Dean of the Graduate Division, University of California, Irvine)
in Computers and Education, p. xiv, McGraw-Hill, 1967.

Advantages and Issues

The Learning-Reference System as outlined here would constitute a significant research facility. Its unique capacity to manipulate and control conditions and to keep records makes possible a rigorous research attack on the important unsolved problems of education and training. Conditions can be changed and running records kept not only for the user's response patterns and performance data but also for the frequency patterns of information-block usage and command usage under each experimental condition.

The issue of how much guidance should be given a learner has long concerned educators. Now, as we have seen, this one system can offer varying degrees of guidance ranging all the way from total control of the learner to no guidance of him at all. Research with each learner using the system under systematically varied control conditions would begin to give us some long-sought answers.

But now the issue becomes one not so much of how much to guide the learner but rather how much to guide what kinds of learners. Recent concern with fitting instruction to the individual student points up the need for studying the effect of guidance conditions on various kinds of users, distinguished on the basis of patterns of data stored in their data bases.

Quite apart from the issue of how much control, if any, is best for each individual, there is the problem of prescribing information sequences and response requirements for the various learners or reviewers who are being in some degree guided by the system. In earlier discussions of this topic in Chapters 3 and 4, prescription-making was largely left on the doorstep of the curriculum specialist or author with the assumption that he would know not only what sorts of sequences should be

continued on next page

(continued) Advantages and Issues

assembled for which kinds of people, but also what kinds of remedial sequences are suitable to each. And we provided him with all sorts of new and old information about each user so that he would have concrete data for making his decision about sequences.

As a matter of fact, no one really knows very much about prescribing for the individual nor about what factors in the short- or long-term history of the person are relevant to such decisions.

One of the most important advantages of the Learning-Reference System is that it is designed to find answers to these problems. It is structured so that sequencing decisions can draw on many aspects of the user's background, interests, objectives, changing behavior within the session, and so on. This capability, coupled with its control over conditions and its record-keeping advantages, offers unprecedented research tools for "learning about learning."

While a major research effort on individualization is a pressing need at the present time, there remain a number of other or related research problems which the Learning-Reference System is equipped to tackle: controlled comparisons of teaching strategies, the effect of feedback variations, motivational effects of different learning conditions, curriculum-materials research, multi-media research, comparison of strategies for improving self-direction, and so on.

The effect of various display parameters not only on learning but on reference and reviewing as well is another fertile research area that can now be explored in relation to individual differences.

While some of the richest research problems center around initial learning, the related topic of reviewing and, by implication, retention, offers some interesting research possibilities--the effects of individualized treatment here also, to mention only one.

In terms of long-run impact, probably the most important aspect of the Learning-Reference System lies in its potential for searching out the answers to the practical problems of making information services more effective.

IMMEDIATE PRACTICAL USE OF THE SYSTEM

Introduction

The present system marks an important step toward making the computer a practical force in education and training.

It can guide the user or free him to use the information base as he wishes.

It can deliver sequences for him that take into account his short-term and long-term history and that reflect a given teaching strategy.

It can make available to him the facilities of a major computing system--to compute, to design, to cross-link, to create, to learn, to browse, to experiment, to explore.

Present Outcomes

Immediate practical outcomes for training and job aids can be expected from the implementation of this system plan on an existing computer--yet implementation is also important for the further evolution and refinement of this system. It is only by practical experience that the validity of certain solutions and the feasibility of some features can be tested.

Through the experience of operating such a system and of receiving feedback from its users, more subtle decision rules can be formulated.

Systematic observation of system users and study of their data and comments can lead to the devising of more useful aids for referencers, reviewers, and other users whose needs are not so clearly recognized now.

Cycles of developmental testing and revision are required to improve not only the information materials of the system but the operation of system functions as well. These are the necessary sequels of implementation on an operating system.

Concluding Statement

The computer-based system we have designed will provide information services for a variety of users who need access to textual materials: learners, reviewers, referencers, browsers, and so on. The quick retrieval of relevant information is achieved by having materials sorted into blocks and labelled according to the class of information concerned. Information Mapping is the name given to the unique classification scheme that guides this basic organization of information; it also includes formatting rules and guidelines for effective display.

The computer-controlled system is so designed that users can explore the information base of organized, labelled blocks with the same freedom they exercise in a library. But for those who need guidance, the system can enter into the process of selecting and assembling those blocks that are relevant to the user's objective.

The system's role in information sequencing can vary from minor prompting all the way to total control of pacing a user through a subject matter to achieve a specific instructional goal.

Whenever the system enters into the process of assembling information for display, it is set up to take into account the individual user's needs, capabilities, interests and the like.

While it is now possible to make reasonable prescriptions for information sequences suited to certain individual differences, (a neophyte in mathematics will obviously not be shown the same displays as the college senior math major), there remain many gaps where research evidence in education and psychology simply does not exist to guide sequencing prescriptions.

The present system is designed with the flexibility not only to incorporate new research findings into the decision-making mechanisms but also to take an active role in gathering under controlled conditions the comparative data that will extend our knowledge of how to make information presentations more effective for each individual.

APPENDIX A

Introduction

The Information Map Classification Chart (in updated form) is reproduced here from a previous report, Information Mapping for Learning and Referen~~. Horn, Nicol, Kleinman and Grace, ESD-TR-69-296.

MAP CLASSIFICATION CHART

Types of Maps	Description	Information Blocks
Concepts	A concept may be a: . technical term . generalization sentence . property sentence . rule sentence . relationship sentence	. name of the concept . definition or description . theorem (or generalization) . formula . use . rule . example . non-example . introduction . synonym . notation . diagram . comment . analogy . related maps

Structures	A structure is:
	. a physical thing, or
	. something which can be divided into parts which have boundaries.
		. name of structure
		  . meaning
		  . function
		. /all of the concept blocks/
		. parts and subparts

Processes	A process is some structure changing through time. The description of a process involves writing about what happens during successive stages of time.	. name of process . /all of concept blocks/ . /all of structure blocks/ . stage table . parts-function table . cycle chart . input-output table . cause-effect table . block diagram . PERT chart . WHIF chart . state table . condition . cause . effect

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MAP CLASSIFICATION CHART, continued

Types of Maps	Description	Information Blocks
Procedures	A procedure is a set of steps performed to obtain some specified outcome.	. name of procedure . /all of concept blocks/ . procedure table . flowchart . occasion for starting . when to stop . decision table . check list . work sheet
Classifi-cations	Classification is the sorting of things by concepts into categor-ies by the use of one or more sorting factors (criteria).	. classification table . classification sheet . classification list . outline
Facts	Facts are sentences about things done, things that are or were in existence, events, conditions, and so on, and are presented without supporting evidence.	. statement of fact
Proofs	Proofs are generally used in mathematical subjects for more dif-ficult theorems.	. name of proof . assumptions . to prove . statement . reason . example

APPENDIX B

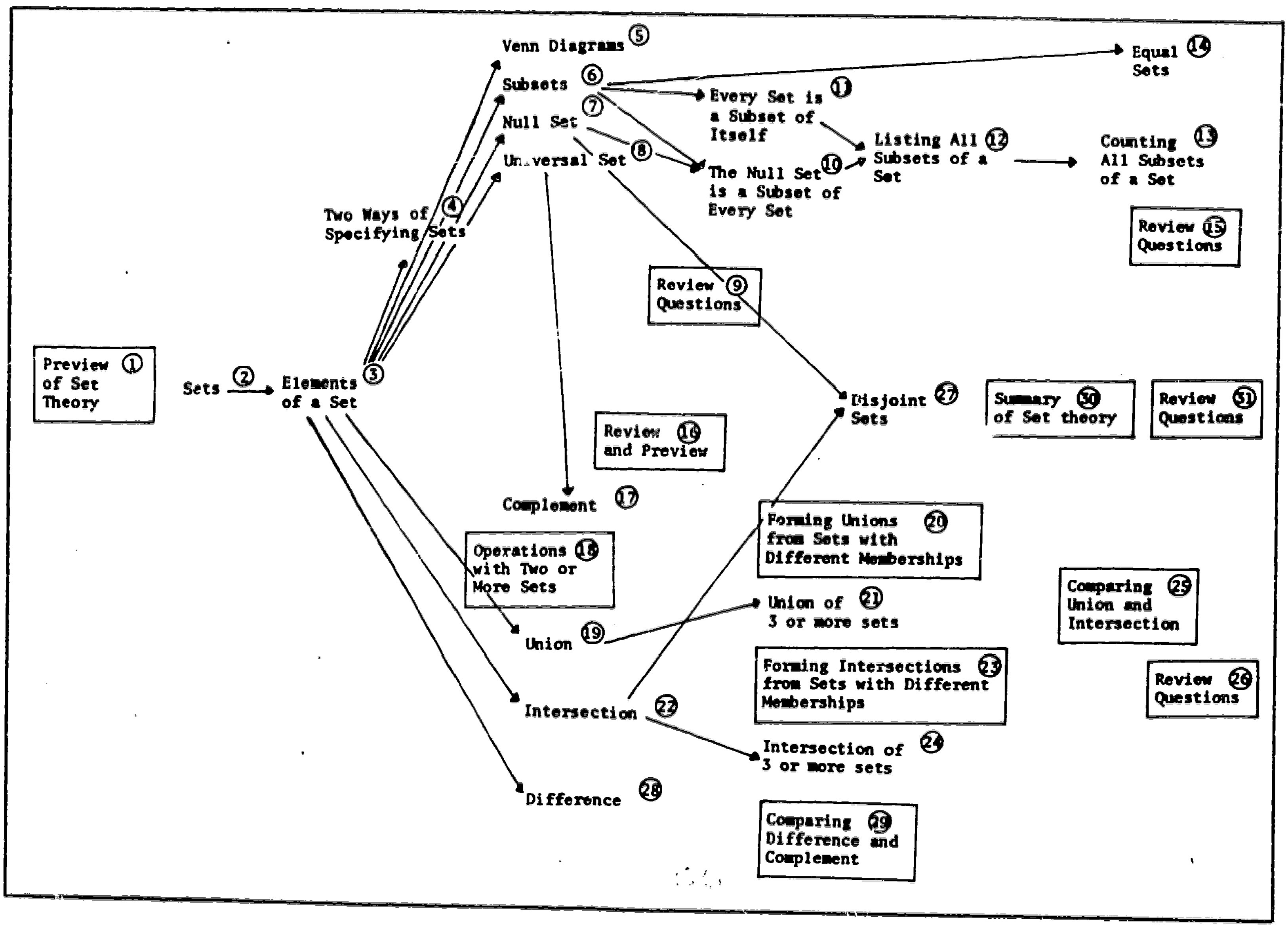
EXAMPLE OF A PREREQUISITE CHART *

Introduction

Before writing begins, the complete prerequisite chart (including the special learning materials) is drawn up. This chart functions as a road map for the writer, showing him the nature of his task and the character of the terrain that lies ahead. But the chart is not only important as a guide to the writer--it can also give the learner a clear idea of his learning task and of the direction the map presentations are heading. Therefore, prerequisite charts are included in information map books.

Example

The arrows are used to indicate the logical structure of the subject matter, i.e., the relationships among the concepts. The numbers refer to the teaching strategy or the sequence in which the topics are presented. The special learning and reference maps are shown in boxes.



* This and the following three maps are reproduced from: Information Mapping for Learning and Reference, Horn et al., 1969, ESD-TR-69-296.

EXAMPLE OF A PROCEDURE MAP

Introduction

This map shows the general case and the worked example side by side.

Example

HOW TO COMPUTE THE STANDARD DEVIATION

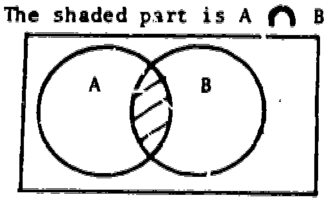
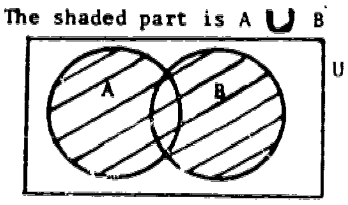
GIVEN	A set of n numbers $X_1, X_2, \ldots, X_n$	EXAMPLE. Find the standard deviation of the following test scores: 86,82,68,93,77,58,89,95,81,71
STEP	PROCEDURE	EXAMPLE
1	Add the given numbers to get the sum: ΣX_i	The sum of the ten test scores is $\Sigma X_i = 86+82+\cdots+71 = 800$
2	Square the sum and then divide by the number of cases to get: $(\Sigma X_i)^2/n$	$(\Sigma X_i)^2/n = (800)^2/10 = 640000/10$ $= 64000$
3	Add the squares of the given numbers to form ΣX_i^2	The sum of the squares of the test scores is $\Sigma X_i^2 = 86^2+82^2+\cdots+71^2 = 65234$
4	Subtract the result of Step 2 from the result of Step 3: $\Sigma X_i^2 - (\Sigma X_i)^2/n$	$\Sigma X_i^2 - (\Sigma X_i)^2/n = 65234 - 64000 = 1234$
5	Divide the result of Step 4 by the number of cases minus one to get: $S^2 = \frac{\Sigma X_i^2 - (\Sigma X_i)^2/n}{n - 1}$	$S^2 = \frac{1234}{9} = 137.1111$
6	The standard deviation is the square root of the result of Step 5: $S = \sqrt{S^2}$	$S = \sqrt{137.1111} = 11.71$

EXAMPLE OF A COMPARE-AND-CONTRAST TABLE

Introduction

We found that the distinction between the concepts of union and intersection was frequently missed by beginning students of set theory. Thus, the following map was written.

Example

COMPARING...	INTERSECTION AND...	UNION
Symbol	∩	∪
Definition	The intersection of two sets P and Q is the set of all members belonging to both P and Q.	The union of two sets P and Q is the set of all elements that are members of P or Q or both.
Venn Diagram	The shaded part is A ∩ B 	The shaded part is A ∪ B 
Example One	M = { 5, 9, 15, 33 } N = { 3, 5, 7, 9 } Notice this intersection, M ∩ N = { 5, 9 }	M = { 5, 9, 15, 33 } N = { 3, 5, 7, 9 } Notice this union, M ∪ N = { 3, 5, 7, 9, 15, 33 }
Example Two	E = { 1, 2, 3 } F = { 4, 5, 6 } Notice this intersection, E ∩ F = ∅ (There are no common elements)	E = { 1, 2, 3 } F = { 4, 5, 6 } Notice this union, E ∪ F = { 1, 2, 3, 4, 5, 6 }

Related Pages elements, 4 intersection, 35 set, 4
union, 30

EXAMPLE OF A SUMMARY MAP

Introduction

This table was designed to tie up the topics related to conditional probability. Readers who are not familiar with the subject matter can nevertheless note several important features of the example. The introduction underlines the importance of the topic and suggests to the student the nature of his learning task. In the left column simple questions are paired with concrete examples to help the student remember the distinctions. Formulas are as usual accompanied by verbal descriptions.

Example

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POSTVIEW OF CONDITIONAL PROBABILITY

Introduction

Conditional probability is one of the most useful tools in probability theory. We have seen how the equation can be rearranged to give the multiplication theorem and the independence definition, both important concepts.

The inter-relatedness of these ideas is a great boon to memory. If the conditional probability definition is thoroughly understood and stored in memory, it can serve as the key to unlock recollection of how the other formulas can be derived.

For review, we re-state the definition of conditional probability along with the concepts derived from it.

QUESTION	CONCEPT AND FORMULA
What is the probability of A, given that B has occurred? [Given a red-haired person, what is the probability that he has blue eyes?]	Conditional Probability: $P(A\|B) = \frac{P(A \cap B)}{P(B)}$ the conditional probability of A, given B = the probability that both events will occur divided by the probability of B
What is the probability that both A and B will occur? [What are the chances of winning Olympic medals in both track and swimming?]	Multiplication Theorem: $P(A \cap B) = P(B) \cdot P(A\|B)$ the probability that both events occur = the probability of B times the probability of A, given B
Are the events A and B independent? [Is the event "flunking math" independent of the event "flunking history?"]	Independence Definition: Two events are independent if and only if: $P(A \cap B) = P(A) \cdot P(B)$ the probability that both events occur = the product of the separate probabilities.
Given two independent events A and B, what is the probability that both of them occur? [If Tom and I both roll a die, what is the probability that we both get sixes?]	Multiplication Rule for Independent Events: [This is the independence equation just above.]

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APPENDIX C

EXAMPLE OF A CONCEPT MAP

DIVISIONS OF A COBOL SOURCE PROGRAM *

Introduction

In leaving detailed instructions for anyone about carrying out a complex task, we commonly give them several types of information: we identify the task and ourselves first of all, then we say what pieces of equipment are to be used and how they are to be set up, and then we specify the kinds of materials that are to be processed or produced, and finally we explain the procedures to be followed.

The computer too needs these same kinds of information in order to perform its tasks. The COBOL source program is organized to specify such instructions in a systematic way.

Description

A source program in COBOL has four divisions:

- the Identification Division, stating the name of the program, its author, and probably the date
- the Environment Division, telling about the equipment to be used, such as the specific computer (if the facility has more than one) and the various input-output devices
- the Data Division, explaining what data items are going to be used and how they are arranged
- the Procedure Division, setting out the steps that are to be followed in processing the data.

In a COBOL source program these four divisions appear in the order given here.

Comment

The Data Division will be described next so that we may see first what sorts of "ingredients" are going to be worked on in the Procedure Division.

In actual program writing, this is the order one would ordinarily follow. It is time enough to add identification and equipment information after the main idea has been worked out about how the procedures are to be applied to the data.

---

* COBOL, Cambridge, Mass., Information Resources, Inc., 1971 (draft), cited on p. 12.

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Information Resources, Inc. 1675 Massachusetts Avenue Cambridge, Massachusetts 02138	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

3. REPORT TITLE

INFORMATION MAPPING FOR COMPUTER-BASED LEARNING AND REFERENCE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

None

5. AUTHOR(S) *(First name, middle initial, last name)*

Robert E. Horn
Elizabeth H. Nicol
Richard A. Roman
Margaret P. Razar

6. REPORT DATE March 1971	7a. TOTAL NO. OF PAGES 159	7b. NO. OF REFS 31
8a. CONTRACT OR GRANT NO. F19628-70-C-0103	9a. ORIGINATOR'S REPORT NUMBER(S) ESD-TR-71-165	
b. PROJECT NO.		
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*	
d.		

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Deputy for Command and Management Systems, Hq Electronic Systems Division (AFSC), L G Hanscom Field, Bedford, Mass. 01730

13. ABSTRACT

A new conception of computer-based instructional systems is presented in this design of a system that can deliver individualized information sequences not only to learners and trainees, but to reference workers, reviewers, browsers and the like. Underlying the system is a flexible data base, organized into labelled, movable information blocks according to the principles of Information Mapping--a system for categorizing and displaying information. This report is itself written in modified Information-Mapping style. A significant feature of this computerized information service is that the control over information selection and arrangement can be assigned entirely to the user, entirely to the system, or to both in one of many possible patterns of shared responsibility. When the system takes part in information-sequencing decisions, its many mechanisms for individualizing come into play. The executive program consults short-term and long-term data about the individual, his objectives, capabilities, interests and present status before it selects and arranges blocks from the data base to display for him. Evaluation and feedback provisions are also individualized. The system's capability for controlling conditions and recording user-system interactions will make it a valuable force in research on individualization in training and education. The development of this complex design was facilitated by a Documentation-Updating System that produced system documents in Information-Mapped form and kept them up to date throughout the project.

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DD FORM 1 NOV 65 1473

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Information Mapping						
education						
learning						
training						
reference						
programmed instruction						
programmed learning						
computer-aided instruction						
computer-assisted instruction						
computer-managed instruction						
computer displays						
information retrieval						
human factors						
human engineering						
man-computer interaction						
computer-aided reference						
documentation procedures						
updating procedures						
computer documentation						
Information-Mapped data base						
individually prescribed instruction						

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